00 ► General

Contr.Session

1111-00-22 **Dirk R. H. Schlingmann*** (dschlingmann@uscupstate.edu), 800 University Way, Spartanburg, SC 29303. *Mathematics and Music.*

In this paper, I will present my work on how I use mathematics and the technical computing software Mathematica to analyze, manipulate, and create music. Musical pieces are available as Musical Instrument Digital Interface (MIDI) files. I will compare the work of well-known composers through statistical analysis, and will present variations of their compositions by performing geometrical transformations on their musical data. Furthermore, I will play musical creations that are entirely based on mathematical functions. (Received December 31, 2014)

Session 39

1111-00-77 **Anne Mendes Burns*** (aburns@liu.edu), Mathematics Department, Long Island University, Brookville, NY 11548. *Variation of Parameters: Visual Proof in Complex Analysis.* Preliminary report.

Complex analysis, taking place in two dimensions, is ideally suited for visualization. In addition to providing insight into the mathematics of complex variable theory, visualization produces beautiful works of art that awe even non-mathematicians. Topics taken from complex variable theory such as complex vector fields, circle inversions, Mobius Transformations and Dynamical Systems provide a variety of ways to assign color, value and transparency to a two-dimensional space. Interpreting a complex function as a vector field, stunning works of art can be produced. Vector fields can be plotted over one or more paths defined by complex functions; singularities and their multiplicities are easily discerned by the assignment of hue, value and transparency as functions of magnitude, direction and time. Transformations acting on circles provides a limitless source for mathematically inspired art. Mobius Transformations are ideal for use in iterated functon systems where circles are mapped to circles. "Continuously" varying the parameters in the Unit Circle Group leads to fascinating and sometimes surprising animations. The complexity of a dynamical system involving rational functions produces amazing pictures suggesting truths that can later be proved analytically. (Received January 19, 2015)

1111-00-89 **Marcus du Sautoy*** (dusautoy@maths.ox.ac.uk), Andrew Wiles Building, Radcliffe Observatory Quarter, Woodstock Road, Oxford, OX2 6GG, United Kingdom. *The Secret Mathematicians.*

Evening Public Lecture

From composers to painters, writers to choreographers, the mathematician's palette of shapes, patterns and numbers has proved a powerful inspiration. Artists can be subconsciously drawn to the same structures that fascinate mathematicians as they hunt for interesting new structures to frame their creative process.

Professor du Sautoy will explore the hidden mathematical ideas that underpin the creative output of well-known artists and reveal that the work of the mathematician is also driven by strong aesthetic values. (Received January 21, 2015)

Session 1

1111-00-197 **Bren Cavallo** and **Delaram Kahrobaei*** (dkahrobaei@gc.cuny.edu), New York, NY 10016. *A family of polycyclic groups over which the uniform conjugacy problem is NP-complete.*

Our main result is that we construct polycyclic groups G_n whose conjugacy problem is at least as hard as the subset sum problem with n indeterminates. As such, the conjugacy problem over the groups G_n is NP-complete where the parameters of the problem are taken in terms of n and the length of the elements given on input. (Received February 02, 2015)

Session 39

1111-00-280 **Carolyn A Yackel*** (yackel_ca@mercer.edu), 1501 Mercer University Dr., Macon, GA 31207. *An Analysis of Fair Isle Knitting.* Preliminary report.

During this talk we will discuss Fair Isle knitting. Fair Isle knitting is a type of stranded knitting employing two strands on any given row with floats of limited length. The combinatorial analysis of a single row defines the variety of potential row patterns, yet further investigation is required to discover how the row patterns can be assembled together to create two-dimensional patterns displaying specific crystallographic symmetries. (Received February 04, 2015)

Session 1

1111-00-284 **Bren Cavallo**, **Jonathan Gryak*** (jgryak@gradcenter.cuny.edu), **Delaram Kahrobaei** and **Conchita Martinez-Perez**. *Conjugacy Problem in Polycyclic and Metabelian Groups: Algorithms and Complexity.* Preliminary report.

In this talk we present a couple of algorithms for solving the conjugacy problem in various polycyclic and metabelian groups. We analyze the complexity of such algorithms, and present experimental results of the algorithms' performance. (Received February 04, 2015)

Session 21

1111-00-386 **José Tenreiro Machado*** (jtenreiromachado@gmail.com), Rua Dr. António Bernardino de Almeida, 431, 4200-07 Porto, Portugal, and **António M Lopes** (aml@fe.up.pt), Rua Dr. Roberto Frias, 4200-465 Porto, Portugal. *Analysis of complex phenomena by means of signal processing and fractional calculus.*

Complex systems (CS) emerge from the relationships between multiple objects that contribute to a collective behaviour often revealing surprising dynamical phenomena. The modelling of CS can adopt sophisticated mathematical tools, but often we verify that those are still far from capturing the overall richness of the involved dynamics. A common property to CS is the absence of a characteristic length-scale, meaning that CS reveal frequency-size power-law (PL) behaviour. PL distributions have been associated to systems with memory, as is the case of fractional-order systems. We study several natural and man-made CS in the perspective of dynamical systems. From such a viewpoint, a CS has an output that results from stimuli, being that signal interpreted as a manifestation of the global system dynamics. The system output is analysed by means of the Fourier transform (FT). The amplitude spectrum is approximated by a PL function and the parameters are interpreted as a signature of the CS characteristics. In a complementary approach, we compare and visualize similarities among several cases studied. Our approach contributes to better understand CS dynamics and their ruling principles, as well as to expose hidden correlations between systems from very distinct areas. (Received February 06, 2015)

Session 39

1111-00-397 **Radmila Sazdanovic*** (rsazdanovic@math.ncsu.edu), Department of Mathematics, North Carolina State University, SAS Hall PO Box 8205, Raleigh, NC 27695, and **Andrew Cooper**. *Visual thinking in mathematics.* Preliminary report.

Visualizations and visual thinking are essential to progress in many areas of mathematics. Visual representations of mathematical objects, structures or relations among them often provide a simple, natural description, useful for communicating complex ideas. But visual methods in mathematics are used for more than just presenting information. Visualization also advances understanding by distilling essential information and building intuition. When there is an equivalence between mathematical objects and their visual descriptions, both can be used exclusively, simultaneously, or interchangeably in constructing proofs. In addition to visualization as a tool, several fields of research study the mathematics of the visual, regarding visual objects as the primitives on which mathematical structures are built. (Received February 06, 2015)

Session 39

1111-00-468 **Susan Goldstine*** (sgoldstine@smcm.edu), Dept of Mathematics and Computer Science, St. Mary's College of Maryland, 18952 E Fisher Road, St. Mary's City, MD 20686. *Thinking Outside the Torus: New directions in bead crochet.* Preliminary report.

For the past six years, Ellie Baker and I have studied the mathematics of bead crochet rope bracelets. The traditional form for such a bracelet is an apparently seamless torus of beads arranged in a single spiral. This spiral structure introduces fascinating constraints on pattern design, and we have spoken about our discoveries at various conferences and published them in several papers and a book.

The underlying crochet in a standard bead crochet bracelet is very simple, with the same stitch repeated throughout the piece; the intricate patterns and textures in a bracelet stem entirely from the choice and arrangement of beads. Incorporating different crochet stitches such as increases, decreases, and chain stitches can produce bead crochet with more complicated geometry and topology. This talk will cover some of these new explorations into the mathematical possibilities of the art form. (Received February 08, 2015)

Contr.Session

1111-00-772 **Luke Wolcott*** (luke.wolcott@lawrence.edu). *The phenomenology of mathematical understanding: an experiential investigation.*

What is it like to understand mathematics? We have investigated the lived experience of understanding the notion of groups in mathematics, and extracted a generic structure of it as a series of mental cognitive gestures and embodiments. We use the first-person methodology of the interview of elicitation (entretien d'explication in French), developed by Pierre Vermersch and Francisco Varela and now used extensively for investigating the microdynamics of lived experience. This work is a collaboration between Luke Wolcott, a mathematics professor from Lawrence University, and Alexandra Van-Quynh, a philosopher of mathematics from Universidade de Lisboa. (Received February 10, 2015)

Contr.Session

1111-00-781 **Luke Wolcott*** (luke.wolcott@lawrence.edu) and **Elizabeth McTernan** (emcternan@gmail.com). *A classification of math-art work.*

We present a rough classification of math-art pieces, based mainly on the relationship between math and art that they employ and demonstrate, as well as their subsequent functionalities. Hermann Hesse's 1946 novel *The Glass Bead Game* is invoked to clarify and illustrate our classification. This work is a collaboration between Luke Wolcott, a mathematician at Lawrence University, Wisconsin, and Elizabeth McTernan, an exhibiting fine artist based in Berlin, Germany. (Received February 10, 2015)

01 ► History and biography

Contr.Session

1111-01-12 **Laurence Kirby*** (laurence.kirby@baruch.cuny.edu), 1 Bernard Baruch Way, New York, NY 10010. *Plimpton 322: The Ancient Roots of Modern Mathematics.*

The purpose of this session is to introduce a 32-minute documentary movie on the contributions of diverse ancient cultures to the mathematics that drives the modern world. The movie is intended for a general audience with the aim of inspiring students to pursue mathematical studies. Set against a backdrop of New York City, it centers on a famous mathematical document from ancient Mesopotamia that has its home in New York. The session will provide an introduction, discuss classroom use of the movie and lessons learned from its making and reception, and show an excerpt. (Received December 19, 2014)

Session 29

1111-01-17 **John Stillwell*** (stillwell@usfca.edu), Mathematics Department, University of San Francisco, 2130 Fulton Street, San Francisco, CA 94117-1080. *Historical Examples of "Reverse Mathematics".*

Reverse mathematics is a narrow and technical area of mathematical logic, but history suggests that its motivating idea applies to other parts of mathematics. In a 1974 ICM address, Harvey Friedman described this idea as follows:

"When the theorem is proved from the right axioms, the axioms can be proved from the theorem."

This talk will give several examples, from Euclid to Zermelo, where the relationship between axioms and theorems seems to fit the reverse mathematics paradigm: a strong new axiom is needed to prove certain theorems, and the theorems turn out to be equivalent to the new axiom. (Received December 22, 2014)

Session 29

1111-01-84 **Monica Blanco*** (monica.blanco@upc.edu), ESAB, Campus del Baix Llobregat, c/ Esteve Terradas, 8, 08860 Castelldefels, Barcelona, Spain. *Edmund Stone and the study of mathematical instruments: of the use of the "English sector" in trigonometry.* Preliminary report.

In 1723 Edmund Stone published The Construction and Principal Uses of Mathematical Instruments, which was essentially a translation from the French of Bion's Traité de la construction et des principaux usages des instrumens de mathématique. In the translator's preface, Stone regarded the study of mathematical instruments as one of the most useful branches of knowledge. However useful it might be, Stone lamented the lack of a general treatise, like Bion's, in English. Although this could explain why Stone translated Bion's treatise, his book cannot be said to be just a translation. As the title of the book indicated, Stone annexed a number of instruments that had been omitted by Bion, in particular those invented or improved by the English. Hence, for instance, after the translation of Book II, on the construction and uses of the 'French sector', Stone added a chapter on the 'English sector'. Again in the preface, Stone stressed the importance of mathematical instruments in connecting the theory to the practice in mathematics. In the context of the study of mathematical instruments in the 18th century, it is worth exploring the link theory-practice in Stone's book. The aim of this contribution is to analyse this link through the use of the 'English sector' in trigonometry. (Received January 21, 2015)

Session 29

1111-01-210 **Adrian Rice*** (arice4@rmc.edu), Department of Mathematics, Randolph-Macon College, Ashland, VA 23005. *Partnership and Partition: The third man in the Hardy-Ramanujan collaboration.*

It is now just over one hundred years since the beginning of the mathematical partnership between the Cambridge analyst G. H. Hardy and the Indian mathematical genius Srinivasa Ramanujan, one of the most celebrated collaborations in the history of mathematics. This paper focuses on one particular product of the Hardy-Ramanujan creative partnership, their 1918 paper on partitions, and considers the extent to which the assistance of a third contributor helped to influence its ultimate form. (Received February 02, 2015)

Session 39

1111-01-293 **Pedro J Freitas*** (pjfreitas@fc.ul.pt) and **Simão Palmeirim Costa**. *The mathematical problems of Almada Negreiros.*

Almada Negreiros was a very important Portuguese painter and writer of the 20th century. Towards the end of his life, he became increasingly interested in geometry, producing artworks with rich geometric content. Among these are constructions for the division of the circle in n parts and golden rectangles. These can be viewed as geometric problems: are Almada's constructions exact or approximations? We present a few examples. (Received February 05, 2015)

Session 29

1111-01-320 **J J Tattersall*** (tat@providence.edu) and **S L McMurran** (smcmurra@csusb.edu). *Mary Cartwright and G.H. Hardy's Oxford Seminar.*

Dame Mary Cartwright matriculated at St. Hugh's, Oxford in the fall of 1918 and received a First in mathematics in 1923. She was the first women to achieve that distinction. She taught at the Alice Oxley School and later at the Wycombe Abbey School before returning to Oxford in 1928 where she attended Hardy's graduate seminar. She received her D.Phil. degree from Oxford in 1930 under the supervision of G.H. Hardy and E.C. Titchmarsh. We focus on her Oxford undergraduate education and her impressions of and contributions to Hardy's seminar. (Received February 05, 2015)

Session 29

1111-01-331 **Maria Zack***, Mathematical, Information & Computer Sciences, Point Loma Nazarene University, 3900 Lomaland Drive, San Diego, CA 92106. *Lisbon, London and the Mathematics of Materials.*

The mathematics of the physical properties of material forms the basis for the modern discipline of engineering, and this area of knowledge expanded rapidly in the period from 1630-1800. In that same interval both London (1666) and Lisbon (1755) were catastrophically destroyed and subsequently rebuilt. The reconstruction process in each of these two capitals was well-resourced and provided an opportunity for the rebuilders to make use of scientific discoveries and enlightenment principles. This talk examines the reconstruction of these two cities in parallel with the European development of the mathematics of materials. It considers what influence mathematical understanding did or did not have on the actual design and construction processes in Lisbon and London. Of particular interest are Lisbon's timber-framed Pombaline buildings. Their construction raises some interesting questions about what mathematics Portuguese military engineers knew in the 1750's. (Received February 06, 2015)

Session 29

1111-01-361 **Jeremy J Gray*** (j.j.gray@open.ac.uk), Department of Mathematics and Statistics, Open University, Milton Keynes, MK7 6AA, United Kingdom. *The Plateau problem from Riemann and Schwarz to the first Fields Medal.*

The Plateau problem asks for a surface of least area that spans a given closed curve in space, and for a long time mathematicians were unable to calculate any but the simplest examples. The talk will concentrate on the progress that was made in two bursts: in the competition between Riemann and Weierstrass and Schwarz in the 1860s, and the competition between Douglas and Radó leading up to the award of the first Fields Medal in 1936. (Received February 06, 2015)

Contr.Session

1111-01-374 **Ângela Cerdeira Lopes*** (angelafafe@gmail.com), **António Leal Duarte** (leal@mat.uc.pt) and **M. Elfrida Ralha** (eralha@math.uminho.pt). *Mathematics at the newly reformed University (Coimbra, 1772): privileged insights gathered from the students' examinations.*

The Statutes for the University of Coimbra, effective after 1772, set, in particular, the official rules to be complied by the new Faculty of Mathematics: a meticulous curriculum for the novel degree of Mathematics, as well as the duties and responsibilities for each of its members (lecturers and/or students). The aim stands clear and exposes an ambitious plan for providing good preparation and scientific consistency for the future graduates.

In this communication, we go further on the analysis of the life/customs at the Faculty of Mathematics as we, literally, disclose some practical aspects in the implementation of the Statutes. We have centered our attention on the evaluation moments of the first students arriving at the University and gathered a set of data, composed by examination documents, which illustrate the mathematical contents for the sorted questions (supposedly chosen at random). We then compared those with some popular mathematical themes of that time, both in Portugal (for instance, with the main scientific interests of professors Anastácio da Cunha and Monteiro da Rocha) and abroad. We are also heading towards unveiling both the performances and the scientific evolution of such university students, in particular, of those who would gain some recognition. (Received February 06, 2015)

Session 29 1111-01-391 **Luis Saraiva*** (lmsaraiva@fc.ul.pt), CMAF, Av. Professor Gama Pinto, 2, 1649-003 Lisboa, Portugal. *The participation of Portuguese mathematicians in the first Iberian Congresses for the Progress of Science (1921-1932).*

In this talk we intend to analyse the contribution of Portuguese mathematicians to the Iberian Congresses for the Progress of Science that were held in the twenties and early thirties of the 20th Century, and the interaction with their Spanish counterparts. We start with the opening Congress in the city of Porto, Portugal, in 1921, and our analysis ends with the Lisbon Congress of 1932. In between we have congresses in Spain – Salamanca, in 1923, Cádiz, in 1927 and Barcelona, in 1929 – and in Portugal – Coimbra, in 1925. We will analyse in more detail the work of Francisco Gomes Teixeira (1851-1933) and Francisco Miranda da Costa Lobo (1864-1945), the former the most important Portuguese mathematician of this period, the latter one of the pioneers of Astrophysics in Portugal and the first Portuguese participant in the meetings of the Spanish Association for the Progress of Science. Both were important members of the Portuguese delegations which participated in these congresses. (Received February 06, 2015)

Session 29 1111-01-427 **June Barrow-Green*** (june.barrow-green@open.ac.uk), Faculty of Mathematics,Computing & Technology, The Open University, Walton Hall, Milton Keynes, MK6 7AA, United Kingdom. *Olaus Henrici and mathematical models.* Preliminary report.

The Danish born mathematician Olaus Henrici (1840–1918) studied in Heidelberg and Berlin before making his career in London, first at University College and then, from 1884, at the newly formed Central Technical College where he established a Laboratory of Mechanics. A proponent of pure geometry, Henrici produced a variety of mathematical models. These included surfaces of the second and third orders, as well as Sylvester's amphigenous surface. He exhibited many of his models in front of the London Mathematical Society and he was a significant contributor to the great exhibitions of scientific instruments and mathematical models in South Kensington in 1876 and Munich in 1893. The Munich exhibition also included an early form of his harmonic analyser, his "most strikingly original piece of work". (Received February 07, 2015)

Session 29 1111-01-432 **Rui Santos*** (rui.santos@ipleiria.pt), Escola Superior de Tecnologia e Gestão, Campus 2, Morro do Lena - Alto do Vieiro, Apartado 4163, 2411 - 901 Leiria, Portugal. *Continuous probabilities, random points, Bernoulli's theorems, and geometric probability applications.*

Comte de Buffon is generally regarded as the founder of geometrical probability (GP) due the presentation of the franc-carreau and the needle problems at the French Royal Academy of Sciences in 1733. Nevertheless, the first known GP problem is from Newton circa 1665, but only published in 1967. In these problems the counting of events was replaced by its measure calculation (length, area, volume and so on). In 1884 Czuber published the first monograph solely devoted to GP. In the French school, the GP also occupies a prominent position in the major books on probability, such as the ones from Laplace, Bertrand, Bachelier, Poincaré or Borel. On the other hand, the estimate of a probability can be performed by the random point count, a crucial idea which gave rise in the XIX century to the estimate of π by carrying out random throws. Moreover, the accuracy of the estimates increases with the number of points as a consequence of the stochastic convergence results.

In Portugal, Pacheco d'Amorim (1914) devotes a cumbersome and messy chapter of his doctoral thesis to the explanation of random figures. Nevertheless, his ideas of estimation based on random throws and on the Bernoulli's theorems are in fact the bases of many current applications of GP. (Received February 07, 2015)

Session 29 1111-01-467 **Hardy Grant*** (hardygrant@yahoo.com), 5010 Opeongo Road, PO Box 165, RR3, Woodlawn, Ontario K0A 3M0, Canada. *"Epistemic Cultures" and the History of Mathematics.* Preliminary report.

Thirty years ago Steven Shapin, surveying the "social" historiography of science, observed that mathematics had traditionally presented, in that line, an "unusually tough nut ... to crack". That perception can surprise: on the face of things the development of mathematics seems simpler in many ways than the course of science. But however that may be, the relation between the history, and hence the historiography, of the two spheres continues to provoke vigorous debate. Some historians of science (Hans-Jorg Rheinberger, Karin Knorr Cetina, ...) have focused on what the latter calls "epistemic cultures": the "arrangements and mechanisms" (such as laboratories) "which ... make up how we know what we know"; and their work has subsequently had an acknowledged influence on some historians of mathematics (Moritz Epple, Stephanie Dick, ...) – Epple for example drawing on Rheinberger for the key concept of culture-defining "epistemic configurations of mathematical research". Epple makes the challenging claim that the ensuing insights "require us to rethink the kind of temporality ascribed to mathematics". I shall attempt an overview and an assessment. (Received February 08, 2015)

Session 29 1111-01-480 **João Caramalho Domingues*** (jcd@math.uminho.pt). *Cunha's calculus in its times.*
The title of this presentation is a direct reference to a 1987 paper by Ivor Grattan-Guinness, "Da Cunha's calculus in its time", which summarizes José Anastácio da Cunha's particular version of the calculus and its context. I will expand on this subject, on one hand drawing on a couple of documents unknown in 1987 and on the other hand focusing on the large gap between Cunha's death in 1787 and the publication of a French translation of his main work in 1813 — several important developments in the foundations of the calculus occurred in the meantime (to the point of changing the standard educational version of the calculus), which would naturally affect the perception of Cunha's calculus in the 1810s. One of the documents Grattan-Guinness did not know in 1987 shows an Italian reviewer in 1816 stating that Cunha had anticipated what was then the usual definition of differential — while Cunha would later be seen as a forerunner of the defintion of differential given by Cauchy in the 1820s. This is an interesting example of how the same piece of mathematics may have different interpretations in different times. (Received February 08, 2015)

Session 29 1111-01-490 **Fernando B. Figueiredo*** (fernandobfigueiredo@gmail.com), Observatório Astronómico, Almas de Freire - Sta Clara, 3040-004 Coimbra, Portugal. *The Enlightened Jesuit: Monteiro Da Rocha (1734-1819) And The Reformation Of The University Of Coimbra (1772).*
José Monteiro da Rocha (1734-1819) was a key figure in 18th century Portugal. As mathematician and astronomer, he played a crucial role in the appropriation of the Enlightenment in the country. Over the last quarter of the century he steered the reorganization of Coimbra University and supervised the elaboration of new curricula in the mathematical sciences. These reformations were promoted by the almighty chancellor of King José I, the Marquis de Pombal. In Pombal's view, revamping the university was as a pressing need in a backward country he deemed plagued by a longstanding influence of the Society of Jesus. Originally a member of the Society of Jesus, Monteiro da Rocha became a frontrunner of Pombal's anti-Jesuitical reformation. A character with such a life path is historiographically difficult to accommodate, since the study of this period remains constrained by the dualism Pombal vs. Jesuits. I intend to show that, by placing these undertakings in a wider biographical frame, we will gain not only a clearer picture of Monteiro da Rocha's life and career, his action as a reformer of mathematical syllabuses, his role in the foundation of the Coimbra's Observatory, but also several clues for a better understanding of how the Enlightenment was appropriated in Portugal. (Received February 08, 2015)

Session 29 1111-01-541 **Helder Pinto*** (hbmpinto1981@gmail.com). *The reasons behind the request of the mathematician Gomes Teixeira to be transferred to the Polytechnic Academy of Porto – a peculiar event in the Portuguese context.*
In this talk we will present a comprehensive analysis of the possible reasons that led the important Portuguese mathematician Gomes Teixeira to move from the University of Coimbra (1290-today) to the Polytechnic Academy of Porto (PAP; 1837-1911) in 1884. Besides the family reasons that appear in the traditional historiography, other significant facts which may have contributed to this transition will be presented, such as: the existence of some conflicts within the Faculty of Mathematics of the University of Coimbra at that time and his friendship with Wenceslau de Lima (also lecturer of the PAP), who was responsible for the approval of the important reform of 1885 in the Parliament, soon after Gomes Teixeira became a professor in PAP. Note that this change was meaningful for a mathematician like Gomes Teixeira that wanted to precede his mathematical studies. Gomes Teixeira left the only pure theoretical superior school in Portugal to a technical school with many problems like, for instance, financial problems. In the other hand, the PAP didn't have a tradition in mathematics and there was no relevant mathematician in Porto before Teixeira (the only courses of mathematics taught in Porto were destined to sailors, merchants and engineers, i.e., a very practical mathematics). (Received February 09, 2015)

Session 29 1111-01-608 **Eliana Manuel Pinho*** (empinho@gmail.com), CEAU/FAUP, Faculdade de Arquitectura da Univ. do Porto, Rua do Gólgota, 215, 4150-755 Porto, Portugal, and **João Pedro Xavier**. *In search of its place. The teaching of Descriptive Geometry in Porto in the nineteenth century. (preliminary report).* Preliminary report.
Descriptive Geometry (DG) is, in the years following the French Revolution, a tool and a symbol of a new way of proceeding in education and scientific practice, which aims to combine utility and formal rigour. The bond of DG with the affirmation of an attitude, makes it a prime element for the study and understanding of a very rich period in the history of mathematical education. In Portugal, the ideals of the French Revolution were present in the organisation of the polytechnic and industrial schools, leading DG to a prominent place. We will present the implementation and evolution of the teaching of DG in Porto until the beginning of the twentieth century, mainly in the Academia Politécnica and in the Escola Industrial, founded respectively in 1837 and 1852. We will describe

DG's permanent compromise between its functional role and its theoretical requirements, ranging from the areas of mathematics, to drawing and mechanics, and either being split between multiple courses or constituting an independent course in itself. A paradigmatic example is given by the structure of the discipline following the 1885 reform of the Academia Politécnica, when Gomes Teixeira teaches DG with a program including projective geometry together with studies on gears and stereotomy. (Received February 09, 2015)

Session 29

1111-01-805 **Catarina Alexandra Mota*** (catlexmota@gmail.com), **M. Elfrida Ralha** and **M. Fernanda Estrada**. *The concept of tangent line in the scientific work of Francisco Gomes Teixeira.*

The concept of tangent line to a curve is as primitive as the mathematics is a science and, usually, it is considered an elementary concept. Hence, the study made on the tangent line its frequently associated to its teaching or its history.

Francisco Gomes Teixeira (1851-1933), a Portuguese mathematician, educator and historian, studied the concept of tangent line to a curve in his didactical and historical works, but we can also find the study of this concept and its properties in his scientific work.

In this work, we will analyze the study done by Gomes Teixeira in his scientific work about the concept of tangent line to a curve, namely: the papers published in Portuguese's and in foreign journals; the scientific relevance of the published results; the properties concerning the tangent line to curves studied in Traité des courbes spéciales remarquables plans et gauches. (Received February 10, 2015)

03 ► Mathematical logic and foundations

Session 44

1111-03-63 **Benno van den Berg*** (bennovdberg@gmail.com), ILLC, Universiteit van Amsterdam, PO Box 94242, 1090 GE Amsterdam, Netherlands. *The proof theory of nonstandard analysis.*

Most approaches towards nonstandard analysis are non-constructive and model-theoretic: they use non-principal ultrafilters or the compactness theorem for first-order logic to construct nonstandard models of the real or natural numbers. In contrast one can also start from the practice of nonstandard analysis and try to erect formal systems in which nonstandard arguments can be formalised directly; a nice example of such a system is Nelson's Internal Set Theory, but plenty of others exist as well. In this talk I will report on some recent developments in the proof-theoretic study of such systems. Together with Eyvind Briseid and Pavol Safarik we defined functional interpretations for systems for nonstandard arithmetic, which can be used to calibrate the strength of nonstandard systems and principles and establish conservation results. I will also explain how such a proof-theoretic approach makes nonstandard analysis more constructive. (Received January 16, 2015)

Session 45

1111-03-135 **Victor Pambuccian*** (pamb@asu.edu), School of Mathematical and Natural Sciences, 4701 W Thunderbird Rd, Arizona State University - West campus, Glendale, AZ 85306. *Provability in axiom systems for weak arithmetic and geometry without actual proofs.*

In 1975, Erdős and Selfridge proved that the product of consecutive integers can never be a power. In 1976, Schinzel and Tijdeman showed that, in a certain sense more generally, if a polynomial $P(x)$ with rational coefficients has at least two simple zeros, then the equation $P(x) = y^m$ has only finitely many integer solutions m, x, y, with $x \geq 0$, $m > 2$, $y > 1$, and these solutions can be found effectively.

It turns out that both of these theorems are true in PA^-, i.e., in all positive cones of discretely ordered rings. However, the proof of this fact does not lead to syntactic proofs of the individual cases of the sentences involved.

Similarly, in elementary geometry, there are theorems, such as the one proved by W. Szmielew in 1970, that the Pasch axiom is a consequence of the circle axiom, which are not effective, i.e., where no syntactic proof is known.

These cases highlight the difference between *provability* from a finite axiom system, which is achieved by a model-theoretical detour, and *actual proof.* (Received January 28, 2015)

Session 44

1111-03-224 **Imme van den Berg*** (ivdb@uevora.pt). *A uniformly bounded nonstandard set theory.* Preliminary report.

In 1977 Nelson presented Internal Set Theory IST, which is an unbounded nonstandard set theory for internal sets. Kanovei and Reeken introduced a bounded nonstandard set theory for internal sets BST, and extended it to external sets. In their theory some practical examples, like the collection of convex subgroups of $\mathbb{R}$ (neutrices), are unbounded and appear as external classes.

In this talk we adapt these set theories, and let them be uniformly bounded in the sense of a Grothendieck universe. Now the neutrices form a true external set, facilitating operations on them. Nelson's Reduction

Algorithm of external formulas, first towards external Σ_2 ($= \Pi_2$) formulas, and then to internal formulas remains intact.

To prove relative consistency to ordinary set theory, one needs to admit the existence of large cardinals.

[1] V. Kanovei, M. Reeken, *Nonstandard Analysis, axiomatically*, Springer Monographs in Mathematics (2004).

[2] E. Nelson, *Internal Set Theory, an axiomatric approach to nonstandard analysis*, Bull. Am. Math. Soc., 83:6 (1977) 1165-1198. (Received February 03, 2015)

Session 11

1111-03-252 **Rita Fioresi*** (`rita.fioresi@unibo.it`), Piazza Porta San Donato 5, 40126 Bologna, BO, Italy. *Quantum Homogeneous Varieties and Supervarieties.*

We want to use the concept of quantum section of a line bundle to construct a quantum deformation of the homogeneous variety G/H, where G is a semisimple algebraic group and H a parabolic subgroup. This quantum deformation comes equipped with a natural coaction of a quantization of the algebraic group G. This construction is naturally extended to give quantum deformations of homogeneous supervarieties G/H, where now G is a supergroup. In the end we give some important examples for physics: the chiral conformal and Minkowski quantum superspaces. (Received February 04, 2015)

Session 45

1111-03-343 **Reinhard Kahle*** (`kahle@mat.uc.pt`), Universidade Nova de Lisboa, 2829-516 Caparica, Portugal, and **Jesse Alama** (`alama@logic.at`), Vienna University of Technology, 1040 Vienna, Austria. *The notion of proof revisited.*

In the 21st century the traditional notion of mathematical proof is being challenged on two sides. On the one hand, we are witnessing a rise in computer-assisted proofs. Such proofs are worth considering with respect to their explanatory significance, but also from the standpoint of (human-readable) representation of proofs. On the other hand, in recent years one sees the rise of "big proofs", such as the classification theorem of finite groups. Such proofs shift our standards regarding verification, modularization, and lucidity of mathematical proofs. (Both aspects can, of course, come together, as we see in the case of the computer-assisted proofs of the four-color theorem.)

Our special session of the AMS-EMS-SPM joint meeting aims to bring together leading experts of the field to take stock of the current state of affairs and to sharpen the questions that the mathematical community has to address in the coming years regarding the notion of proof. In our talk we will set the stage for our special session by introducing the various conceptual challenges and perspectives at play in discussions about the notion of mathematical proof these days. (Received February 06, 2015)

Session 44

1111-03-416 **Abdelmadjid Boudaoud*** (`boudaoudab@yahoo.fr`), B.P.166, Ichbilia, 28000 M'sila, Algeria. *A nonstandard construction of an $\aleph_\alpha-$universal set.*

This communication is in the frame work of IST and in which we construct an $\aleph_\alpha-$universal set, where this notion is defined as follows.

Definition. A linearly ordered set $(P, \leq)$ is said to be $\aleph_\alpha-$universal, if there holds: Every linearly ordered set M of cardinality $\leq \aleph_\alpha$ is isomorphic to a subset of P (which is equipped with the induced order), the same M is embeddable in P.

For instance, the set $\mathbb{Q}$ of all rational numbers with the usual ordering $\leq$ is an $\aleph_0-$universal set of cardinality $\aleph_0$.

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Session 44

1111-03-504 **Jose Chagas Roquette*** (`joseroquette@iol.pt`). *Calculus with Indiscernibility.* Preliminary report.

We introduce a generalization of the Cantor-Dedekind continuum with explicit infinitesimals. These infinitesimals are used as numbers obeying the same basic rules as the other elements of the generalized continuum, in accordance with Leibniz' original intuition with the exception of one important result: their product is null, as the Dutch theologian Bernard Nieuwentijt sustained, against Leibniz' opinion. The starting-point is the notion of shadow, and from it we define indiscernibility (the central notion) and monad. Monads of points have a global-local nature, because in spite of being infinite-dimensional real affine spaces with the same cardinal as the whole generalized continuum, they are closed intervals with length 0. Monads and shadows (initially defined for points) are then extended to subsets of the new continuum, revealing interesting results of preservation in the areas of set theory and topology. All these notions do not depend on a definition of limit in the new continuum, and using them we obtain the basic results of the differential calculus. Finally, we give two examples illustrating how the global-local nature of the monad of a real number can be applied to the differential treatment of certain singularities. (Received February 09, 2015)

Session 44

1111-03-584 **Bruno Dinis*** (`bmdinis@fc.ul.pt`), , Portugal, and **Fernando Ferreira** (`fjferreira@fc.ul.pt`). *Nonstandard Intuitionistic Interpretations.*

We present a notion of realizability and a functional interpretation in the context of intuitionistic logic, both incorporating nonstandard principles. In a recent paper Ferreira and Gaspar showed how the bounded functional interpretation can be recast without intensional notions by going to a wider nonstandard setting. This was carried out in the classical setting. The bounded functional interpretation relies on the Howard/Bezem notion of strong majorizability. The functional interpretation that we present corresponds to the intuitionistic counterpart of the interpretation given by Ferreira and Gaspar. It has some similarities with an interpretation given by B. van den Berg et al. but it replaces finiteness conditions by majorizability conditions. Nonstandard methods are often regarded as nonconstructive. Our interpretations intend to seek for constructive aspects in nonstandard methods (in the spirit of recent papers by B. van den Berg and S. Sanders. (Received February 09, 2015)

Session 45

1111-03-637 **Thomas Hales***, 416 Thackeray Hall, Department of Mathematics, University of Pittsburgh, Pittsburgh, PA 15260. *The formal proof of the Kepler Conjecture.*

The Kepler conjecture asserts that no packing of congruent balls in space can have density greater than the familiar cannonball arrangement, called the face-centered cubic packing. This conjecture has been established as a theorem. A long-term project to give a formal proof of this theorem has recently been completed. This talk will report on this formalization project, which has been carried out in a combination of the HOL Light and Isabelle proof assistants. (Received February 09, 2015)

Session 45

1111-03-684 **Matthias Baaz*** (`baaz@logic.at`). *Eigenvariable conditions and the structure of proofs.*

We study two weakened Eigenvariable conditions:

(1) The Eigenvariable of a strong quantifier inference might occur in the conclusion but not in the end sequent and be eigenvariable of this inference only.

(2) The Eigenvariable of a strong quantifier inference might occur in the conclusion but not in the end sequent and might be eigenvariable of inferences of exactly this quantified formula anywhere in the proof.

Theorem

a. 1 and 2 are sound for LK but not for LJ.

b. LK with 2 is homorphic to LK with all classical quantifier shifts of already infered quantifiers.

c. There is a non-elementary speed-up of cut-free proofs with 1 or 2 wrt usual cut-free proofs.

d. LK with 1 or 2 admits cut-elimination.

e. There is no local (Genzen style) cut-elimination in a general sense for LK with 1 or 2.

(Received February 10, 2015)

Session 45

1111-03-696 **Angus John Macintyre*** (`a.macintyre@qmul.ac.uk`). *Proofs in PA (first-order Peano arithmetic).*

One can write down examples of diophantine equations over Z, unsolvable in Z, but whose unsolvability is not provable in PA. However, no natural example is known or even conjectured.It is plausible that all of mainstream number theory which can be formulated in PA can be decided in PA. Of course existing proofs in number theory are rarely done in PA,and typically make free use of methods of analysis and geometry. At one time there was much interest in understanding whether or not the Prime Number Theorem (readily formulated in PA) has an elementary proof "not using analysis". The elementary proofs now known do work in PA, though the set theory underlying complex analysis cannot naturally be formulated in PA. The talk will consider two aspects of the process of making elementary (say,doable in PA) higher-order proofs of elementary diophantine statements. The first is how one sets about fitting the Modularity Theorem into the language of PA, and then proving it in PA.The second is the analysis (following work of Kreisel from the 1950's) of what more one knows when one has proved an elementary statement in PA rather than in some higher-order system. (Received February 10, 2015)

Session 45

1111-03-701 **N. A. Vavilov*** (nikolai-vavilov@yandex.ru). *Complexity and reliability of proofs and computations.*

In the talk I plan to discuss the following phenomenon: a short formal or computational proof that we do not understand may be much less reliable than a very long conceptual proof that we understand. I will illustrate this thought in many real life examples. In particular, we could not find a single formula in recent number theory books, which would be longer than 2.5in, and yet stand a computer verification. Also, I will discuss what it really means to verify an extremely long and complex proof, such as Thompson-Feit theorem, by computer. (Received February 10, 2015)

05 ▶ Combinatorics

Session 3

1111-05-30 **Ricardo Mamede*** (mamede@mat.uc.pt), Departamento de Matemática da FCTUC, Universidade de Coimbra, 3001-501 Coimbra, Portugal, Portugal. *Lexicographical combinatorial generation and Gray codes for noncrossing and nonnesting set partitions of classical type.*

A Gray code is a listing structure for a set of combinatorial objects such that some consistent (usually minimal) change property is maintained throughout adjacent elements in the list. I shall present combinatorial Gray codes and explicit designs of efficient algorithms for lexicographical combinatorial generation of the sets of noncrossing and nonnesting set partitions of length n and types A, B and D. This is a joint work with Alessandro Conflitti (CMUC). (Received January 06, 2015)

Session 3

1111-05-95 **Daniel Birmajer**, **Juan B. Gil** and **Michael Weiner*** (mdw8@psu.edu), 3000 Ivyside Park, Altoona, PA 16601. *Colored partitions of a convex polygon by non-crossing diagonals.* Preliminary report.

For any positive integers a and b, we enumerate all colored partitions made by non-crossing diagonals of a convex $(n+2)$-gon into $(aj+b)$-gons, $j \geq 1$. For the number of partitions made by a fixed number of diagonals, we give both a recurrence relation of convolution type and an explicit representation in terms of partial Bell polynomials. We use basic properties of these polynomials to efficiently incorporate restrictions on the type of polygons allowed in the partitions. (Received January 21, 2015)

Session 3

1111-05-137 **Deniz Kus*** (dkus@math.uni-koeln.de), Weyertal 86-90, 50931 Cologne, Germany. *Demazure characters and fusion products.*

We discuss the category of indecomposable finite–dimensional graded representations of untwisted and twisted current algebras and present various objects in that category. In fact, it contains many well-known indecomposable reducible representations such as the Kirillov-Reshetikhin modules and Demazure modules associated to positive level integrable representations of affine Lie algebras. We present character formulas for Demazure modules and show that these formulas can be used to obtain character formulas for (truncated) Weyl modules, certain fusion products and Kirillov–Reshetikhin modules. Finally, we discuss the connection of Demazure characters with Macdonald polynomials. (Received January 28, 2015)

Session 3

1111-05-143 **Yosuke Ito** and **Soichi Okada*** (okada@math.nagoya-u.ac.jp), Graduate School of Mathematics, Nagoya University, Furo-cho, Chikusa-ku, Nagoya, Aichi 464-8602, Japan. *On the existence of generalized parking spaces for complex reflection groups.*

Let W be an irreducible complex reflection group and V its reflection representation. For a positive integer k, we consider a class function φ_k and its q-analogue $\widetilde{\varphi}_k$ on W given by $\varphi_k(w) = k^{\dim V^w}$ and $\widetilde{\varphi}_k(w) = \det_V(1-q^k w)/\det_V(1-qw)$ for $w \in W$, where V^w is the fixed-point subspace of w. We give a complete answer to the question when φ_k (resp. $\widetilde{\varphi}_k$) is the character (resp. graded character) of a representation (resp. graded representation) of W. Such a representation can be regarded as a generalization of the permutation representation of the symmetric group on classical parking functions ($W = S_n$ and $k = n+1$). We also discuss a relation with the polynomiality of generalized q-Catalan numbers $\mathrm{Cat}_k(W,q) = \prod_{i=1}^r (1-q^{k+d_i-1})/(1-q^{d_i})$, where $d_1, \ldots, d_r$ are the degrees of W. (Received January 28, 2015)

Session 3

1111-05-185 **Cedric Lecouvey*** (cedric.lecouvey@lmpt.univ-tours.fr), UFR Sciences et Technique, Parc Grandmont, Batiement E, 37000 Tours, France. *Quantisation of Littlewood-Richardson Beyong type A.*

Littlewood-Richardson coefficients admit various interesting quantisation related to affine crystals and Kazhdan-Lusztig polynomials. We will review their definitions and explain how similar notions can be defined for the other classcial root systems. (Received February 02, 2015)

Session 3

1111-05-244 **Ilse Fischer*** (ilse.fischer@univie.ac.at), University of Vienna, Fakultät für Mathematik, Oskar-Morgenstern-Platz 1, 1090 Vienna, Austria, and **Mihai Ciucu**. *Lozenge tilings of hexagons with arbitrary dents.*

MacMahon's classical theorem on the enumeration of plane partitions that fit in an $a \times b \times c$ box is equivalent to the enumeration of lozenge tilings of a hexagon of side lengths a, b, c, a, b, c. We present a generalization of this result where an arbitrary set of unit triangles is removed from along the sides of the hexagon. Our proof is based on Ciucu's extension of Kuo's elegant graphical condensation method. (Received February 03, 2015)

Session 3

1111-05-262 **Meesue Yoo*** (meesue.yoo@univie.ac.at), Fakultät für Mathematik, Oskar-Morgenstern-Platz 1, 1090 Wien, Austria. *Schur coefficients of the integral form MacDonald polynomials.*

In this talk, we consider the combinatorial formula for the Schur coefficients of the integral form of the Macdonald polynomials. As an attempt to prove Haglund's conjecture that $\left\langle \frac{J_\mu(X;q,q^k)}{(1-q)^{|\mu|}}, s_\lambda(X) \right\rangle \in \mathbb{N}[q]$, we have found explicit combinatorial formulas for the Schur coefficients in one row case, two column case and certain hook shape cases. A result of Egge-Loehr-Warrington gives a combinatorial way of getting Schur expansion of symmetric functions when the expansion of the function in terms of Gessel's fundamental quasi symmetric functions is known. We apply this result to the combinatorial formula for the integral form Macdonald polynomials of Haglund in quasi symmetric functions to prove the Haglund's conjecture in more general cases. As a different approach, we consider the expansion of $P_\mu(X; q, qt)$ in terms of $P\lambda(X; q, t)$ and see how the transition matrix looks. (Received February 04, 2015)

Session 3

1111-05-263 **Olga Azenhas** (oazenhas@mat.uc.pt) and **Aram Emami*** (emami@fasau.ac.ir). *Growth diagrams and a Lascoux's non-symmetric Cauchy identity over near staircases.*

Lascoux has generalized the classical Cauchy kernel expansion to arbitrary Ferrers shapes so that the former is a limit case of the latter. The non-symmetric version of the Cauchy formula expands in the product of Demazure atoms and characters under the action of Demazure operators specified by the cells above the biggest staircase inside the Ferrers shape. We give a bijective proof of this expansion for near staircases based on a growth-diagram interpretation of Mason's Robinson-Schensted-Knuth correspondence analogue for semi-skyline augmented fillings. Previously, we have studied for truncated staircases. Joint work with Olga Azenhas. (Received February 04, 2015)

Session 29

1111-05-410 **Robin J Wilson*** (r.j.wilson@open.ac.uk). *A century of graph theory.*

This talk features some of the highlights in the development of graph theory over the period 1890 to 1990. Among the topics covered will be planarity and colouring, enumeration, algorithms, and recent structural advances. No previous knowledge of graph theory is required. (Received February 07, 2015)

Session 3

1111-05-430 **Greta C Panova*** (greta.panova@gmail.com), 209 south 33rd street, UPenn Mathematics Department, Philadelphia, PA 19104. *Kronecker coefficients – combinatorics, complexity and beyond.*

The Kronecker coefficients $g(\lambda, \mu, \nu)$ are defined as the multiplicity of an irreducible representation S_λ of the symmetric group S_n in the tensor product of two other irreducibles, $S_\mu \otimes S_\nu$. Finding a positive combinatorial formula for these nonnegative integers or even criteria for their positivity has been a 75+ year old problem in representation theory and algebraic combinatorics. Recently, the Kronecker coefficients appeared as central objects in the field of Geometric Complexity Theory and more questions about their computational complexity emerged.

In this talk we will discuss a few problems of different characters involving these coefficients – the Saxl conjecture on the tensor square $S_\delta \otimes S_\delta$ where δ is the staircase partition, the combinatorial side with the new proof of Sylvester's theorem on the unimodality of the q-binomial coefficients as polynomials in q, and some complexity results. (Received February 07, 2015)

Session 3

1111-05-475 **Mercedes Rosas*** (mrosas@us.es), Sevilla, Spain. *Commutation And Normal Ordering For Operators On Symmetric Functions.*

I will present some commutator relations for several operators on the ring of symmetric functions. In particular to those related to multiplication, Kronecker products, and their adjoints.

The work presented in this talk is based on a collaboration with Emmanuel Briand, Peter McNamara, and Rosa Orellana. (Received February 08, 2015)

Session 3

1111-05-477 **Emmanuel Briand*** (ebriand@us.es), Departamento de Matemática Aplicada I, Escuela de Ingeniería Informática, Avda. Reina Mercedes, S/N, 41012 Sevilla, Spain. *Vertex operators and Kronecker coefficients.*

The Kronecker coefficients are the multiplicities that arise in a tensor product of irreducible representations of the symmetrc group. They are still much more mysterious than their cousins the Littlewood-Richardson coefficients.

In this talk I will present new results, obtained in a joint work with Mercedes Rosas (U. de Sevilla) and Amarpreet Rattan (Birkbeck College, U. of London) on two types of sequences of Kronecker coefficients: those obtained by growing the biggest hook of the three indexing partitions, that happen to be eventually constant, under some conditions; and those obtained by growing the first two rows, with a precise result of linear increasing.

The main tools for this work are the vertex operators for symmetric functions that were introduced by Jing in the 1990s and already used by Thibon and his collaborators to prove a variety of stability results. (Received February 08, 2015)

Session 1

1111-05-529 **João Jorge Araújo*** (jaraujo@uab.pt), Av Gama Pinto, 2, 1649-003 Lisboa, Lisbon, Portugal. *New Results on How to Save Prisoners from Pirates and Dinosaurs.*

Imagine some pirates kidnapped a person and had her put in a dungeon consisting of a number of interconnected caves, all of which appear identical. Each cave has a number of one-way doors of different colours leading to other caves. There is one more door in each cave; one of these leads to freedom, all the others lead to instant death at the jaws of a dinosaur. The prisoner has a map of the dungeon, she knows in which cave is the door to freedom, but she does not know in which cave she is. If lucky, there is a sequence of doors through which she may pass which take her to the escape cave from any starting point. In this situation the dungeon (in fact a finite deterministic automaton) admits a *synchronizing* word. These words are critical in many different real world situations and pose very demanding mathematical problems that require the use of results and techniques from automata, semigroups, permutation groups and combinatorics. Some new results mixing all these areas will be presented here. (Received February 09, 2015)

Session 23

1111-05-535 **Marina Iliopoulou*** (m.iliopoulou@bham.ac.uk), School of Mathematics, University of Birmingham, Edgbaston, Birmingham, B15 2TT, United Kingdom. *Kakeya-type questions and polynomial partitioning.*

A Kakeya set in $\mathbb{R}^n$ is a subset of $\mathbb{R}^n$ containing a unit line segment in each direction. It is conjectured that such sets have Minkowski (and Hausdorff) dimension n. This question gives rise to problems involving tubes in $\mathbb{R}^n$, and, in the effort to answer it, discrete analogues have been formulated, which involve lines instead. Such analogues seem to be dealt with effectively with polynomial partitioning. This is a relatively new technique, which lies in decomposing our space in smaller sets, using the zero set of a polynomial; this enriches our setting with extra structure, allowing us to do calculations. Polynomial partitioning was also recently used on the restriction problem, which is related to the Kakeya problem. The aim of this talk is to explain how polynomial partitioning is used in problems as above, and what obstacles seem to appear so far in applying it on the original Kakeya problem. (Received February 09, 2015)

Session 11

1111-05-571 **Jeanne S. Scott*** (jeanne@imsc.res.in), Universidad de los Andes, Bogota, Colombia. *the Grassmannian's BFZ-twist automorphism.*

I will discuss a combinatorial formula for computing Laurent polynomial expansions for BFZ-twisted Plücker coordinates with respect to clusters of the Grassmannian associated to Postnikov diagrams. (Received February 09, 2015)

Session 3

1111-05-580 **J. Haglund*** (jhaglund@math.upenn.edu). *Interpretations for a four-parameter Catalan sequence.* Preliminary report.

We discuss a function $C_n(q,t,w,z)$ which reduces to Garsia and Haiman's q,t-Catalan sequence when $w = z = 0$. We introduce conjectured interpretations for $C_n(q,t,w,z)$ involving Macdonald polynomials and the representation theory of diagonal harmonics. Connections with knot invariants and the h-vector of the type A_{n-1} associahedron are also highlighted. Part of this is joint work with Jeff Remmel and Andy Wilson. (Received February 09, 2015)

Session 3

1111-05-585 **Peter R. W. McNamara*** (peter.mcnamara@bucknell.edu). *Comparing skew Schur functions: a quasisymmetric perspective.*

This story begins with work of Reiner, Shaw and van Willigenburg, where they showed that if two skew Schur functions s_A and s_B are equal, then the skew shapes A and B must have the same "row overlap partitions." Unfortunately, the converse is not true. Recently, we have shown that these row overlap equalities are also implied by a much weaker condition than skew Schur equality: that s_A and s_B have the same support when expanded in the fundamental quasisymmetric basis F. Surprisingly, there is significant evidence supporting a conjecture that the converse is also true.

In fact, we will work in terms of inequalities: if the F-support of s_A contains that of s_B, then the row overlap partitions of A are dominated by those of B. Again, we conjecture that the converse also holds. After giving evidence in favor of our conjecture, we will conclude with a consideration of how the quasisymmetric Schur basis and the dual immaculate basis fit into our framework. (Received February 09, 2015)

Contr.Session

1111-05-642 **Tomasini*** (tomasini.jerome87@gmail.com), Angers, France. *About a combinatorial invariant on the branched coverings of the sphere.*

Since Hurwitz initial works at the end of the 19th century, it is known that the topological classification of the branched coverings of the sphere can be realize using combinatorial objects defined either in terms of permutations, or more recently in terms of planar maps. During this talk, I will present a combinatorial invariant of these branched coverings. The key idea of the construction is the following: given a branched covering $\pi : \mathbb{S}^2 \to \mathbb{S}^2$, we construct a star map T by connecting a chosen regular point with each the critical value of π, and we consider the pull-back of this map. I will finish by giving some properties of these planar maps. (Received February 09, 2015)

Session 3

1111-05-652 **Rosa C Orellana*** (rosa.c.orellana@dartmouth.edu), Mathematics Department, 6188 Kemeny Hall, Hanover, NH 03755, and **Geoffrey Scott** (gsscott@umich.edu). *Graphs with the same chromatic symmetric function.*

In 1995 Stanley introduced the chromatic symmetric function associated to every simple graph. In this talk, I'll present a novel technique to write this function as a linear combination of symmetric chromatic functions for smaller graphs. I will give two applications of this technique, the first is a sufficient condition for two graphs to have the same chromatic symmetric function; and the second is a construction of pairs of unicyclic graphs with the same symmetric chromatic function.

In addition, I will discuss some progress on the question of whether it is possible to determine a tree from its chromatic symmetric function. (Received February 09, 2015)

Session 13

1111-05-676 **Bogdan Ichim*** (bogdan.ichim@imar.ro), **Lukas Katthän** and **Julio José Moyano-Fernández**. *How to compute the Stanley depth of a module.*

We introduce an algorithm for computing the Stanley depth of a finitely generated multigraded module M over the polynomial ring $K[X_1, \dots, X_n]$. Moreover, we give an example of a module whose Stanley depth is strictly greater than the depth of its syzygy module. In particular, we obtain complete answers for two open questions raised by J. Herzog. (Received February 10, 2015)

Session 13

1111-05-706 **Manuel Delgado**, **Pedro A. García-Sánchez** and **Aureliano M. Robles-Pérez*** (arobles@ugr.es), Department of Applied Mathematics, Sciences Faculty, Campus de Fuentenueva s/n, 18071 Granada, Spain. *On the pseudo-Frobenius numbers of numerical semigroups.*

Let S be a numerical semigroup. An integer x is said to be the *Frobenius number* of S (respectively, a *pseudo-Frobenius* number of S) if $x \notin S$ and $x + s \in S$, for all $s \in \mathbb{N} \setminus \{0\}$ (respectively, for all $s \in S \setminus \{0\}$).

It is well known that, if f is a positive integer, then there exist numerical semigroups with Frobenius number equal to f. Moreover, there are algorithms to compute all numerical semigroups with a given Frobenius number.

Let PF be a set of n positive integers. Denote by $\mathcal{S}(PF)$ the set of numerical semigroups whose set of pseudo-Frobenius numbers is PF. This set is always finite but it may clearly be empty if $n > 1$. In this way, two questions arise naturally: find conditions on the set PF that ensure that $\mathcal{S}(PF) \neq \emptyset$ and find an algorithm to compute $\mathcal{S}(PF)$.

We present some theoretical results about the first question and two different procedures to determine the set of all numerical semigroups with a given set of pseudo-Frobenius numbers. (Received February 10, 2015)

Session 23

1111-05-717 **Michael Bateman*** (m.bateman@dpmms.cam.ac.uk), Centre for Mathematical Sciences, DPMMS, Wilberforce Road, Cambridge, CB3 0WA, United Kingdom, and **Victor Lie**. *Inverse 2D Kakeya theorems.*

We discuss recent progress with Victor Lie on a type of inverse Kakeya problem in two dimensions. If the Cordoba-Kakeya estimate is sharp, can we say anything meaningful about the set of bad points? What do the level-sets of the rectangles look like? This is related to the family of problems including Bourgain's sum-product theorem, Katz-Tao ring conjecture, and Furstenburg's generalization of the Kakeya problem. There will be a companion talk by Victor Lie. (Received February 10, 2015)

Session 3

1111-05-789 **Sabine Beil*** (sabine.beil@univie.ac.at), Oskar-Morgenstern-Platz 1, 1090 Wien, Austria. *Wieland drift for triangular fully packed loop configurations.*

Fully packed loop configurations (FPLs) of size n are subgraphs of the $n \times n$ square grid together with $4n$ external edges such that each vertex is of degree 2 and every other external edge is occupied. The link pattern of an FPL stores the information which external edges are connected by a path in the FPL. Wieland invented a map on FPLs – Wieland gyration – to prove that the number of FPLs with a fixed link pattern is rotationally invariant. In the talk I will focus on triangular FPLs (TFPLs) which came up in the study of FPLs corresponding to link patterns with a large number of nested arches. In a special case, TFPLs are enumerated by Littlewood Richardson coefficients. So far, not many enumeration results for TFPLs have been found. In the talk I will present a map on TFPLs – Wieland drift – which is based on Wieland gyration for FPLs. Furthermore, I will discuss some interesting properties of this map and also show how it gives rise to a new enumeration result for TFPLs that generalizes already existing results. (Received February 10, 2015)

Contr.Session

1111-05-795 **Juan D Gil*** (jzg216@psu.edu). *A recurrence relation for the Narayana numbers.* Preliminary report.

We give a combinatorial proof of a recurrence relation of convolution type satisfied by the Narayana numbers. (Received February 10, 2015)

Session 3

1111-05-810 **Rui Duarte*** (rduarte@ua.pt) and **António Guedes de Oliveira**. *From parking functions to the regions of the Shi arrangement.*

In the nineties Pak and Stanley introduced a labelling λ of the regions of the Shi arrangement with parking functions. In this talk we present an algorithm that returns a region R out of $\lambda(R)$. This is done by relating λ to another bijection, that labels every region S of the braid arrangement with $r(S)$, the unique central parking function f such that $\lambda^{-1}(f) \subseteq S$. In addition, we present a variant of the parking algorithm that is in the very origin of the term "parking function". (Received February 10, 2015)

Session 23

1111-05-812 **Victor D Lie*** (vlie@purdue.edu), 2435 A Kestral Blvd., West Lafayette, IN 47906, and **Michael Bateman** (mdb59@dpmms.cam.ac.uk). *Extremizers for the 2D Kakeya problem.*

Our talk will address the following theme:

Formulation of the problem. Let Q_0 be the unit square and let $\mathbf{T}$ be a collection of M^{-2n} separated tubes inside Q having length one and width M^{-2n} for some large $M \in \mathbb{N}$. Assume that $\mathbf{T} = \mathbf{T}_1 \cup \mathbf{T}_2$ with $\mathbf{T}_1$ consisting of tubes that have slopes between $[0, \frac{1}{10}]$ and $\mathbf{T}_2$ having tubes with slopes in $[\frac{9}{10}, 1]$. Our goal is to understand *both the structure and the size* of the level sets $\{F > \alpha\}$ where $\alpha > 0$ and $F := (\sum_{\tau \in \mathbf{T}_1} \chi_\tau)(\sum_{\tau \in \mathbf{T}_2} \chi_\tau)$ stands for the bilinear Kakeya function.

Specifically, the main interest is for the situation $\epsilon \in (0,1)$ fixed small number such that
$$\#\mathbf{T}_1 \approx \#\mathbf{T}_2 \approx M^{2n} \text{ and } \alpha \in [M^{2(1-\epsilon)n}, M^{2(1+\epsilon)n}]. \tag{1}$$
From just Chebyshev's inequality we know that
$$|\{F > \alpha\}| \lesssim \frac{1}{\alpha},$$
and we also know that this upper bound is attained when all the tubes are focussing in a square region of side-length $\frac{1}{\sqrt{\alpha}}$. Informally, our goal is to say that this is the "only" geometric instance is which this upper bound can be attained thus characterizing the extremizers for the bilinear Kakeya function.

Our analysis will involve additive combinatorics (e.g. Plünnecke sum-set estimate) and incidence geometry (e.g. Szemeredi-Trotter inequality) techniques and relates with a class of problems including Bourgain's sum-product theorem and Katz-Tao ring conjecture.

This is a joint work with Michael Bateman who will also deliver a companion talk at this conference. (Received February 10, 2015)

06 ► Order, lattices, ordered algebraic structures

Session 1

1111-06-53 **Miguel Couceiro*** (miguel.couceiro@inria.fr), LORIA, Equipe Orpailleur – Bat. B, Campus Scientifique B.P. 239, 54506 Vandoeuvre-les-Nancy, France. *An Arrow-like theorem for aggregation procedures over median algebras.* Preliminary report.

Conservative median algebras subsume several ordered structures (such as linearly ordered sets) pertaining to decision making and social choice. In this talk we will consider the problem of describing aggregation processes over such algebras that preserve their algebraic structure. To describe such processes, we first provide a characterization of conservative median algebras in terms of forbidden substructures, analogous to Birkhoff's characterization of distributive lattices and Kuratowski's characterization of planar graphs, and show that they can be represented as linearly ordered sets. Using this result we can show that homomorphisms between conservative median algebras are essentially order-preserving or order-reversing mappings. This result is then lifted to mappings between products of linearly ordered sets, and as a by-product we derive an impossibility theorem analogous to that of Arrow for aggregation procedures over convervative median algebras.

Some of the results we will present constitute ongoing research work being done with Bruno Teheux and Jean-Luc Marichal (University of Luxembourg). (Received January 14, 2015)

Session 1

1111-06-540 **Maria João Gouveia*** (mjgouveia@fc.ul.pt), Departamento de Matemática, FCUL, Campo Grande, Edifício C6, piso 2, P-1749-016 Lisboa, Portugal. *Completions of ordered structures.*

In this talk we will focus on some completions of ordered structures. In particular we consider canonical extensions of ordered algebras. The poset reduct of such an extension is a completion of the underlying ordered structure of the algebra. That completion has special properties that permit to lift the basic operations from the algebra to operations on the completion. Canonical extensions were first proved to exist and to be unique up to isomorphism for any bounded lattice. Later their special properties of density and compactness were shown to carry over to posets.

Profinite completions are the limits of certain projective systems of finite algebras. When the ordered algebras sit in a finitely generated variety of lattice-based algebras, their canonical extensions coincide with their profinite completions. The Boolean algebra and the distributive bounded lattice cases are classical examples that illustrate the coincidence of these two completions. Profinite completions and canonical extensions may also be closely related even when the poset reduct of the algebras is not a lattice. As we will show, this is evidenced in the (unital) semilattice case for which the canonical extensions sit inside the semilattice profinite completions as subsemilattices. (Received February 09, 2015)

Session 7

1111-06-568 **Javier Gutiérrez García*** (javier.gutierrezgarcia@ehu.eus), Department of Mathematics, University of the Basque Country UPV/EHU, Apdo. 644, 48080 Bilbao, Spain, **Imanol Mozo Carollo**, Department of Mathematics, University of the Basque Country UPV/EHU, Apdo. 644, 48080 Bilbao, Spain, and **Jorge Picado** (picado@mat.uc.pt), CMUC, Department of Mathematics, University of Coimbra, 3001-501 Coimbra, Portugal. *Around the frame of reals: extended and partial reals and the unit circle in Pointfree Topology.* Preliminary report.

In Pointfree Topology, a continuous real function on a frame L is a map from the frame $\mathfrak{L}(\mathbb{R})$ of reals into L. The frame of reals can be specified in terms of generators and relations. By dropping some of the relations we obtain the extended and partial variants of the frame of reals. If we replace now the frame of reals with these variants we obtain the pointfree counterpart of functions with values in the extended real line and the interval domain. Some results from [1] and [2] will be presented in the first part of the talk.

In the second part we will show how the same generators used to present $\mathfrak{L}(\mathbb{R})$ (with different relations) can provide a presentation of the frame of the unit circle. This is the object of study of the ongoing research project [3].

References

[1] B. Banaschewski, J. Gutiérrez García, J. Picado, Extended real functions in pointfree topology, J. Pure Appl. Algebra 216 (2012) 905-922.

[2] I. Mozo Carollo, J. Gutiérrez García, J. Picado, The Dedekind order completion of function rings, (to appear in Forum Mathematicum).

[3] J. Gutiérrez García, I. Mozo Carollo, J. Picado, Presenting the frame of the unit circle, (in progress).

(Received February 09, 2015)

Session 7

1111-06-693 **N. Martins-Ferreira***, Rua General Norton de Matos, Apartado 4133 — 2411 - 901, Leiria, Portugal. *On abstract systems of neighbourhoods and a relational approach to the theory of topological groups.* Preliminary report.

This talk can be seen as the continuation of the work [1], where the notions of (spatial) fibrous preorder and fibrous morphism are introduced, showing that the category of topological spaces is the quotient category of the category of spatial fibrous preorders, obtained by identifying two fibrous morphisms whenever they have the same underlying map.

The examples show that this notion provides a convenient setting to work with the intuitive notion of base of open neighbourhoods. Another possible application for the notion of (spatial) fibrous preorder is in the characterization of descent and effective descent morphisms in the category of topological spaces and other kinds of categories of spaces.

In this talk, the topological spaces arriving from a particular structure of fibrous preorder, which is called an 'abstract system of neighbourhoods', are considered and some of its categorical properties are presented, namely the ones concerning topological groups and other algebraic structures.

[1] N. Martins-Ferreira, From A-spaces to arbitrary spaces via spatial fibrous preorders, CMUC Preprints, 32, 2013.

(This is a joint work with G. Gutierres) (Received February 10, 2015)

Session 7

1111-06-707 **Jorge Picado*** (picado@mat.uc.pt), CMUC, Department of Mathematics, University of Coimbra, 3001-501 Coimbra, Portugal. *Order completions of pointfree function rings as function rings.*

The Dedekind completion of the ring of continuous real functions on a frame L was constructed in [1]. Is this completion again a function ring?

In this talk, we will give an overview of the results from [2] that address the question above. Namely, in the bounded case the completion is indeed isomorphic to some function ring, more specifically the ring of bounded continuous real functions on the *Booleanization* of L, while in the general case (modulo some condition on L) it is isomorphic to the ring of continuous real functions on the *Gleason cover* of L.

Two new classes of frames, the continuously bounded frames (*cb-frames*) and the *weakly cb-frames*, appear naturally in the picture. They are conservative extensions of their classical counterparts.

References

[1] I. Mozo Carollo, J. Gutiérrez García, J. Picado, On the Dedekind completion of function rings, *Forum Mathematicum* (in press).

[2] J. Gutiérrez García, I. Mozo Carollo, J. Picado, Normal semicontinuity and the Dedekind completion of pointfree function rings, *Algebra Universalis* (in press).

(Received February 10, 2015)

08 ► General algebraic systems

Session 1

1111-08-401 **Victor Dalmau**, **Andrei Krokhin*** (andrei.krokhin@durham.ac.uk) and **Rajsekar Manokaran**. *On constant-factor approximable Minimum Constraint Satisfaction Problems.*

We study the approximability of Minimum Constraint Satisfaction Problems (Min CSPs), where one is given a collection of constraints on overlapping sets of variables, and the goal is to assign values from a given domain to the variables so as to minimise the number of violated constraints. Constraints are usually given by relations, and we study how the approximability of Min CSP depends on the relations that are allowed to appear in constraints. In this talk, we will focus on algebraically characterising Min CSPs that admit a constant-factor approximation algorithm. (Received February 06, 2015)

Session 1

1111-08-563 **Peter Mayr*** (peter.mayr@jku.at), JKU Linz, Altenberger Str. 69, 4040 Linz, Austria. *Computational problems for direct products of algebras.* Preliminary report.

Let A be a fixed finite algebraic structure (e.g., a loop, a semigroup, ...). Given subalgebras of direct powers of A by generators, we consider algorithms for deciding membership, computing intersections, ..., and analyze their complexity.

This is joint work with A. Bulatov (Vancouver), M. Steindl (Linz), and Á. Szendrei (Boulder). (Received February 09, 2015)

11 ► Number theory

Session 25

1111-11-254 **Daniel Persson*** (daniel.persson@chalmers.se), Chalmers University of Technology, Department of Fundamental Physics, 412 96 Gothenburg, Sweden. *BPS-instantons and automorphic representations.* Preliminary report.

Instanton corrections to BPS-saturated couplings in torus compactifications of type II string theory are captured by certain U-duality invariant automorphic forms. The BPS-condition requires that these automorphic forms have very few Fourier coefficients, a fact that can be understood representation-theoretically. I will present a new method for computing such Fourier coefficients explicitly, thereby opening the possibility of finding explicit instanton corrections to higher derivative couplings in the effective action. (Received February 04, 2015)

Session 25

1111-11-339 **Sameer Murthy*** (sameer.murthy@kcl.ac.uk), Strand, London, WC2R2LS, United Kingdom. *Little string theories, Umbral moonshine and mock modular forms.*

The recently formulated "Mathieu and Umbral moonshine conjectures" propose unexpected relations between K3 surfaces, Niemeier lattices, and certain mock modular forms. A central element that naturally explains these relations remains to be understood. I will discuss the appearance of the Umbral mock modular forms as generating functions of supersymmetric states in a certain two-dimensional superconformal field theory (the "Little string theory"). This gives hints about the possible nature of such a central element. (Received February 06, 2015)

12 ► Field theory and polynomials

Contr.Session

1111-12-565 **Zélia da Rocha*** (mrdioh@fc.up.pt), Departamento de Matemática da FCUP, Rua do Campo Alegre n.687, 4169 - 007 Porto, Portugal. *A symbolic general method for deriving some semi-classical properties of perturbed second degree forms: the case of the Chebyshev form of second kind.*

In this work, we present a general method, an ordered procedure of algebraic computations, in order to explicit some semi-classical properties of perturbed of second degree forms, namely: the functional equation, the class of the form, the Stieltjes function, the Stieltjes equation, a structure relation and the second order differential equation. The case of the Chebyshev form of second kind is taken as study example and we give results for several perturbations until order four. Moreover, we deduce the connection coefficients and the connection relations for the r-generalized co-recursive and co-dilated of the Chebyshev form of second kind, for any r. (Received February 09, 2015)

13 ► Commutative rings and algebras

Session 13

1111-13-41 **Shalom Eliahou*** (eliahou@lmpa.univ-littoral.fr), LMPA-ULCO, 50, rue Ferdinand Buisson, CS 80699, 62228 Calais, France. *Some progress towards Wilf's conjecture.*

Let S be a numerical semigroup, i.e. a subset of $\mathbb{N}$ containing 0, closed under addition and with finite complement in $\mathbb{N}$. This last condition means that a suitable translate $c + \mathbb{N} = \{c, c+1, c+2, \dots\}$ of $\mathbb{N}$ is contained in S. The smallest such integer c is known as the conductor of S. Let e be the embedding dimension of S, i.e. its least number of generators. Let also m be the multiplicity of S, i.e. its smallest non-zero element. In 1978, Wilf conjectured that the number of elements in S which are smaller than c is bounded below by c/e. Wilf's conjecture is known to hold in various cases, including when $c \leq 2m$. In this talk, we settle Wilf's conjecture in the case where $c \leq 3m$, which asymptotically represents, in an appropriate sense, the majority of numerical semigroups. One main ingredient in our proof is a classical theorem of Macaulay on the growth of Hilbert functions of standard graded algebras. (Received January 09, 2015)

Session 13

1111-13-55 **Christopher ONeill*** (coneill@math.tamu.edu), **Vadim Ponomarenko**, **Reuben Tate** and **Gautam Webb**. *Catenary degrees of elements in numerical monoids.*

Nonunique factorization in commutative monoids is often studied through the use of factorization invariants. One such invariant, called the catenary degree, measures the distance between factorizations within a given monoid, and can be computed using a graph theoretic construction. In this talk, we present results from an undergraduate research project involving the catenary degree in additive submonoids of the natural numbers. (Received January 14, 2015)

Session 32

1111-13-91 **Henrik Holm*** (holm@math.ku.dk), Department of Mathematical Sciences, Universitetsparken 5, 2100 Copenhagen, Denmark. *The structure of balanced big CM modules over CM rings.*

Over a Cohen-Macaulay (CM) local ring, we characterize those modules that can be obtained as a direct limit of finitely generated maximal CM modules. Two consequences of this characterization are: (1) Every balanced big CM module, in the sense of Hochster, can be written as a direct limit of small CM modules. In analogy with Govorov and Lazard's characterization of flat modules as direct limits of finitely generated free modules, one can view this as a "structure theorem" for balanced big CM modules. (2) Every finitely generated module has a preenvelope with respect to the class of finitely generated maximal CM modules. This result is, in some sense, dual to the existence of maximal CM approximations, which is proved by Auslander and Buchweitz. (Received January 21, 2015)

Session 12

1111-13-108 **Joachim Jelisiejew*** (jjelisiejew@mimuw.edu.pl). *Deformations and smoothability of Artin Gorenstein algebras.*

In the talk I explain a method of constructing families of Artin algebras, so-called *ray families*. They are used to prove smoothability of certain Artin Gorenstein algebras or, geometrically, irreducibility of Hilbert schemes of points parametrizing Gorenstein subschemes.

This is a joint work with G. Casnati and R. Notari. (Received January 23, 2015)

Session 12

1111-13-164 **Jorge Neves**, **Maria Vaz Pinto*** (maria_vazpinto@hotmail.com) and **Rafael H. Villarreal**. *Regularity of vanishing ideals associated to certain families of graphs.*

Let X be an algebraic toric set in a projective space, parameterized by the s edges of a simple graph over a finite field K, and let $I(X)$ be the vanishing ideal of X, which is a binomial ideal of $S = K[t_1, ..., t_s]$. For certain families of graphs, we find explicit sets of binomial generators for $I(X)$, obtained combinatorially from the respective graphs, and use those generators to compute the Castelnuovo-Mumford regularity of $S/I(X)$. (Received January 31, 2015)

Session 12

1111-13-167 **Juan Elias*** (elias@ub.edu), Gran Via 585, 08007 Barcelona, Spain. *How far is an Artin ring to be Gorenstein.*

Teter in 1974 characterized Artin local rings A that are of the form $G/soc(G)$ where G is a Gorenstein ring and $soc(G)$ is its socle. These rings are known as Teter rings.

In this talk we give a new characterization, in the equicharacteristic case, of Teter rings by using Macaulay inverse systems. We extend the previous characterizations due to Teter, Huneke-Vraciu and Ananthnarayan-Avramov-Moore, to any characteristic of the ground field and removing the hypothesis on the socle ideal. (Received January 31, 2015)

Session 12

1111-13-168 **Oana Veliche***, 360 Huntington Avenue, Boston, MA 02115, and **Lars Winther Christensen**. *Intersections and sums of Gorenstein ideals with special attention to codepth 3.*

Let k be a field and let R be a quotient of the polynomial ring $Q = k[x, y, z]$ by a perfect ideal of grade 3. There is a classification of such rings by multiplicative structures $\mathrm{Tor}^Q(R, k)$. For intersections and sums of generic Gorenstein ideals, we relate this classification to the degrees of socle elements. (Received January 31, 2015)

Session 12

1111-13-172 **Aldo Conca*** (conca@dima.unige.it). *Absolutely Koszul algebras.*

We will discuss absolutely Koszul algebras and Koszul algebras with the Backelin-Roos property. In particular we will describe some families of absolutely Koszul algebras including "small" Veronese algebras. This is a joint work with Srikanth Iyengar, Hop D. Nguyen and Tim Roemer. (Received January 31, 2015)

Session 12

1111-13-173 **Lars Winther Christensen*** (lars.w.christensen@ttu.edu) and **Oana Veliche**. *Intersections and sums of Gorenstein ideals.* Preliminary report.

Let k be a field. A commutative artinian local k-algebra R is as quotient of a ring Q of polynomials with coefficients in k. We study such algebras that arise a quotients by intersections and sums of generic Gorenstein ideals. Guidance for our investigation has come from experiments in which multiplicative structures on $\mathrm{Tor}^Q(R, k)$ have played a central role. We will briefly discuss a Macaulay 2 package that facilitates such experiments. (Received January 31, 2015)

Session 12

1111-13-175 **Gianfranco Casnati*** (casnati@calvino.polito.it), Gianfranco Casnati, Dipartimento di Scienze Matematiche, Politecnico di Torino, 10129 Torino, Italy. *A quick overview on c–stretched algebras.* Preliminary report.

Let A be a local Artin Gorenstein k–algebra, and let H_A be its Hilbert function.

We say that the algebra A is c–stretched if $H_A(c) > H_A(c+1) = 1$ for some $c \geq 1$. This talk is an overview on some classical and recent classification results on c–stretched algebras when c is low. (Received February 01, 2015)

Session 13

1111-13-183 **Valentina Barucci*** (barucci@mat.uniroma1.it). *On symmetric oversemigroups of a numerical semigroup.* Preliminary report.

In the context of numerical semigroups, the symmetric ones are particularly relevant. It is well known for example their connection with Gorenstein rings. It seems interesting to study when an oversemigroup of a given numerical semigroup S is symmetric. Some results on that subject, obtained in collaboration with Lance Bryant, will be given in the talk. Particular attention will be paid to oversemigroups obtained by blowing up the maximal ideal of S and to almost-symmetric semigroups S. (Received February 02, 2015)

Session 32

1111-13-204 **Azucena Tochimani**, **Maria Vaz Pinto** and **Rafael H Villarreal*** (vila@math.cinvestav.mx). *Projective Segre codes.*

Using commutative algebra we study the basic parameters of projective Segre codes over finite fields and show that these linear codes are direct products of projective Reed-Muller-type codes. As a consequence we recover some results on projective Reed-Muller-type codes over the Segre variety and over projective tori. (Received February 02, 2015)

Session 13

1111-13-231 **Santiago Zarzuela*** (szarzuela@ub.edu), Departament d'Àlgebra i Geometria, Universitat de Barcelona, Gran Via 585, E-08029 Barcelona, Barcelona, Spain. *Shifted numerical semigroups and their tangent cones.* Preliminary report.

Given a numerical semigroup $S = \langle m_1, \dots m_d \rangle$ we may consider for any $j \in \mathbb{N}$ the shifted numerical semigroup $S + j = \langle m_1 + j, \dots, m_d + j \rangle$. It has been recently proved by J. Herzog and D. I. Stamate that for $j \gg 0$ the tangent cone of $S + j$ is Cohen-Macaulay. The proof of this result is based on work by T. Vu proving a conjecture of Herzog- Srnivasan saying that the Betti numbers of the defining ideals $S + j$ are eventually periodic in j with period $m_d - m_1$. As a consequence, the bound N depends on the regularity of the ideal generated by the homogeneous elements of the defining ideal of S. By using more direct numerical semigroups techniques we give a new proof of the result by Herzog and Stamate, providing a bound K which does not depend on the above regularity and that can be easily computed in terms of the generators of S. In fact, it only depends on what we call the *shifting type of a numerical semigroup*. We also analyze this condition in the context of what we call *numerical semigroups of homogeneous type*, that is, numerical semigroups such that their Betti numbers and the ones for their tangent cones coincide.

This is a joint work in progress with Raheleh Jafari. (Received February 03, 2015)

Session 32

1111-13-233 **Santiago Zarzuela*** (szarzuela@ub.edu), Departament d'Àlgebra i Geometria, Universitat de Barcelona, Gran Via 585, E-08029 Barcelona, Barcelona, Spain. *Computing local cohomology by using spectral sequences.* Preliminary report.

Spectral sequences are often used to compute local cohomology functors. In this talk I'm going to review how to use them in order to calculate local cohomology from the primary decomposition of an ideal I in a commutative Noetherian ring R. In the homological case, we shall deal with the computation of several generalized local cohomology functors supported on I. In the cohomological case we shall mainly be concerned with the computation of the local cohomology of R/I. The construction of these spectral sequences is done by means of the computation of the left and right derived functors of the direct and inverse limits in terms of the homology (or cohomology) of a particular explicit homological (or cohomological) complex. In each case, one can also give sufficient conditions in order to guarantee the degeneration of the corresponding spectral sequence. As a guiding cases we will have in mind the results obtained by Àlvarez-García-Zarzuela in 2003 and G. Lyubeznik in 2007 in the homological case, and the well known Hochster's decomposition formula for the local cohomology of Stanley-Reisner rings in the cohomological case.

Ongoing joint work with Josep Àlvarez-Montaner and Alberto F. Boix. (Received February 03, 2015)

Session 13

1111-13-267 **Marco D'Anna*** (mdanna@dmi.unict.it), Dipartimento di Matematica e Informatica, Viale A. Doria, 6, 95125 Catania, Catania, Italy, and **Vincenzo Micale** and **Alessio Sammartano**. *Classes of complete intersection numerical semigroups.*

We consider several classes of complete intersection numerical semigroups, arising from many different contexts like algebraic geometry, commutative algebra, coding theory and factorization theory. In particular, we determine all the logical implications among these classes and provide examples. Most of these classes are shown to be well-behaved with respect to the operation of gluing. (Received February 04, 2015)

Session 12

1111-13-291 **Mats Boij*** (boij@kth.se), Department of Mathematics, KTH, 100 44 Stockholm, Sweden. *The non-Lefschetz locus of artinian complete intersections.* Preliminary report.

In a joint work with Migliore, Miró-Roig and Nagel we study the weak and the strong Lefschetz properties of artinian complete intersections. In codimension four and higher, it is an open problem whether all complete intersections have the weak Lefschetz property.

We here look at a given artinian complete intersection A and ask what linear forms are Lefschetz elements for this particular algebra, i.e., which linear forms L give maximal rank for all the multiplication maps $\times L\colon A_i \to A_{i+1}$.

In some cases, we are able to give a complete description of the locus where the linear form fails to be a Lefschetz element and, in particular, we can give a large family of examples where this locus is empty. Among other techniques we use linkage and dimension formulas for the parameter spaces of Gorenstein algebras given by Conca and Valla. (Received February 05, 2015)

Session 13

1111-13-300 **Veronica Crispin Quiñonez*** (veronica.crispin@math.uu.se), Department of Mathematics, P.O. Box 480, Uppsala University, 75106 Uppsala, Sweden. *The Ratliff-Rush operation on monomial ideals in three variables.*

Let R be a Noetherian ring and I a regular ideal. Then the ideals $(I^{l+1} : I^l)$ increase with l. In 1978 Ratliff and Rush showed that $\tilde{I} = \bigcup_{l \geq 1}^{\infty}(I^{l+1} : I^l)$ is the unique largest ideal with the same high powers as I. The union $\tilde{I}$ is called the Ratliff-Rush ideal associated to I, and an ideal such that $\tilde{I} = I$ a Ratliff-Rush ideal.

Several results on the Ratliff-Rush operation are given in papers by W. Heinzer et al. (1992, 1993), and in a paper by M. E. Rossi and I. Swanson (2003) there are many examples with respect to other ideal operations. An algorithm for computing the Ratliff-Rush operation, that uses the Poincaré series and a tame superficial sequence, is given in by J. Elias (2004).

In 2006 we presented a rather simple algorithm using numerical semigroups for computing the Ratliff-Rush operation valid for any ideal generated by monomials of the same degree in a two-dimensional ring. This work was later generalized by I. Al-Ayyoub (2009) to other classes of monomial ideals in the same rings. Here we describe a generalization of the algorithm to three and more variables by means of positive affine semigroups. (Received February 05, 2015)

Session 12

1111-13-326 **H. Ananthnarayan** and **E. Celikbas*** (ela.celikbas@uconn.edu), Department of Mathematics, 196 Auditorium Rd., Storrs, CT 06269, and **Z. Yang**. *Decomposing Gorenstein Rings as Connected Sums - I.* Preliminary report.

In topology, amalgamating two manifolds near a chosen point on each creates another manifold, called a "connected sum". This concept plays a significant role in the classification of closed surfaces. Connected sums in algebra are related to connected sums in topology through an expression of the cohomology algebras.

Gorenstein rings have various kinds of symmetries and duality properties, and form an important and ubiquitous class of rings. In 2012 Ananthnarayan, Avramov and Moore introduced a new construction, called a connected sum of two Gorenstein local rings as a quotient of their fiber product. Although the fiber product is rarely Gorenstein, they proved that a connected sum of two Gorenstein local rings is always a Gorenstein ring.

In this talk, we discuss the properties of fiber products and connected sums of algebras over a field. We then investigate when a standard graded k-algebra is indecomposable as a connected sum. Finally we identify necessary conditions for Gorenstein Artin local algebras over a field to be connected sums and obtain a characterization for the same. This is the first half of a two-part talk and it is based on a recent joint work with H. Ananthnarayan and Z. Yang. (Received February 06, 2015)

Session 12

1111-13-333 **Roberto Notari*** (roberto.notari@polimi.it), Dipartimento di Matematica "F.Brioschi", Politecnico di Milano, Piazza Leonardo da Vinci, 32, 21033 Milano, MI, Italy. *Obstructed local Artin Gorenstein algebras.*

Let $\mathcal{H}ilb^G$ be the open subset parameterizing local Artin Gorenstein k–algebras of given length. A local Artin Gorenstein k–algebra whose associated point in $\mathcal{H}ilb^G$ is singular is called obstructed. In this talk, we present some results on the obstructed local Artin Gorenstein k–algebras. Particular care will be given to the case of the 2–stretched ones. (Received February 06, 2015)

Session 12

1111-13-349 **Ines B. Henriques*** (i.henriques@sheffield.ac.uk), School of Mathematics and Statistics, Hicks building, Hounsfield Road, S3 7QW, Sheffield, United Kingdom, and **Luchezar L. Avramov** and **Liana M Sega**. *Quasi-complete intersection ideals.*

Generic Gorenstein algebras R of socle degree 4 have a remarkable property: every finitely generated R module has a syzygy which is Koszul. In particular, every finitely generated R-module has a rational Poincaré series. This talk will concern a broader class of ideals, denoted quasi-complete intersections, with similarly nice properties and including the class of complete intersection ideals. (Received February 06, 2015)

Session 12

1111-13-375 **Ananthnarayan Hariharan***, Department of Mathematics, IIT Bombay, Powai, Mumbai, MH 400076, India, and **Ela Celikbas** and **Zheng Yang**. *Decomposing Gorenstein Rings as Connected Sums - II.*

In topology, amalgamating two manifolds near a chosen point on each creates another manifold, called a "connected sum". This concept plays a significant role in the classification of closed surfaces. Connected sums in algebra are related to connected sums in topology through an expression of the cohomology algebras.

Gorenstein rings have various kinds of symmetries and duality properties, and form an important and ubiquitous class of rings. In 2012, Ananthnarayan, Avramov and Moore introduced a new construction, called a connected sum of two Gorenstein local rings as a quotient of their fiber product. Although the fiber product is rarely Gorenstein, they proved that a connected sum is always a Gorenstein ring.

In this talk, we discuss Artinian connected sums of algebras over a field. For a Gorenstein Artin local ring Q, we look at some conditions on its associated graded ring (which, for example, are satisfied when Q is either a short, or a stretched Gorenstein rings) which force Q to decompose as connected sum. We will see some applications to Poincare series and the minimal number of generators of the defining ideal of Q. This is the second half of a two-part talk, and is based on recent joint work with E. Celikbas and Z. Yang. (Received February 06, 2015)

Session 32

1111-13-387 **Sandra Spiroff*** (spiroff@olemiss.edu), Department of Mathematics, Hume Hall 305, P.O. Box 1848, University, MS 38677-1848, and **Sean Sather-Wagstaff**. *Connected components, S_2-ifications, and module decompositions.*

Motivated by a result of M. Hochster and C. Huneke, we investigate an invariant of a complete equidimensional unmixed local ring via several constructions related to the S_2-ification of the ring. (Received February 06, 2015)

Session 32

1111-13-452 **Maria Evelina Rossi*** (rossim@dima.unige.it), Department of Mathematics, University of Genoa, Via Dodecaneso 35, 16146 Genoa, Italy. *The structure of the Inverse System of Gorenstein local rings.*

Macaulay's inverse system transforms Matlis duality in an effective method to compute Artinian Gorenstein rings. Gorenstein rings are a generalization of complete intersections, and indeed the two notions coincide in codimension 2. A part the structure theorem by Buchsbaum-Eisenbud in codimension 3, results by Reid, Kustin and Miller in codimension 4 and other sporadic geometric constructions, to date an algebraic description of Gorenstein rings of any dimension is not understood. In this talk we present an extension of Macaulay's result characterizing the submodules of the polynomial ring in one-to-one correspondence with Gorenstein d-dimensional rings. The result will be used in the construction of a significant number of examples. The content of the talk is part of a joint work with J. Elias (University of Barcelona, Spain). (Received February 08, 2015)

Session 32

1111-13-469 **Matteo Varbaro*** (varbaro@dima.unige.it). *Linear Syzygies and Regularity.*

A recent result by Dao, Huneke and Schweigh says that, if I is a quadratically generated monomial ideal in N variables having linear syzygies, then the Castelnuovo-Mumford regularity grows at most as log(N).

They asked whether the bound is (asymptotically) sharp, being a priori unclear even if there can be examples with unbounded regularity. This question is surprisingly related to the question of Gromov whether there exist hyperbolic Coxeter groups of arbitrarily high virtual cohomological dimension. The answer to Gromov's question has shown to be negative by Januszkiewicz and Swiatkowski, whose example also provides quadratically generated monomial ideals having linear syzygies with arbitrarily high regularity.

The purpose of the talk will be to explain the connection between curvature of right-angled Coxeter groups and syzygies of squarefree quadratic monomial ideals, drawing some nice consequences one can get from this interplay: for example, there exist quadratic monomial ideals with free resolution linear for how many step as one wants but unbounded regularity. Everything is based on an ongoing collaboration with Alexandru Constantinescu and Thomas Kahle. (Received February 08, 2015)

Session 32

1111-13-497 **Anurag K Singh*** (singh@math.utah.edu). *Frobenius action on the cohomology of thickenings.* Preliminary report.

Let X be a projective hypersurface of dimension d, over a field of characteristic $p > 0$. It is readily seen that there exist thickenings tX such that the induced Frobenius map

$$H^d(X, \mathcal{O}_X) \longrightarrow H^d(tX, \mathcal{O}_{tx})$$

is injective. We will discuss some recent results regarding bounds on t that are independent of p, and how these extend earlier calculations of F-thresholds. This is ongoing work with Bhatt, Blickle, Lyubeznik, and Zhang. (Received February 08, 2015)

Session 32

1111-13-518 **Martina Juhnke-Kubitzke*** (kubitzke@math.uni-frankfurt.de) and **Satoshi Murai** (s-murai@ist.osaka-u.ac.jp). *A generalized balanced lower bound theorem for balanced polytopes.*

The generalized lower bound conjecture by McMullen and Walkup states that the h-vector entries of a simplicial polytope P are weakly increasing up to the middle degree and that $h_r(P) = h_{r-1}(P)$ if and only if P is $(r-1)$-stacked. This conjecture is now known to be true. The first part follows from the g-theorem by Stanley and the equality case follows from results by McMullen and Walkup respectively recent results by Murai and Nevo. In analogy with these results, Klee and Novik proposed a balanced generalized lower bound conjecture for balanced polytopes. In this talk, we provide a proof of the inequality case of this conjecture. In order to do so, we will use an idea by Klee and Novik and show that rank-selected subcomplexes have a weak Lefschetz property, thereby obtaining further inequalities for the h-vectors of rank-selected subcomplexes. This is joint work with Satoshi Murai. (Received February 09, 2015)

Session 32

1111-13-598 **Juergen Herzog** and **Antonio Macchia*** (macchia.antonello@gmail.com), Fachbereich Mathematik und Informatik, Hans-Meerwein-Straße 6, 35032 Marburg, Germany, and **Sara Saeedi Madani** and **Volkmar Welker**. *On the ideal of orthogonal representations of a graph in* $\mathbb{R}^2$.

We study orthogonal representations of simple graphs G in $\mathbb{R}^d$ from an algebraic perspective in case $d = 2$. Orthogonal representations of graphs, introduced by Lovász, are maps from the vertex set to $\mathbb{R}^d$ where non-adjacent vertices are sent to orthogonal vectors. We exhibit algebraic properties of the ideal generated by the equations expressing this condition and deduce geometric properties of the variety of orthogonal embeddings for $d = 2$ and $\mathbb{R}$ replaced by an arbitrary field. In particular, we classify when the ideal is radical and provide a reduced primary decomposition if $\sqrt{-1} \notin K$. This leads to a description of the variety of orthogonal embeddings as a union of varieties defined by prime ideals. In particular, this applies to the motivating case $K = \mathbb{R}$. (Received February 09, 2015)

Session 32

1111-13-611 **Ragnar-Olaf Buchweitz*** (ragnar@utsc.utoronto.ca), Dept. of Computer & Mathematical Sciences, University of Toronto Scarborough, 1265 Military Trail, Toronto, Ontario M1C1A4, Canada, and **Eleonore Faber** and **Colin Ingalls**. *A Representation Generator for Simple Curve Singularities (joint work with Eleonore Faber and Colin Ingalls).* Preliminary report.

Let G be a finite subgroup of GL(2,K) for a field K whose characteristic does not divide the order of G. The group G then acts linearly on the polynomial ring S in two variables over K and a crucial ingredient in our current understanding of the McKay correspondence in this case is the fact, first proved by J. Herzog in 1978, that S is a representation generator for maximal Cohen-Macaulay, or, equivalently, reflexive modules over the fixed ring R.

While it is has long been known that for simple curve singularities a corresponding representation generator can be obtained from representations of reflection subgroups of GL(2,K), no such compact description was available. As part of our joint effort to understand an analogue of the McKay correspondence for general reflection groups we found such an elegant description: A representation generator is provided by the coordinate ring of the hyperplane(= line) arrangements of the mirrors of that reflection group. (Received February 09, 2015)

Session 32

1111-13-617 **Dolors Herbera*** (dolors@mat.uab.cat), Departament de Matematiques, Universitat Autonoma de Barcelona, E08193 Bellaterra, Barcelona, Spain. *Big pure projective modules.*

Let R be a ring, and let M_R be a right R-module. Denote by $V(M)$ the monoid of isomorphism classed of direct summands of M^n for some $n \in \mathbb{N}$, and by $V^*(M)$ the monoid of isomorphism classed of direct summands of $M^{(\aleph_0)}$.

Let M be a module with a semilocal endomorphism ring. Then $V(M)$ can be seen, in a natural way, as a submonoid of $\mathbb{N}^k$, and the precise class of monoids that appear this way are already characterized (in 2000 Facchini and Herbera dealed with the general case, and in the same year Wiegand tackled the case of finitely generated modules over noetherian local rings). On the other hand the monoid $V^*(M)$ can be seen as a submonoid of $(\mathbb{N} \cup \{\infty\})^k$ but the general characterization of such monoids is quite a challenging problem.

In this talk I will present some results on the structure of $V^*(M)$ for M a finitely generated module over a local noetherian ring, they are part of an ongoing project with Pavel Prihoda. (Received February 09, 2015)

Session 32

1111-13-636 **Luchezar Avramov**, **Courtney Gibbons** and **Roger Wiegand*** (rwiegand@math.unl.edu), Department of Mathematics, University of Nebraska, Lincoln, NE 68588-0130. *Betti diagrams and Hilbert functions of Koszul modules over short Gorenstein rings.*

Let k be a field and R a short, standard graded Gorenstein k-algebra. ("Short" means that $R = k \oplus R_1 \oplus R_2$.) When the embedding dimension $e := \dim_k R_1$ is three or more, R has wild representation type, but one can learn a lot about module structure by studying the semigroup of Betti tables of Koszul modules. (These are the modules that are generated in degree zero and have linear resolutions.) In this talk I will describe this semigroup explicitly and say a little about its structure. In particular, we will identify the atoms as the Betti tables of cosyzygies of ideals generated by linear forms. This semigroup is far from being factorial, that is, an element can have many decompositions as a sum of atoms. (Received February 09, 2015)

Session 32

1111-13-743 **Alexandru Constantinescu*** (aconstant@math.fu-berlin.de), Mathematisches Institut, Arnimallee 3, 14195 Berlin, Germany. *Hilbert schemes, Groebner cells, and extension algebras.*

Groebner cells are to Hilbert schemes as Schubert cells are to Grassmannians. Given a term order τ and a monomial ideal I_0, the corresponding Groebner cell contains all ideals which degenerate to I_0 under τ. For a degree-compatible term order, we present a parameterization of Groebner cells of the Hilbert scheme of points in the plane. Using this parameterization, we study the Betti strata in the projective Hilbert scheme, and the noncommutative multiplicative structure of the extension algebras $\mathrm{Ext}_S(S/I, S/I) = \bigoplus_{i=0}^{2} \mathrm{Ext}_S^i(S/I, S/I)$ for artinian ideals $I \subset S = \mathbb{K}[x, y]$. (Received February 10, 2015)

Session 32

1111-13-750 **Anthony Iarrobino** and **Pedro Macias Marques*** (pmm@uevora.pt). *Symmetric decomposition of the associated graded algebra of a Gorenstein Artinian algebra.*

A *Gorenstein sequence* here is an integer sequence that occurs as the Hilbert function of a (not necessarily graded) Gorenstein Artinian algebra A. It is the sum of symmetric non-negative sequences arising from the symmetric subquotient decomposition of the associated graded algebra of A. We will report on recent results on the existence of Gorenstein sequences and on the structure of their symmetric decomposition. (Received February 10, 2015)

Contr.Session

1111-13-799 **Qimh Richey Xantcha*** (qimh@math.uu.se), Uppsala, Sweden. *On Extensions of Polynomial Functors.*

We discuss a formula for calculating extensions of integral polynomial functors, which we base upon projective resolutions taken in a combinatorial category encoding functors of abelian groups. As an application, we shall prove the existence of a surprising non-trivial extension of divided cubes by symmetric cubes. (Received February 10, 2015)

Session 13

1111-13-827 **Julio-José Moyano-Fernández***, moyano@uji.es. *Duality and syzygies for semimodules over numerical semigroups.*

Let $\Gamma = \langle \alpha, \beta \rangle$ be a numerical semigroup.

In this article we consider the dual Δ^* of a Γ-semimodule Δ; in particular we deduce a formula that expresses the minimal set of generators of Δ^* in terms of the generators of Δ. As applications we compute the minimal graded free resolution of a graded $K[t^\alpha, t^\beta]$-submodule of $K[t]$, and we investigate the structure of the selfdual Γ-semimodules, leading to a new way of counting them. This is a joint work with Jan Uliczka. (Received February 11, 2015)

Session 13

1111-13-830 **Manuel Delgado*** (mdelgado@fc.up.pt), Departamento de Matematica e, Centro de Matematica da Universidade do Porto, Rua do Campo Alegre, 687, Porto, 4169-007, and **Pedro A. García-Sánchez** (pedro@ugr.es), Departamento de Algebra, Universidad de Granada, Granada, 18071. *numericalsgps GAP package (tutorial).*

This is a small tutorial on how to use the numericalsgps GAP package - a package to compute with numerical semigroups and also with affine semigroups. The tutorial is to be presented by both authors. (Received February 11, 2015)

14 ► Algebraic geometry

Session 53

1111-14-44 **Abel Castorena*** (abel@matmor.unam.mx), CCM-UNAM CAMPUS MORELIA, 58194 Morelia, Michoacan, Mexico. *Rank two vector bundles with canonical determinant and four sections on algebraic curves.* Preliminary report.

Let $B^4(2, K_C)$ be the locus parametrizing classes of (semi)-stable vector bundles E of rank two with canonical determinant over C with $h^0(C, E) \geq 4$. We show that $B^4(2, K_C)$ has an irreducible component $\mathcal{B}$ of dimension $3g - 13$ on a general curve of genus $g \geq 8$. Moreover, we show that for the general element $[E]$ of $\mathcal{B}$, E fits in a exact sequence $0 \to \mathcal{O}_C(D) \to E \to K_C(-D) \to 0$, with D a general effective divisor of degree three, and the corresponding coboundary map $\partial : H^0(C, K_C(-D)) \to H^1(C, \mathcal{O}_C(D))$ has cokernel of dimension three. This is a Joint work with Graciela Reyes-Ahumada. (Received January 10, 2015)

Session 27

1111-14-46 **Vicente Muñoz*** (vicente.munoz@mat.ucm.es). *E-polynomials of the SL(2,C)-character varieties of surface groups.*

We use a geometric technique developed by Logares, Munoz and Newstead to study the moduli spaces of representations of the fundamental group of a once-punctured surface of any genus into SL(2,C), for any possible holonomy around the puncture. In particular, we compute the E-polynomials of these moduli spaces, and prove that the mixed Hodge structures are of Tate type. (Joint work with J. Martínez) (Received January 12, 2015)

Session 27

1111-14-65 **Sean Dodd Lawton*** (seanlawton@gmail.com), George Mason University, Department of Mathematical Sciences, 4400 University Drive, Exploratory Hall, Fairfax, VA 22030. *Homotopy Groups of Character Varieties.*

Given a Lie group G (assumed real reductive) and a finitely generated group Γ, the moduli space of G-valued representations of Γ, denoted $\mathfrak{X}_\Gamma(G)$, is called the *G-character variety of* Γ. When Γ is the fundamental group of a manifold M, $\mathfrak{X}_\Gamma(G)$ is the moduli space of G-local systems on M. In this talk we will survey recent results concerning the homotopy groups of $\mathfrak{X}_\Gamma(G)$ when the fundamental group of M coincides with that of an open or closed surface, or a product of circles. Results in this survey reflect collaborations with I. Biswas, C. Florentino, and D. Ramras. (Received January 16, 2015)

Session 20

1111-14-67 **Yoav Len*** (yoav.len@yale.edu), Saarbrücken, Germany, and **Tyler Foster**. *Tropical vector bundles.* Preliminary report.

I will discuss work in progress on higher rank tropical Brill–Noether theory. I will present a combinatorial analog for vector bundles on graphs, and various related invariants. By applying a generalization of the specialization lemma for such objects, this can be used to study vector bundles on curves via degeneration. Finally, I will describe ongoing work towards a tropical Grothendieck–Riemann–Roch theorem. This is joint work with Tyler Foster. (Received January 17, 2015)

Session 53

1111-14-90 **George Harry Hitching*** (george.hitching@hioa.no), Hoegskolen i Oslo og Akershus, Postboks 4 St Olavs plass, 0130 Oslo, Norway. *Theta divisors of stable vector bundles with many maximal subbundles.*

To a generic semistable bundle W of integral slope over a curve X, one can canonically associate a divisor $\Theta(W)$ in the Jacobian of X, called the *theta divisor of* W. If W_1 and W_2 are generic semistable bundles of the same slope over X, then the theta divisor of the direct sum $W_1 \oplus W_2$ is the sum $\Theta(W_1) + \Theta(W_2)$. Conversely, Raynaud and Beauville have each given examples of *stable* bundles with reducible theta divisors. In this talk, we describe stable bundles of arbitrary rank $r \geq 5$ with reducible and nonreduced theta divisors, over any curve of genus $g \geq 5$. Another nongeneric aspect of these bundles is that they admit positive-dimensional families of maximal subbundles of largest possible degree. (Received February 08, 2015)

Session 20

1111-14-152 **Gilberto Bini*** (gilberto.bini@unimi.it). *From Calabi-Yau Manifolds to Surfaces of General Type.*

Here we construct a family of minimal surfaces of general type with geometric genus zero, $K^2 = 3$ and fundamental group of order 16. We show that this family dominates an irreducible component of dimension 4 of the moduli space of the surfaces of general type. This is joint work with Filippo F. Favale, Roberto Pignatelli and Jorge Neves. (Received January 29, 2015)

Session 53

1111-14-161 **Simone Marchesi**, **Pedro Macias Marques*** (pmm@uevora.pt) and **Helena Soares**. *Monads over projective varieties.*

Given a smooth projective variety X over an algebraically closed field K of characteristic zero, a monad over X is a complex

$$M : 0 \longrightarrow A \xrightarrow{\alpha} B \xrightarrow{\beta} C \longrightarrow 0$$

of coherent sheaves over X that is exact at A and C. The coherent sheaf $E := \ker\beta/\mathrm{im}\,\alpha$ is called the cohomology (sheaf) of the monad M. We will report on recent results on their existence and on the simplicity and stability of their cohomology sheaf. (Received January 30, 2015)

Session 12

1111-14-257 **Alessandra Bernardi*** (alessandra.bernardi5@unibo.it), piazza di Porta San Donato 5, 40126 Bologna, Bologna, Italy, **JOACHIM JELISIEJEW** (jjelisiejew@mimuw.edu.pl), Banacha 2, 02-097 Warszawa, Warszawa, Poland, **Pedro Macias Marques** (pmm@uevora.pt), Rua Romao Ramalho, 7000-671 Evora, Evora, Portugal, and **Kristian Ranestad** (ranestad@math.uio.no), PO Box 1053, Blindern, 0316 Oslo, Oslo, Norway. *On the cactus variety of cubic forms.*

The minimal length of a fi nite apolar subscheme for a form is called the cactus rank. We give a dimension formula for the cactus variety of cubic forms, the closure of the family of cubic forms in $\mathbb{P}^{\binom{n+3}{3}-1}$ of cactus rank at most r, when $1 \leq r \leq 2n+2$. = (Received February 04, 2015)

Session 20

1111-14-275 **Felix Janda*** (felix.janda@math.ethz.ch). *Pixton's formula for the double ramification cycle.*

In the Chow ring of the moduli space of curves, the double ramification cycle is a compactification of the locus of curves admitting maps to the projective line with specified ramification profiles over zero and infinity. There is a formula by Hain expressing this class, when restricted to the locus of curves with compact Jacobian, as a power of the theta divisor. Recently, A. Pixton has given a conjectural generalization of this formula to the complete moduli space. I want to discuss his formula and the idea of a proof of it.

This is joint work with R. Pandharipande, A. Pixton and D. Zvonkine. (Received February 04, 2015)

Session 27

1111-14-279 **Alfonso Zamora*** (alfonsozamora@tecnico.ulisboa.pt), Instituto Superior Técnico, Departamento de Matemática, Av. Rovisco Pais, 1049-001 Lisboa, Portugal. *GIT characterizations of Harder-Narasimhan filtrations.*

We will discuss constructions of moduli spaces in algebraic geometry by using Geometric Invariant Theory (GIT). When performing such constructions we usually impose a notion of stability for the objects we want to classify and another notion of GIT stability appears, then it is shown that both notions coincide. For an object which is unstable there exists a unique canonical filtration, called the Harder-Narasimhan filtration. Onthe other hand, GIT stability is checked by 1-parameter subgroups by the classical Hilbert-Mumford criterion, and it turns out that there exists a unique 1-parameter subgroup giving a notion of maximal unstability in the GIT sense. We show how to prove that this special 1-parameter subgroup can be converted into a filtration of the object and coincides with the Harder-Narasimhan filtration, hence both notions of maximal unstability are the same. We will present the correspondence for the moduli problem of classifying coherent sheaves on a smooth complex projective variety. A similar treatment can be used to prove the analogous result for other moduli problems: pairs, Higgs sheaves, rank 2 tensors and quiver representations. Finally, we will talk about work in progress: extending the results to principal bundles. (Received February 04, 2015)

Session 27

1111-14-302 **Marina Logares*** (marina.logares@icmat.es), ICMAT, C/Nicolás Cabrera 15, 28049 Madrid, Spain. *Bohr-Sommerfeld Lagrangians for the moduli space of Higgs bundles.*

We will use a natural algebraic one-form on the moduli space of Higgs bundles to describe Bohr-Sommerfeld Lagrangians on it. These Lagrangians happen to be precisely the irreducible components of the nilpotent cone in the moduli space given by the Hitchin fibration. The result extends to some other moduli spaces like moduli spaces of parabolic Higgs bundles. In the talk we will define and describe all the notions involved. This is joint work with Indranil Biswas and Niels Leth Gammelgaard. (Received February 05, 2015)

Inv.Adresses

1111-14-311 **Annette Huber*** (annette.huber@math.uni-freiburg.de). *Differential forms in algebraic geometry – a new perspective in the singular case.*

Differential forms originally show up when integrating or differentiating on manifolds. However, the concept also makes perfect sense on algebraic varieties because the derivative of a polynomial is a polynomial.

The object has very many important uses, e.g., as a source of invariants needed in order to classify varieties. This approach was very successful for smooth varieties, but the singular case is less well-understood.

We explain how the use of the h-topology (introduced by Suslin and Voevodsky in order to study motives) gives a very good object also in the singular case, at least in characteristic zero. The approach unifies other ad-hoc notions and simplies many proofs. We also explain the necessary modifications in positive characteristic and the new problems that show up. (Received February 05, 2015)

Session 53

1111-14-317 **Ada Boralevi***, a.boralevi@tue.nl. *Orthogonal instantons and skew-Hamiltonian matrices.* Let $M(r,n)$ be the moduli space of stable vector bundles on $\mathbb{P}^2$ of rank $r \geq 2$ and Chern classes $(c_1, c_2) = (0, n)$. An element E of $M(r,n)$ is called orthogonal (symplectic) if it is isomorphic to its dual via a symmetric (skew-symmetric) map. In 1980 Hulek proved that the space $M(r,n)$ is smooth irreducible; using similar techniques, in 2007 Ottaviani showed that the same holds true for the moduli space of symplectic elements of $M(r,n)$. In my talk I will explain an irreducibility result for orthogonal bundles on $\mathbb{P}^2$, obtained in joint work with R. Abuaf (Imperial College). Among the techniques that we used are some interesting properties of skew-Hamiltonian matrices and the study of special hyperplane sections of determinantal varieties. I will also illustrate possible generalizations of our work. (Received February 05, 2015)

Session 53

1111-14-368 **Emilia Mezzetti*** (`mezzette@units.it`), Department of Mathematics and Geosciences, Section of Mathematics and Computer Science, Via A. Valerio 12/1, 34127 Trieste, Italy. *Linear spaces of matrices of constant rank and vector bundles.*

I will report on recent results about existence and methods of construction of linear systems of matrices of constant rank, mainly in the case of skew-symmetric matrices.

These are joint results with Ada Boralevi and Daniele Faenzi. (Received February 06, 2015)

Session 53

1111-14-405 **Angela Ortega*** (`ortega@math.hu-berlin.de`). *Higher rank Brill-Noether theory.*

The generalization of classical Brill-Noether theory to higher rank is known to be a hard problem which is wide open in the general setting. In this direction, Mercat's conjecture proposes an upper bound on the dimension of the space of sections of a vector bundle on a curve C, involving the Clifford index of C. This conjecture has been verified only for rank 2-vector bundles over curves of genus < 16.

We will present the state of art of the higher rank Brill-Noether theory on algebraic curves and discuss the role of K3 surfaces in providing counterexamples to Mercat's conjecture. (Received February 07, 2015)

Session 53

1111-14-409 **Elena Angelini*** (`elena.angelini@unife.it`). *Torelli type results for logarithmic bundles of arrangements in $\mathbb{P}^n$.*

Let $\mathcal{D} = \{D_1, \ldots, D_\ell\}$ be a multi-degree arrangement of smooth hypersurfaces with normal crossings on the complex projective space $\mathbb{P}^n$ and let $\Omega^1_{\mathbb{P}^n}(\log \mathcal{D})$ be the associated logarithmic bundle. When ℓ is sufficiently large, we prove a Torelli type theorem by recovering the components of $\mathcal{D}$ as unstable smooth hypersurfaces of $\Omega^1_{\mathbb{P}^n}(\log \mathcal{D})$. Then we analyze the conic case: if $\ell \in \{1, 2\}$ then we get examples of non-Torelli arrangements, if $\ell \geq 4$ of Torelli arrangements and if $\ell = 3$ the problem is still open. Finally we describe some line-conic cases. (Received February 07, 2015)

Session 20

1111-14-418 **Bashar Dudin*** (`dudin@mat.uc.pt`), Centro de Matematica, Universidade de Coimbra, Apartado 3008, EC Santa Cruz, 3001-501 Coimbra, Portugal. *Closure of the Hurwitz scheme in the space of stable maps.*

The Hurwitz scheme classifies simply branched covers of the projective line. It is not proper and there are essentially two ways to compactify it: either by fixing the target while only allowing the domain curve to degenerate, or by allowing both domain and target curves to become singular while asking for finite morphisms. The latter is the Harris and Mumford compactification by admissible covers while the former is the one by stable maps due to Kontsevich. The space of stable maps is too big to contain the Hurwitz scheme as a dense open subset. By linking both previous compactifications, and carefully studying the combinatorics of involved dual graphs, we describe the closure of the Hurwitz scheme and some of its variants in the space of stable maps. (Received February 07, 2015)

Session 27

1111-14-434 **Steven Rayan*** (`stever@math.toronto.edu`), Department of Mathematics, University of Toronto, Toronto, Ontario M5S 2E4, Canada. *Hyperpolygons and Hitchin systems.*

Just as the moduli space of semistable n-gons in complex projective space can be realized as the representation space of a certain shape of quiver, their hyperkähler analogues (moduli spaces of hyper-n-gons) are quiver varieties for the same quiver, doubled. We study the cohomology of hyperpolygon spaces, and show that, at least for rank up to and including 3, they carry the structure of complete integrable systems. To do this, we relate hyperpolygon spaces to singular parabolic Hitchin systems. This is joint work with Jonathan Fisher (arXiv:1410.6467). (Received February 07, 2015)

Session 20

1111-14-470 **Gavril Farkas** and **Nicola Tarasca*** (tarasca@math.utah.edu). *Pointed Castelnuovo numbers.*

The classical Castelnuovo numbers count linear series of minimal degree and fixed dimension on a general curve, in the case when this number is finite. For pencils, that is, linear series of dimension one, the Castelnuovo numbers specialize to the better known Catalan numbers. Using the Fulton-Pragacz determinantal formula for flag bundles and combinatorial manipulations, we obtain a compact formula for the number of linear series on a general curve having prescribed ramification at an arbitrary point, in the case when the expected number of such linear series is finite. The formula is then used to solve some enumerative problems on moduli spaces of curves. (Received February 08, 2015)

Session 20

1111-14-522 **Dan Petersen*** (danpete@math.ku.dk), Copenhagen, Denmark. *Counterexamples to the Faber conjectures.*

Faber and Pandharipande conjectured that there should be Poincaré duality in the tautological rings of the moduli spaces of n-pointed curves of genus g which are either (i) stable, (ii) of compact type, or (iii) with rational tails. I will explain how to construct counterexamples in case (i) when $g = 2$ and $n \geq 20$ (P.-Tommasi) and in case (ii) when $g = 2$ and $n \geq 8$ (P.). (Received February 09, 2015)

Session 53

1111-14-530 **Alexander H.W. Schmitt*** (alexander.schmitt@fu-berlin.de), Freie Universitaet Berlin, Institut fuer Mathematik, Arnimallee 3, 14195 Berlin, Berlin, Germany. *Quiver sheaves.*

Quivers are basic combinatorial objects, consisting of vertices and arrows between them. Given a quiver Q and an abelian category A, one may investigate representations of Q in the category A. The best studied case is when A is the category of finite dimensional vector spaces over a field k. Classification problems for quiver representations include the problem of the Jordan normal form as well as the representation theory of finite dimensional k-algebras. If A is the category of coherent sheaves over a complex projective manifold X, one arrives at the notion of a quiver sheaf. One may classify quiver sheaves by introducing adequate notions of semistability for them and constructing moduli spaces for semistable quiver sheaves as GIT quotients of some generalized quot schemes. This approach was developed by Alvarez-Consul, Garcia-Prada, and the speaker. A fundamental question is how the moduli spaces depend on the stability parameter. In particular, one would like to know, if there are infinitely many distinct notions of semistability or not. If not, there are only finitely many distinct moduli spaces. In the talk, we will survey the theory of quiver sheaves, report on recent progress of the speaker regarding the problem just mentioned and illustrate it with examples. (Received February 09, 2015)

Session 53

1111-14-573 **Joan Pons-Llopis***, ponsllopis@gmail.com. *The representation type of a projective variety.*

Inspired by the classification of quivers in finite (Gabriel, 1972), tame (Bernstein-Gelfand-Ponomarev, 1973) and wild (Kac, 1980) type, it was proposed to study the representation type of a projective variety X in terms of the size of families of Cohen-Macaulay homogeneous modules over the coordinate ring of X. Varieties of finite type, i.e., those that support a finite number of isomorphism classes of CM-modules, were classified by Eisenbud-Herzog (1988). I will talk about recent work with Daniele Faenzi in which it is shown that, besides the aforementioned varieties of finite type and some completely classified cases of tame type, the rest of projective varieties are of wild CM type. (Received February 09, 2015)

Session 20

1111-14-625 **Nathan Pflueger*** (pflueger@math.brown.edu), Department of Mathematics, Box 1917, 151 Thayer street, Providence, RI 02912. *Tableaux in Brill-Noether theory.*

I will describe a certain mild generalization of standard young tableaux, called displacement tableaux, and their relationship to the existence of curves with certain special linear series. Given three positive integers g,r, and d, I will consider the moduli space of genus g curves with a chosen linear series of degree d and rank r. Enumeration of displacement tableaux can be used to prove the existence of components of this moduli space with dimension equal to the classical prediction of Brill and Noether. I will describe the techniques involved in this proof as well as some further applications of displacement tableaux. (Received February 09, 2015)

Session 27

1111-14-629 **Richard Alan Wentworth*** (raw@umd.edu), Department of Mathematics, University of Maryland, College Park, MD 20742, and **Gerard Freixas i Montplet** (freixas@math.jussieu.fr), C.N.R.S., Institut de Mathematiques de Jussieu, 4, Place Jussieu, 75005 Paris, France. *Deligne pairings and holomorphic extension of analytic torsion.*

On a smooth holomorphic fibration of projective curves the Deligne pairing produces a line bundle on the base from a pair of line bundles on the family. If the latter are endowed with metrics, the pairing has a canonically defined metric as well. I will introduce a generalization of this construction where metrics are replaced by relatively flat connections. This gives an interpretation of the holomorphic extension of the analytic torsion on unitary characters from the Deligne isomorphism. The hyperholomorphic line bundle on the twistor space of the moduli of Higgs bundles admits a meromorphic connection with certain properties. I will show that the existence of this connection for rank one Higgs bundles also follows from our construction. (Received February 09, 2015)

Session 25

1111-14-631 **Emanuel Scheidegger***, Mathematisches Institut, Universität Freiburg, Eckerstr. 1, 79104 Freiburg, Germany. *Topological strings and modularity.*

We discuss aspects of the relation between topological strings on Calabi-Yau threefolds and modular forms. We show that there is a special differential ring of functions which plays the analogous role of the ring of quasimodular forms in the case of elliptic curves. This ring can be viewed as a coordinate ring of a moduli space of enhanced Calabi-Yau varieties describing pairs of a variety and a choice of a Hodge filtration. (Received February 09, 2015)

Session 53

1111-14-678 **Daniele Faenzi*** (daniele.faenzi@u-bourgogne.fr), 5 rue Sambin, 21000 Dijon, France. *Fano threefolds of genus 10 and Coble cubics.*

Fano threefolds of genus 10 are related to G2 geometry according to classical work of Mukai. I will show the role of instantons in connecting these threefolds with the Coble cubic associated with a curve of genus 2. (Received February 10, 2015)

Session 27

1111-14-704 **Ana Peon-Nieto*** (apeonnieto@mathi.uni-heidelberg.de), Mathematisches Institut, Im Neuenheimer Feld 288, 69120 Heidelberg, Germany. *Quasi-split real groups and the Hitchin map.*

Given a real semisimple algebraic group G, and a smooth complex projective curve X, we consider the moduli space of G-Higgs bundles over X, Higgs(G).

This moduli space fibers over a vector space via the Hitchin map $h : \mathrm{Higgs}(G) \to B_G$. In the complex group case, h defines an algebraically completely integrable Hamiltonian system. For real groups, this fails to be the case, as for example, the fibers are not abelian varieties, or even if they are, their dimension is not right.

In this talk I will explain the structure of the Hitchin map in the case of quasi-split real groups. These are the groups for which abelianization of the fibers holds. Moreover, the fibration admits a section determining a connected component with smooth points. I will use these results to derive topological invariants of the corresponding character variety. (Received February 10, 2015)

Session 32

1111-14-753 **Leovigildo Alonso-Tarrío*** (leo.alonso@usc.es), Departamento de Álxebra, Facultad de Matemáticas, Campus Sur s/n, 15782 Santiago de C., Galicia, Spain. *Hopf algebroids belong in commutative algebra.* Preliminary report.

There is a fruitful correspondence between algebraic and geometric objects through the adjunction global sections – spectrum that relies commutative rings to affine schemes. This correspondence allows us to go back and forth the algebraic and the geometric world enriching both points of view and enabling us to answer questions thanks to this new perspective.

If we consider a covering of a quasi-compact and semi separated scheme (or, more generally, a *geometric* stack), an algebraic structure arises, that of Hopf algebroid. Roughly speaking it corresponds to a cogroupoid object in the category of commutative rings. We will explain how to extend the algebra – geometry dictionary to this new context. (Received February 10, 2015)

Session 20

1111-14-779 **Mathieu Guay-Paquet**, **Hannah Markwig** and **Johannes Rau***, Fachrichtung Mathematik, Postfach 151150, 66123 Saarbrücken, Germany. *Constructing real algebraic curves using tropical geometry.*

From the beginnings, one of the main goals of tropical geometry were applications in enumerative geometry, in particular regarding the count of real algebraic curves. In my talk I would like to give an overview on that and

explain a recent result in this direction. It deals with a tropical method for counting real Hurwitz numbers.
(Received February 10, 2015)

Session 27

1111-14-784 **Susana Carvalho Ferreira*** (`susfer@ipleiria.pt`), Campus 2, Morro do Lena, Alto do Vieira, Apartado 4163, 2411-901 Leiria, Portugal, **Carlos Arango Florentino** (`carlos.florentino@math.ist.utl.pt`), Lisbon, Portugal, and **Ana Malheiro Casimiro** (`amc@fct.unl.pt`), Lisbon, Portugal. *Schottky bundles.* Preliminary report.

The Schottky uniformization theorem states that every Riemann surface X can be written as a quotient of a domain in the Riemann sphere by a Schottky group. On the other hand, the Narasimhan-Seshadri and Ramanathan well-known theorems can be viewed as uniformization results for vector and principal bundles over X.

In this presentation, motivated by a tentative Schottky uniformization for bundles, we introduce Schottky principal G-bundles over compact Riemann surfaces generalizing, to principal G-bundles, the notion of Schottky vector bundle given by Florentino, with G a connected reductive algebraic group.

We describe a correspondence between the character variety of a certain type of Schottky representations to the moduli space of flat semistable principal bundles with trivial topological type. We prove that this correspondence, under certain conditions, is locally surjective. Moreover, we show that the topological type of every Schottky principal bundle is trivial. (Received February 10, 2015)

Session 53

1111-14-825 **Laura Costa*** (`costa@ub.edu`), Gran Via, 585, B, 08007, and **Rosa Maria Miró-roig**. *Ulrich bundles on Grassmannians.*

The existence of Ulrich bundles (i.e. bundles without intermediate cohomology whose corresponding module has the maximal number of generators) on a projective variety is a challenging problem with a long and interesting history behind and few known examples. The goal of this talk is to give a full classification of all homogeneous Ulrich bundles on a Grassmannian $Gr(k,n)$ of k-planes on P^n. (Received February 11, 2015)

15 ► Linear and multilinear algebra; matrix theory

Session 34

1111-15-202 **Sónia Carvalho*** (`soniarfcarvalho@hotmail.com`), Rua Professor Gama Pinto,2, Lisbon, Portugal, and **Pedro J. Freitas**. *On Derivatives and Norms of Generalized Matrix Functions and Respective Symmetric Powers.*

In recent papers, S. Carvalho and P. J. Freitas obtained formulas for directional derivatives, of all orders, of the immanant and of the m-th ξ-symmetric tensor power of an operator and a matrix, when ξ is an irreducible character of the full symmetric group. The operator bound norm of these derivatives was also calculated. In this paper similar results are established for generalized matrix functions and for every symmetric tensor power associated with thw same character.

Keywords: Generalized matrix function, derivative, ξ-symmetric tensor power
(Received February 02, 2015)

Session 44

1111-15-232 **Nam Van Tran*** (`vannamtran1205@gmail.com`). *On singular and homogeneous flexible systems of linear equations.* Preliminary report.

Flexible systems of linear equations are systems with coefficients in the form of external numbers [1] of non-standard analysis. The calculus of external numbers may be seen as a model for propagation of errors. In [2] conditions were given to solve non-singular and non-homogeneous flexible systems, both by Cramer's rule and the Gaussian method. In this talk we consider singular and homogeneous flexible systems. The matrices of these systems may include lines of neutrices, i.e. convex subgroups of the set of real number, a sort of generalized zero's. It appears that Cramer's Rule is still a useful tool. We extend the notions of linear independence and dependence of vector systems to this context and characterize them through determinants.

Keywords: flexible system, linear independence, external number, nonstandard analysis.

[1]B. Dinis, I. P. van den Berg, Algebraic properties of external numbers, Journal of Logic & Analysis 3:9 (2011) 1-30. [2]J. Justino, I. P. van den Berg, Cramer's rule applied to flexible sysems of linear equations, Electronic Journal of Linear Algebra, Volume 24 (2012) 126-152. (Received February 03, 2015)

Session 44

1111-15-371 **Júlia Justino*** (`julia.justino@estsetubal.ips.pt`), Departamento de Matemática, Escola Superior de Tecnologia de Setúbal, 2914-508 Setúbal, Portugal. *Solution of Linear Flexible Systems.*

Systems of linear equations, called flexible systems, with coefficients having uncertainties of type o(.) or O(.) are studied from the point of view of nonstandard analysis. The uncertainties of the afore-mentioned kind will be given in the form of the so-called neutrices, for instance the set of all infinitesimals. In some cases an exact solution of a flexible system may not exist. Still conditions are presented that guarantee the existence of an admissible solution, in terms of inclusion, and also conditions that guarantee the existence of a maximal solution. These conditions concern restrictions on the size of the uncertainties appearing in the matrix of coefficients and in the constant term vector of the system. Applying Cramer's rule under these conditions, one obtains, at least, an admissible solution of the system. In the case a maximal solution is produced by Cramer's rule, one shows that it is the same solution produced by Gauss-Jordan elimination. (Received February 06, 2015)

Session 46 1111-15-393 **Pavel Stovicek*** (stovicek@fjfi.cvut.cz), Department of Mathematics, Faculty of Nuclear Science, CTU, Trojanova 13, 12000 Praha, Czech Rep. *A family of explicitly diagonalizable weighted Hankel matrices generalizing the Hilbert matrix.*

A three-parameter family $B(a,b,c)$ of semi-infinite weighted Hankel matrices is introduced supposing a, b, c are positive and $a < b+c$, $b < a+c$, $c < a+b$. The famous Hilbert matrix is included as a particular case. The direct sum $B(a,b,c) \oplus B(a+1,b+1,c)$ is shown to commute with a discrete analogue of the dilatation operator. It follows that there exists a three-parameter family of real symmetric Jacobi matrices, $T(a,b,c)$, commuting with $B(a,b,c)$. The orthogonal polynomials associated with $T(a,b,c)$ turn out to be the continuous dual Hahn polynomials

$$S_n(x;(b+c-a)/2,(a+c-b)/2,(a+b-c)/2).$$

Since the corresponding measure of orthogonality is known explicitly, a unitary mapping U diagonalizing $T(a,b,c)$ can be constructed explicitly. The spectrum of $T(a,b,c)$ is simple and therefore U diagonalizes $B(a,b,c)$ as well. It turns out that the spectrum of the matrix operator $B(a,b,c)$ is purely absolutely continuous and fills the interval $[0, M(a,b,c)]$ where $M(a,b,c)$ is known explicitly. If the assumption $c < a+b$ is relaxed while the remaining inequalities on a, b, c are all supposed to be valid, the spectrum contains also a finite discrete part lying above the threshold $M(a,b,c)$. Again, all eigenvalues and eigenvectors are described explicitly. (Received February 06, 2015)

Session 34 1111-15-588 **M. C. Gouveia*** (mcag@mat.uc.pt), Dep. Matematica, FCTUC, Ap.3008, EC Universidade, Coimbra, Portugal. *Solving Linear and Nonlinear Equations with Generalized Inverses.*

The aim of this work is to give a scope of the advantages of applications of some types of generalized inverses in the resolution of systems modeled by linear differential equations, nonlinear equations, and singular linear difference equations.

Some examples of resolution of specific equations with Toeplitz pencils are given. (Received February 09, 2015)

Session 47 1111-15-690 **Mirta M. Castro Smirnova*** (mirta@us.es), Universidad de Sevilla, Dpto. Matemática, Aplicada II, EPS, calle Virgen de África 7, 41011 Sevilla, Spain, and **F. Alberto Grünbaum** (grunbaum@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, Berkeley, CA 94720. *Matrix orthogonal polynomials and time-band limiting.*

In this talk we will consider examples of matrix valued orthogonal polynomials satisfying differential equations (i.e a bispectral situation) in connection with time and band limiting. For a given family of matrix orthogonal polynomials one considers the global operator defined by the full symmetric matrix given by the truncated inner products. We exhibit a narrow band matrix, with simple spectrum, commuting with this matrix. The existence of a commuting local operator is very useful to compute numerically the eigenfunctions of the given global operator. We extend this analysis after applying the non commutative version of the Darboux process. (Received February 10, 2015)

Contr.Session 1111-15-745 **Graça Soares*** (gsoares@utad.pt), Escola das Ciências e Tecnologia, Quinta dos Prados, 5000 801 Vila Real, Portugal, **Rute Lemos** (rute@ua.pt), 3810 193 , Portugal, and **Alexander Guterman** (guterman@lis.ru), Faculty of Algebra, Departament of Mathematics and Mechanics, 119991, Russia. *When the C-determinantal range becomes real.*

For n-square matrices A, C the C-determinantal range of A is the following subset of the complex plane $\{\det(A - UCU^*) : UU^* = U^*U = I_n\}$. If A, C are Hermitian matrices, then by a result of M. Fiedler [**?**] this set is a real line segment. In this talk, we establish some necessary and sufficient conditions for the C-determinantal range of A to be a subset of the real line. (Received February 10, 2015)

Contr.Session

1111-15-771 **Rute Lemos*** (rute@ua.pt), Departamento de Matemática, Universidade de Aveiro, Campus de Santiago, 3810-193 Aveiro, Portugal. *Aczél type operator inequalities.*

In a Lorentz space, the Schwarz inequality holds for timelike vectors with the reverse sign. This yields an inequality for sequences of real numbers known in the literature as Aczél inequality. Callebaut inequality is a refinement of Cauchy-Schwarz inequality. Having in mind the Kubo-Ando theory of operator means, an operator inequality of Aczél type is presented and, in particular, a Callebaut's type interpolation of Aczél inequality is derived.

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16 ► *Associative rings and algebras*

Session 2

1111-16-11 **Gabriella Böhm***, Wigner RCP, Budapest. *Weak multiplier bialgebras.*

Classically, (weak) Hopf algebras are defined as (weak) bialgebras admitting the further structure of an antipode. In Van Daele (and Wang)'s approach, however, (weak) multiplier Hopf algebras are defined directly without considering the 'antipodeless' situation of (weak) multiplier bialgebra. In this talk we report about a work filling this conceptual gap by finding the suitable notion of (weak) multiplier bialgebra. Our definition is supported by the fact that (assuming some further properties like 'regularity' or 'fullness of the comultiplication'), the most characteristic features of usual, unital, weak bialgebras extend to this generalization. While it is not known if any (not necessarily regular) weak multiplier Hopf algebra (in the sense of Van Daele and Wang's definition) obeys our axioms of weak multiplier bialgebra, we present sufficient and necessary conditions for a weak multiplier bialgebra to be a weak multiplier Hopf algebra. A large part of the talk is based on a joint work with José Gómez-Torrecillas and Esperanza López-Centella. (Received December 19, 2014)

Session 2

1111-16-16 **Tomasz Brzezinski*** (t.brzezinski@swansea.ac.uk), Mathematics Department, Swansea University, Swansea, SA2 8PP, United Kingdom. *Noncommutative smoothing.*

The aim of this lecture is twofold. In the first instance we would like to explain the notion of differential smoothness of algebras. There are many ways in which a noncommutative algebra can be understood as a coordinate algebra of a smooth noncommutative variety. Most commonly, one studies homologically smooth algebras, i.e. algebras that admit a finite resolution by finitely generated and projective bimodules. More demanding is the requirement of the existence of a Poincare-type duality between Hochschild homology and cohomology, which is embodied in the Calabi-Yau condition. Here we propose the notion of differential smoothness which is based on the existence of a differential structure which explicitly displays a Poincare-type duality. To formulate this duality, in addition to the de Rham complex of differential forms one needs the complex of integral forms, which we define. The ideas of differential smoothness are explained on two (classes of) examples: the noncommutative pillow and quantum cones. These are both deformations of singular varieties which become smooth upon quantization and they serve as the illustration of the second point of the talk, namely that deformation can often lead to resolution of singularities. (Received December 22, 2014)

Session 2

1111-16-37 **Earl J Taft*** (etaft@math.rutgers.edu), Department of Mathematics, Rutgers University, Piscataway, NJ 08854, and **Uma Iyer** (uma.iyer@bcc.cuny.edu), Department of Mathematics & Computer Science, 2155 University Avenue, Bronx New York, NY 10453. *Is there a left Hopf algebra containing quantum U(sl(2)?*

By using only some of the relations for $SL_q(2)$, S. Rodriguez and E. Taft constructed a left Hopf alegebra H, i.e. H is a bialgebra with a linear endomorphism S satisfying the left but not right antipode condition[J. Algebra 286 (2005), 154-160]. H has $SL_q(2)$ as homomorphic image. $U_q(sl(2))$ is contained in the continuous dual of $SL_q(2)$, which is in turn contained in the continuous dual H^0 of H. We had hoped that H^0 would be a left Hopf algebra. But we show that H and $SL_q(2)$ have the same continuous dual, so that H^0 is a Hopf algebra. We use the characterization of the continuous dual as the coordinate functions coming from finite-dimensional representations. Thus the search for a left Hopf algebra containing $U_q(sl(2))$ remains open. (Received January 08, 2015)

Session 2

1111-16-57 **Julien Bichon***, Laboratoire de Mathematiques, Universite Blaise Pascal Clermont-Ferrand II, Campus des Cezeaux, 63171 Aubiere, France. *Cohomological dimensions of Hopf algebras.*

I will discuss the relation between two possible notions of cohomological dimension for a Hopf algebra: the (usual) Hochschild cohomological dimension and the Gerstenhaber-Schack cohomological dimension. This is linked to the problem of relating the Hochschild cohomologies of Hopf algebras having equivalent tensor categories of comodules. (Received January 15, 2015)

Session 2

1111-16-71 **Jeroen Dello** and **Yinhuo Zhang*** (`yinhuo.zhang@uhasselt.be`). *Braided autoequivalences and quantum-commutative Galois objects.*

Let (H, R) be a finite dimensional quasitriangular Hopf algebra over a field k, and ${}_H\mathcal{M}$ the representation category of H. We study the braided autoequivalences of the Drinfeld center ${}^H_H\mathcal{YD}$ trivializable on ${}_H\mathcal{M}$. We establish a group isomorphism between the group of those autoequivalences and the group of quantum commutative bi-Galois objects of the transmutation braided Hopf algebra ${}_RH$. We then apply this isomorphism to obtain a categorical interpretation of the exact sequence of the equivariant Brauer group $\mathrm{BM}(k, H, R)$ of (H, R). (Received January 19, 2015)

Session 12

1111-16-86 **Julia Pevtsova*** (`julia@math.washington.edu`), Dept. of Mathematics, University of Washington, Seattle, WA. *Support varieties, local Jordan type, and applications.*

Modular representation theory studies representations of a finite group over a field of positive characteristic that divides the order of the group. The situation is very different from the more familiar case of representations over $\mathbb{C}$: modular representations need not be direct sums of irreducible representations. Except in a handful of cases, it is impossible to classify modular representations, making the theory "wild". Modular representation theory, more broadly construed, includes the representation theory of numerous other Artin algebras, such as restricted enveloping algebras.

Associating geometric invariants living on an appropriate projective variety to modular representations allows one to give some structure to this wild territory and even parameterize naturally occurring classes of representations. We'll discuss the classical concept of support variety which has its roots in the seminal work of D. Quillen on group cohomology, as well as more recent developments which include local Jordan type and vector bundles associated to modular representations. Despite the general nature of the theory, many interesting phenomena occur even for the "simplest" examples of Artin algebras such as $k[x, y]/(x^p, y^p)$ which will be used for illustration. (Received January 20, 2015)

Session 51

1111-16-110 **Burkhard Kuelshammer*** (`kuelshammer@uni-jena.de`). *The depth of subrings and subgroups.*

The depth is a numerical invariant which can be attached to subrings of rings and subgroups of groups. A subring B of a ring A is said to have depth $d(B, A) \leq 2i + 1$ if the $i + 1$-fold tensor product $T_{i+1} := A \otimes_B \cdots \otimes_B A$ is a direct summand of the i-fold tensor product T_i, as a B-B-bimodule. It is said to have depth $d(B, A) \leq 2i$ if T_{i+1} is a direct summand of T_i, as an A-B-bimodule and a B-A-bimodule. The definition of the depth $d(H, G)$ for a subgroup H of a group G is similar, with bisets instead of bimodules. If G is finite then $d(H, G)$ is always finite and an upper bound for $d(RH, RG)$ where RH and RG are the group algebras of G and H, respectively, over a commutative ring R. We have $d(RH, RG) \leq 2$ if and only if H is a normal subgroup of G. One can also characterize the subgroups H of G such that $d(KH, KG) \leq 1$ where K is a field. We will give examples and will also mention some of the open problems in the area. The talk will be a report on work by R. Boltje, S. Burciu, S. Danz, T. Fritzsche, L. Kadison, C. Reiche and myself. (Received January 24, 2015)

Session 8

1111-16-127 **Daniel Tubbenhauer*** (`dtubben@qgm.au.dk`), Ny Munkegade 118, building 1530, room 316, 8000 Aarhus C, Denmark. $\mathbf{U}_q(\mathfrak{sl}_2)$ *diagram categories via q-symmetric Howe duality.*

The Temperley-Lieb algebra $\mathcal{TL}_d$ is the mother of all diagram algebras. It was introduced by Temperley and Lieb in the 70ties in their study of statistical mechanics. Also due to its simple presentation, it reappears nowadays in low dimensional topology, operator theory, algebraic combinatorics and Lie theory (to name a few).

It has its origin in the study of $\mathfrak{sl}_2$-modules: Rumer, Teller and Weyl showed (more or less) already in the 30ties that $\mathcal{TL}_d$ can be seen as a diagrammatic realization of the representation category of $\mathfrak{sl}_2$-modules (consisting of tensor powers of the vector representation) - providing a topological tool to study the latter.

The goal of this talk is to explain how one can extend the results to give a diagrammatic category for all $\mathfrak{sl}_2$-modules. Our main tool is symmetric quantum Howe duality.

Applications to Jones-Wenzl projectors, colored Jones polynomials and, hopefully realized in future work, categorification are sketched.

This is joint work with David Rose (Received January 27, 2015)

Session 11

1111-16-148 **Jason P Bell*** (jpbell@uwaterloo.ca), University of Waterloo, Waterloo, Ontario N2L3G1, Canada, and **Stephane Launois**, **Omar Leon-Sanchez** and **Rahim Moosa**. *Poisson algebras and the Poisson Dixmier-Moeglin equivalence.*

We give an overview of the so-called Poisson Dixmier-Moeglin equivalence, which asks for which Poisson algebras A do we have the equivalences: P Poisson primitive $\iff$ P Poisson locally closed $\iff$ P (Poisson) rational, for all prime ideals P of A. A Poisson algebra of Krull dimension 4 that does not satisfy the Poisson Dixmier-Moeglin equivalence was produced by the authors. After describing this example, we will give some thoughts on what are the right additional conditions to impose on a Poisson algebra in order to ensure that it satisfies the Poisson Dixmier-Moeglin equivalence. (Received February 02, 2015)

Session 11

1111-16-150 **Tom Lenagan*** (tom@maths.ed.ac.uk), Maxwell Institute and School of Mathematics, JCMB, King's Buildings, Peter Guthrie Tait Road, Edinburgh, EH9 3FD, United Kingdom. *Torus invariant primes in the quantum grassmannian.* Preliminary report.

A survey of known and conjectured results on the invariant prime spectrum of the quantum grassmannian. Joint work (or work in progress) at various times with Casteels, Kelly, Launois and Rigal (Received January 29, 2015)

Session 11

1111-16-153 **Seçil Çeken*** (cekensecil@gmail.com), Akdeniz University Department of Mathematics Antalya, Turkey, and **John Palmieri**, **Yanhua Wang** and **James Zhang**. *Discriminant Criterion and Automorphism Groups of Some Quantized Algebras.*

(Joint work with John Palmieri, Yanhua Wang and James Zhang) Determining the automorphism group of an algebra is generally a difficult problem. In [1] we introduced the discriminant method to compute automorphism groups of some noncommutative algebras. In this talk we introduce new methods and extend ideas from [1] for both discriminants and automorphism groups. We compute the automorphism groups of some quantized algebras, including tensor products of quantum Weyl algebras and some skew polynomial rings. We also verify the Tits alternative for the automorphism groups of a class of quantum Weyl algebras and skew-polynomial rings.

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(Received January 29, 2015)

Session 11

1111-16-203 **Ken Brown*** (ken.brown@glasgow.ac.uk). *Connected Hopf algebras of finite Gelfand-Kirillov dimension.*

I will give a survey of recent progress by myself, Paul Gilmartin (U Glasgow) and James Zhang (U Washington), in understanding the algebras of the title, over an algebraically closed field k of characteristic 0. A Hopf algebra is by definition connected if its coradical is just the base field k. In characteristic 0, the connected cocommutative Hopf algebras of finite GK-dimension are just the enveloping algebras U(g) of the finite dimensional k-Lie algebras; and the connected affine commutative Hopf algebras are the coordinate rings of the unipotent algebraic groups over k. So one can view this subject as a simultaneous generalisation of both these topics. I will give theorems, examples, and open questions. (Received February 02, 2015)

Session 51

1111-16-229 **Sebastian M Burciu***, 21 Calea Grivitei Street, 010702 Bucharest,, Romania. *On the depth of subgroups and semisimple Hopf subalgebras.*

We present some recent results concerning the notion of depth for semisimple subalgebras and Hopf subalgebras. In particular depth one extensions of finite dimensional semisimple algebras will be completely characterized in terms of their algebra centers. For extensions of semisimple Hopf algebras this characterization translates into a trivial monoidal action of the dual fusion category Rep(A^*) on Rep(B). This result generalizes a result obtained by R. Boltje and B. Külshammer in "Group algebra extensions of depth one", Algebra Number Theory 5 (2011), 63-73. (Received February 03, 2015)

Session 11

1111-16-255 **Arkady Berenstein*** (arkadiy@math.uoregon.edu), 1222 University of Oregon, Eugene, OR 97403-1222, and **Jacob Greenstein**. *Integrable clusters.*

The goal my talk is to describe quantum clusters in which the variables (not coefficients) commute which each other. It turns out that this property is preserved by mutations if one starts with a principal quantum seed. Remarkably, this is equivalent to the celebrated sign coherence conjecture recently proved by Gross, Hacking, Keel and Kontsevich. (Received February 04, 2015)

Session 11

1111-16-296 **Christopher Fish** and **David A Jordan***, d.a.jordan@sheffield.ac.uk. *Quantum cluster algebras for mutation-periodic quivers.* Preliminary report.

Mutation-periodic quivers have been classified by Fordy and Marsh. We shall consider the quiver with n vertices, whose edges form an n-sided polygon and are oriented with one edge anticlockwise and all others clockwise. This gives rise to a single source and quiver mutation at the source rotates the quiver clockwise. We assume that n is even, in which case the cluster algebra has a Poisson structure and there is an associated quantum cluster algebra $Q_{q,n}$. We also assume that the parameter q is not a root of unity. The periodicity of mutation at the source gives rise to an automorphism θ of $Q_{q,n}$ and, as Fordy discovered in the Poisson case, there is an orbit $\{x_1, \dots, x_{n-1}\}$ of order $n-1$. We shall describe all the quantum cluster variables in $Q_{q,n}$ in terms of the automorphism θ, the orbit $\{x_1, \dots, x_{n-1}\}$ and the initial quantum cluster variables. The algebra $Q_{q,n}$ will be presented as a homomorphic image of an iterated skew polynomial ring over the base field. As such, it is Noetherian but, perhaps more surprisingly, it is simple. Passing to the semiclassical limit gives a presentation of the commutative cluster algebra which is Noetherian and Poisson simple. (Received February 05, 2015)

Session 8

1111-16-313 **You Qi***, Department of Mathematics, Yale University, 442 Dunham Lab, 10 Hillhouse Ave., New Haven, CT 06511. *A New Year Resolution.*

We construct a braid group action on the p-DG derived category of a zig-zag algebra. This is joint work with J. Sussan. (Received February 05, 2015)

Session 2

1111-16-334 **Hans-Juergen Schneider***, hanssch@mathematik.uni-muenchen.de, and **István Heckenberger**. *The braided Hopf algebra structure of reflected Nichols algebras.* Preliminary report.

This is joint work with István Heckenberger. The reflection operator is a basic construction in the theory of Nichols algebras of semisimple Yetter-Drinfeld modules over some Hopf algebra. We give a new and transparent description of the Hopf algebra structure of a reflected Nichols algebra based on an abstract isomorphism of braided monoidal categories. We obtain a new and direct proof of the bijection between right coideal subalgebras in a Nichols algebra and in the reflected Nichols algebra. This bijection is the main tool to prove the existence of a general PBW-decomposition of Nichols algebras extending Lusztig's PBW-basis of the plus part of quantum groups. (Received February 06, 2015)

Session 11

1111-16-364 **Sian Fryer*** (`s.fryer@leeds.ac.uk`). *On prime ideals in quantum matrices and Poisson-primes in the semi-classical limit.*

It is well known that the prime ideals in (generic) quantum matrices and the Poisson-prime ideals in the corresponding Poisson matrix varieties behave in remarkably similar ways; they can even be studied using the many of the same techniques. In all but the very simplest of cases, however, it remains an open question whether these two spaces of primes are actually homeomorphic. Building on recent techniques developed to study the prime spectra of quantum algebras, I will talk about how we can reduce the study of both spaces to the same purely commutative setting, and hence compare their topological structures. (Received February 06, 2015)

Session 41

1111-16-372 **Julian Külshammer*** (`kuelsha@mathematik.uni-stuttgart.de`), Institute for algebra and number theory, Unversity of Stuttgart, Pfaffenwaldring 57, D-70567 Stuttgart, BW, Germany. *Boxes and filtered representation type of Schur algebras.*

Schur algebras are finite dimensional algebras which relate the representation theories of general linear and symmetric groups. Important modules for a Schur algebra include the Weyl modules, the universal highest weight modules. This talk is about the structure of the category of modules filtered by Weyl modules.

In joint work with S. Koenig and S. Ovsienko we have shown that for a more general class of algebras, such a filtered category is equivalent to the category of modules over a box (a coalgebra over a path algebra of a quiver with relations). This description can be used to determine the representation type of the category of filtered modules for Schur algebras. The representation type of a category roughly measures, how difficult it is to classify all its indecomposable objects up to isomorphism. (Received February 06, 2015)

Session 51

1111-16-421 **Yorck Sommerhäuser*** (`yorcksom@buffalo.edu`), University at Buffalo (SUNY), Department of Mathematics, 244 Mathematics Building, Buffalo, NY 14260. *Triviality Theorems for Yetter-Drinfel'd Hopf Algebras.*

Usually, a Yetter-Drinfel'd Hopf algebra is not a Hopf algebra. Yetter-Drinfel'd Hopf algebras that are ordinary Hopf algebras are called trivial; by a result of P. Schauenburg, this happens if and only if the quasisymmetry in the category of Yetter-Drinfel'd modules accidentally coincides with the ordinary flip of tensor factors on the second tensor power of the Yetter-Drinfel'd Hopf algebra.

In certain situations, every Yetter-Drinfel'd Hopf algebra is trivial. In the talk, we consider a semisimple Yetter-Drinfel'd Hopf algebra A over the group ring $K[G]$ of a finite abelian group G, where K is an algebraically closed field of characteristic zero, and first discuss the following triviality theorem:

If A is commutative and its dimension is relatively prime to the order of G, then A is trivial.

Even if the Yetter-Drinfel'd Hopf algebra is not completely trivial, it sometimes must contain a trivial part, as stated in the following partial triviality theorem:

If A is cocommutative and its dimension is greater than 1, then A contains a trivial Yetter-Drinfel'd Hopf subalgebra of dimension greater than 1.

We also discuss the methods needed for the proof of these two results. (Received February 07, 2015)

Session 2 1111-16-424 **Daniel Bulacu*** (daniel.bulacu@fmi.unibuc.ro). *On Frobenius and separable algebra extensions in monoidal categories.*

We characterize Frobenius and separable monoidal algebra extensions $i : R \to S$ in terms given by R and S. For instance, under some conditions, we show that the extension is Frobenius, respectively separable, if and only if S is a Frobenius, respectively separable, algebra in the category of bimodules over R. In the case when R is separable we show that the extension is separable if and only if S is a separable algebra. Similarly, in the case when R is Frobenius and separable in a sovereign monoidal category we show that the extension is Frobenius if and only if S is a Frobenius algebra and the restriction at R of its Nakayama automorphism is equal to the Nakayama automorphism of R. (Received February 07, 2015)

Session 8 1111-16-448 **Thomas Gobet*** (gobet@mathematik.uni-kl.de), Technische Universität Kaiserslautern, Fachbereich Mathematik, Postfach 3049, 67655 Kaiserslautern, Germany. *On analogues of Soergel bimodules for the Temperley-Lieb algebra.*

A Weyl line is a line in the geometric representation of a Coxeter group which is obtained as an intersection of reflecting hyperplanes. Using regular functions on unions of such lines in type A_n one can introduce an additive graded category having analogues of Soergel bimodules as objects. One can define as product a slightly different operation than a usual tensor product, which is not associative in general as product of bimodules, but becomes associative on the subcategory which we are interested in. The Temperley-Lieb algebra (for a non usual choice of polynomial for the circle) turns out to be isomorphic to the split Grothendieck ring of that category. The image of the canonical diagram basis under this isomorphism is the set of classes of indecomposable bimodules and one can associate to the left and right annihilators of any indecomposable bimodule two varieties which carry out all the information about the corresponding Temperley-Lieb diagram. We present the construction as well as some conjectures on the link between the indecomposable bimodules and the geometry of Weyl lines. (Received February 08, 2015)

Session 51 1111-16-453 **Eliezer Batista**, **Stefaan Caenepeel*** (scaenepe@vub.ac.be) and **Joost Vercruysse**. *Hopf categories.*

We introduce Hopf categories enriched over braided monoidal categories. The notion is linked to several recently developed notions in Hopf algebra theory, such as Hopf group (co)algebras, weak Hopf algebras and duoidal categories. We generalize the fundamental theorem for Hopf modules and some of its applications to Hopf categories. (Received February 08, 2015)

Session 11 1111-16-472 **Matyas Domokos*** (domokos.matyas@renyi.mta.hu). *On the FRT bialgebra of orthogonal type.*

Quantized algebras of functions on simple Lie groups can be defined as the dual Hopf algebra of the corresponding quantized universal enveloping algebra. For the classical groups there is a different approach due to Faddeev-Reshetikhin-Takhtajan, which starts with the quantum coordinate algebra of a matrix space associated with an R-matrix. This algebra is given in terms of generators and quadratic relations, and is called the FRT bialgebra. In the case of the special linear group one gets the quantum coordinate ring of matrices, an object thoroughly studied from the point of view of ring theory. In particular, one knows a convenient basis in it and an associated rewriting algorithm, so it is possible to perform computations in this ring. In the talk we shall discuss the problems one faces when trying to gain a similar understanding of the FRT bialgebras of orthogonal or symplectic type, and shall present some partial results. (Received February 08, 2015)

Session 41

1111-16-482 **Robert J Marsh*** (marsh@maths.leeds.ac.uk), School of Mathematics, University of Leeds, Woodhouse Lane, Leeds, LS2 9JT, United Kingdom, and **Idun Reiten**. *Rigid and Schurian modules over cluster-tilted algebras of tame type.*

We give an example of a cluster-tilted algebra Λ with quiver Q with the property that the corresponding cluster algebra $A(Q)$ has a denominator vector which does not coincide with the dimension vector of any indecomposable Λ-module. This answers a question which was posed by T. Nakanishi.

The example is a cluster-tilted algebra associated to a tame hereditary algebra. We prove that for such a cluster-tilted algebra Λ, we can write any denominator vector as a sum of the dimension vectors of at most 3 indecomposable rigid modules over Λ. The proof involves the classification of the indecomposable rigid Λ modules. We also classify the Schurian Λ-modules. (Received February 08, 2015)

Session 11

1111-16-508 **Raf Bocklandt*** (raf.bocklandt@gmail.com), KdV institute for mathematics, Science park 107, 1098 XG Amsterdam, Netherlands. *Stability, Clusters and tropicalization.*

We discuss the connection between stability conditions for algebras and derived categories and Cluster structures and work this out in detail for dimer models.

In particular we explain how one can construct a space of King stability conditions for a collection of dimers related by mutation. We show that this space is a tropical version of work by Kenyon and Goncharov on cluster integrable systems. Finally we relate this to the space of Bridgeland stability conditions of the derived category associated to a dimer. (Received February 09, 2015)

Session 2

1111-16-524 **Alexei Davydov*** (davydov@ohio.edu), Department of Mathematics, Ohio University, Athens, OH 45701. *Twisted automorphisms and derivations of Hopf algebras.*

Twisted homomorphisms of bialgebras are bialgebra homomorphisms from the first into twisted forms of the second. They possess a composition operation extending composition of bialgebra homomorphisms. Gauge transformations of twists,compatible with adjacent homomorphisms, give rise to gauge transformation of twisted homomorphisms, which behave nicely with respect to compositions. Twisted derivations are infinitesimal versions of twisted automorphisms of bialgebras. Twisted derivations naturally form a Lie algebra (the tangent algebra of the group of twisted automorphisms). Moreover this Lie algebra fits into a crossed module (tangent to the crossed module of twisted automorphisms).

Twisted automorphisms (and derivations) provide a convenient language for describing tensor autoequivalences of categories of modules over the Hopf algebra. In the talk examples (such as Drinfeld doubles) will be discussed. (Received February 09, 2015)

Session 11

1111-16-525 **Karel Casteels*** (k.l.casteels@kent.ac.uk), School of Mathematics, University of Kent, Canterbury, Kent CT2 7NF, United Kingdom. *Path Models for Quantum Algebras.* Preliminary report.

I will discuss combinatorial models that can be used to study various quantum algebras, including quantum matrices, the quantum Grassmannian, quantum symmetric and skew-symmetric matrices and others. (Received February 09, 2015)

Session 42

1111-16-527 **Christian Lomp***, Departamento de Matematica, Faculdade de Ciencias, Universidade do Porto, Porto, Portugal, and **Can Hatipoglu**. *Essential Extensions of simple modules over enveloping algebras of Lie superalgebras.*

Matlis showed that the injective hulls of simple modules over an associative commutative Noetherian ring have finite length. For non-commutative Noetherian rings this might not be true anymore. The first Weyl algebra over the integers has this property, but not the first Weyl algebra over the rational numbers. However the later algebra satisfies that any finitely generated essential extension of a simple module has finite length. In this talk we will classify those finite dimensional nilpotent Lie superalgebras whose enveloping algebra satisfies that any finitely generated essenential extension of a simple module has finite length. (Received February 09, 2015)

Session 11

1111-16-557 **Stephane Launois** (s.launois@kent.ac.uk), School of Mathematics, Statistics and Actuarial Science (SMSAS), Cornwallis Building, University of Kent, Canterbury, Kent CT2 7NZ, United Kingdom, and **Cesar Lecoutre*** (cesar.lecoutre@yahoo.fr), School of Mathematics, Statistics and Actuarial Science (SMSAS), Cornwallis Building, University of Kent, Canterbury, Kent CT2 7NZ, United Kingdom. *Poisson deleting derivations algorithm: Poisson birational equivalence and Poisson spectrum.*

This talk is based on [1] and [2]. We present a method, the so-called *Poisson deleting derivations algorithm*, to study a class $\mathcal{P}$ of polynomial Poisson algebras over an arbitrary field. We will give two applications of the Poisson deleting derivations algorithm.

Firstly we will show that if $A \in \mathcal{P}$ then A satisfies the quadratic Poisson Gel'fand-Kirillov problem, that is the field of fractions of A is isomorphic to the field of fractions of a Poisson affine space (a polynomial algebra where the Poisson bracket of two generators is equal to (a scalar multiple of) their product). Secondly we will show how the algorithm help us to understand better the Poisson spectrum of a Poisson algebra $A \in \mathcal{P}$. In particular we will show how the Poisson spectrum of the matrix Poisson variety can be understood combinatorially.

References

[1] Stéphane Launois and César Lecoutre, *A quadratic Poisson Gel'fand-Kirillov problem in prime characteristic*, to appear in Trans. Amer. Math. Soc., arXiv:1302.2046v2 (2014)

[2] Stéphane Launois and César Lecoutre, *Poisson Deleting Derivations Algorithm and Poisson Spectrum*, arXiv:1409.4604v2 (2014)

(Received February 09, 2015)

Session 28

1111-16-562 **Lucio Simone Cirio*** (lcirio@uni-math.gwdg.de), Mathematisches Institut, Bunsenstraße 3-5, 37073 Göttingen, Germany. *A categorification of infinitesimal braidings and of Casimir Lie algebras.*

Infinitesimal braidings and Casimir Lie algebras (Lie algebras endowed with a symmetric invariant tensor) are respectively the 'classical limit' of braided categories and of quantum groups.

Drinfeld showed how it is possible to quantize Casimir Lie algebras via the holonomy of the Knizhnik-Zamolodchikov connection. After recalling Drinfeld construction I will address its 2-categorical analogue, which involves infinitesimal braidings in 2-categories and invariant tensors on Lie 2-algebras.

I will conclude by sketching why this is relevant for the study of quantum 2-groups and higher knot invariants. Based on joint works with J.F. Martins. (Received February 09, 2015)

Session 41

1111-16-589 **Ivan Yudin*** (yudin@mat.uc.pt). *Twisted products, stratifying ideals, and Schur algebras.*

An idempotent ideal $J = AeA$ of an associative algebra A is called *stratifying* if $\mathrm{Tor}_k^A(A/J, A/J) = 0$ for all $k \geq 1$. If J is a stratifying ideal then the functor $A/J \otimes_A -$ preserves (minimal) projective resolutions of (A/J)-modules. We will give a sufficient condition, based on a twisted product structure of A over a subalgebra S, for an ideal J to be stratifying. We will show how one can apply this result for constructing (minimal) projective resolutions of simple modules over the Borel-Schur algebra $S_{\mathbb{K}}^{+}(n, r)$. This is joint work with Ana Paula Santana. (Received February 09, 2015)

Session 8

1111-16-648 **Joshua Sussan*** (joshuasussan@gmail.com), 1650 Bedford Ave, Brooklyn, NY 11225, and **Sabin Cautis**. *Categorical Heisenberg and related structures.*

A graphical category whose Grothendieck group contains a Heisenberg algebra was constructed by Khovanov. By considering certain complexes in the corresponding homotopy category we obtain a conjectural boson-fermion correspondence on the level of categories. We will also study a super version of Khovanov's category in order to obtain a twisted Heisenberg algebra. (Received February 09, 2015)

Session 8

1111-16-657 **Catharina Stroppel*** (stroppel@math.uni-bonn.de), , Germany. *Gradings on centralizer algebras and categorification.* Preliminary report.

Classical Schur-Weyl duality provides an intriguing connection between the representations of the general linear group and the symmetric group. This dualty generalizes to other classical groups, to Lie algebras and Lie superalgebras and corresponds to several interesting classes of centralizer algebras. We like to present a general setup for studying such centralizer algebras as well as a machinery to construct gradings on these centralizer algebras. There are two main tools: the theory of tilting modules for quantum groups and the theory of categorification. The theory of tilting modules provides nice cellular bases with good representation theoretic properties. As an application we repreove several known nontrivial results in representation theory in a general framework. On the other hand we use techniques from categorification to compute decomposition numbers for centralizer algebras in the non-semisimple case. This gives for instance new results for the structure and representation theory of (walled) Brauer algebras, blob algebras, Temperley-Lieb algebras and other famous diagram algebras. (Received February 09, 2015)

Session 51

1111-16-679 **A Stolin*** (astolin@chalmers.se), Department of Math. Sciences, Chalmers/GU, 41296 Göteborg, Sweden, and **E Zelmanov**. *Classification of Quantum Groups and Lie Bialgebras.*

In the present talk we describe a classification of Quantum Groups, which have simple finite dimensional Lie algebras as their classical limits. The method for this classification was developed for the classification of the Lie bialgebra structures on current Lie algebras. (Received February 10, 2015)

Session 7

1111-16-796 **Qimh Richey Xantcha*** (qimh@math.uu.se), Uppsala, Sweden. *The Combinatorics of Polynomial Functors.*

We present a new description of Endofunctors of Module Categories, based upon a combinatorial category comprising finite sets and so-called mazes, and bringing about a vast generalisation of a result from 2001 by Baues, Dreckman, Franjou & Pirashvili. Polynomial functors, in particular, find a natural interpretation in this framework.

We further show how strict polynomial functors are encoded by the category of multi-sets and so-called multations. This is a slight modification of work done by Salomonsson in 2003.

The two strains of functors may then be compared and contrasted through juxtaposing the respective combinatorial structures, leading to the Polynomial Functor Theorem, giving an effective criterion for when a polynomial functor is strict polynomial. (Received February 10, 2015)

Session 8

1111-16-798 **Michael Ehrig*** (mehrig@math.uni-bonn.de), Endenicher Allee 60, 53115 Bonn, Germany. *Categorification of Quantum Symmetric Pairs.*

In the talk I will discuss how one can use categorification methods to study special quantum symmetric pairs. I want to investigate how the Lie theory used in the categorification can be used to determine nice properties of the categorified representation, like canonical bases and positivity properties. In addition to the representation one gets natural versions of Schur-Weyl duality and skew Howe duality for these quantum symmetric pairs and I will discuss how this come up naturally from the structures of the studied categories. If time permits I want to talk about the relations to classical Brauer algebras and how one might have to modify the theory of KLR algebras to be useful in this setup. All of this is based on a series of papers joint with Catharina Stroppel. (Received February 10, 2015)

Session 51

1111-16-815 **Miodrag C Iovanov*** (miodrag-iovanov@uiowa.edu) and **Gerard D Koffi**. *Incidence algebras, deformations and related monoidal structures.* Preliminary report.

We introduce and study a generalization of incidence algebras, their deformations, and monoidal structures on their category of representations, all of which are controlled by the singular cohomology of the simplicial realization of the underlying generalized PO-set. We find intrinsic characterization of such algebras, and show that algebras of finite representation type with no oriented cycles in their Ext-quiver are such deformations of generalized incidence algebras, and we conjecture they are in fact trivial deformations. This is joint work with G.Koffi (PhD student, University of Iowa) (Received February 10, 2015)

17 ► Nonassociative rings and algebras

Session 51

1111-17-13 **Arturo Pianzola*** (a.pianzola@gmail.com). *Affine-like algebras related to Grothendieck's dessins d'enfants.*

Over the last decade some deep connections have been discovered between the theory of reductive groups schemes [SGA3] developed by Demazure and Grothendieck and infinite dimensional Lie theory. The appearance of affine-like algebras related to dessins d'enfants (joint work with V. Chernousov and P. Gille) is quite recent. Whether there are meaningful connections with quantum groups is unknown. (Received December 21, 2014)

Session 51

1111-17-26 **Volodymyr Mazorchuk*** (mazor@math.uu.se), SE75106 Uppsala, Sweden. *Extension full subcategories in Lie theory.*

An abelian subcategory A of an abelian category C is said to be extension full provided that the natural inclusion of A to C induces isomorphisms for extensions of any degree between any pair of objects in A. In this talk we will show that many natural examples of modules categories appearing in Lie theory are extension full in each other or in the category of all modules. This includes various versions of category O, the category of generalized weight modules, the category of Gelfand-Zeitlin modules and the category of Whittaker modules. As a bonus, we compute various homological invariants for the categories mentioned above.

This is a report on a project joint with Kevin Coulembier. (Received January 03, 2015)

Session 2

1111-17-39 **Christoph Schweigert*** (christoph.schweigert@uni-hamburg.de), Bereich AZ, Fachbereich Mathematik, Bundesstrasse 55, 20146 Hamburg, Germany, and **Jurgen Fuchs**, Universitetsgatan 21, 65188 Karlstad, Sweden. *Invariants for mapping class group actions from ribbon Hopf algebra automorphisms.*

We show how to produce, from a given finite-dimensional factorizable ribbon Hopf algebra, for a Riemann surface of arbitrary genus and any number of punctures, invariants under the corresponding mapping class group. The ribbon Hopf algebra is not supposed to be semisimple. (Received January 09, 2015)

Session 42

1111-17-45 **Rodrigo L Rodrigues*** (rlucasrodrigues@uol.com.br), Avenida Humberto Monte, s/n, Campus do Pici, Bloco 914, Fortaleza, 60.455-760, and **Henrique Guzzo Jr.**. *The additivity of Jordan derivable maps in alternative rings.*

As established by Martindale, in 1969, today it is a well-known fact that every multiplicative bijective map from a prime associative ring containing a nontrivial idempotent onto an arbitrary associative ring is additive.

During the past few years, several authors have been studying the interrelation between the multiplicative and the additive structure of a ring. Most of these results have focused on the additivity of multiplicative maps, Jordan multiplicative maps and Jordan triple multiplicative maps.

The concept of a multiplicative derivation appeared for the first time in the paper by Daif, who was motivated by the work of Martindale. In his paper, Daif answered the question: under what conditions is a multiplicative derivation additive in an associative ring? Ferreira, Guzzo and Rodrigues generalized his result for the variety of alternative rings.

Recently, Lu showed that if R is a 2-torsion free unital prime associative ring containing a nontrivial idempotent element, then a Jordan derivable map is additive, namely a derivation. Our main object is to generalize this result for alternative rings.

The first author was supported by FUNCAP and CNPq (Grant: DCR-0024-01092.02.00/). (Received January 12, 2015)

Session 2

1111-17-88 **Alexander Schenkel*** (as880@hw.ac.uk), Department of Mathematics, Heriot-Watt University, Edinburgh, EH14 4AS, United Kingdom. *Nonassociative geometry in quasi-Hopf representation categories.*

We study the noncommutative and nonassociative differential geometry of bimodule objects in the representation category of a quasitriangular quasi-Hopf algebra. Geometric structures such as differential operators, connections and tensor fields are described in terms of the internal homomorphisms of this category via equalizer conditions. We in particular focus on the construction of tensor products of connections on such bimodule objects, which turns out to be much less restrictive than in a generic algebraic setting. Examples are obtained by cochain twisting of equivariant vector bundles and their relation to non-geometric string theory is briefly discussed. This talk is based on joint work with Gwendolyn E. Barnes and Richard J. Szabo (arXiv:1409.6331 [math.QA], to appear in JGP). (Received January 21, 2015)

Session 42

1111-17-106 **N. P. Rego*** (nrego@ipca.pt), Campus do IPCA, Lugar do Aldão, 4750-810 Barcelos, Portugal, and **J. M. Casas, supported by MTM2013-43** (jmcasa@uvigo.es), 36005 P, Spain. *Semi-direct product of universal α-central extensions of Hom-Leibniz algebras.*

The goal of this talk is to present the generalization of results about the universal central extension of the semi-direct product of Leibniz algebras to the framework of Hom-Leibniz algebras, based on the investigations on universal (α)-central extensions of (α)-perfect Hom-Leibniz algebras in [1].

The talk is organized as follows: we introduce the notions of Hom-actions and semi-direct product and establish the equivalence between split extensions and the semi-direct product extension. We analyze the functorial properties of the universal (α)-central extensions of (α)-perfect Hom-Leibniz algebras ((L, α) is α-perfect if $L = [\alpha(L), \alpha(L)]$). We establish the relationships between the universal α-central extension of the semi-direct product of two α-perfect Hom-Leibniz algebras and the semi-direct product of the universal α-central extensions of both of them.

References

[1] J. M. Casas, M. A. Insua, N. P. Rego, *On universal central extensions of Hom-Leibniz algebras*, J. Algebra Appl. **13** (8) (2014), 22 pp. (Received January 23, 2015)

Session 51

1111-17-117 **Arvid Siqveland*** (arvid.siqveland@hbv.no), Postbox 235, Kongsberg, Norway. *The Noncommutative Serre's Theorem.*

The local rings of a commutative variety can be computed by commutative deformation theory of modules, where the modules are the residues $A/\mathfrak{p}$, $\mathfrak{p}$ prime. A noncommutative deformation theory is developed, where we consider finite families of modules $\{M_1, \ldots, M_r\}$ with incidences (tangents) between them. These objects are called diagrams. The noncommutative deformation theory computes the semi-local rings of a finite diagram, local in a set of points identified with modules, and we let the direct limits of these semi-local rings represent the semi-regular functions on the possibly infinite diagram. These notes are made to prove that this is a true generalization of the commutative algebraic geometry, in particular that if A is a commutative ring, if $\underline{c}$ is the set of quotients by a prime ideal, i.e. $\underline{c} = \{A \to A/\mathfrak{p} | \mathfrak{p} \subset A \text{ prime}\}$, then the semi-local ring of $\underline{c}$ gives the ring back:

$$\mathcal{O}(\underline{c}, \pi) = \mathcal{O}(\{A \to A/\mathfrak{p} | \mathfrak{p} \subset A \text{ prime}\}, \pi) \cong A,$$

where $\pi : \mathbf{Mod}_A \to \mathbf{Vec}_k$ is the forgetful functor. The lecture will include a sketch of the proof of the generalized Burnside's theorem. (Received January 26, 2015)

Session 42

1111-17-142 **José M. Pérez-Izquierdo*** (jm.perez@unirioja). *Non-associative universal enveloping algebras.*

Non-associative universal enveloping algebras are the non-associative counterpart of universal enveloping algebras of Lie algebras. These non-associative Hopf algebras have become one of the building blocks of the non-associative Lie Theory for loops. Groups form one of the infinitely many possible varieties of loops. Classical results such as Lie's theorems, Ado's theorem or the Baker-Campbell-Dynkin-Hausdorff formula are natural for these non-associative groups too. However, challenging problems such as an adequate Representation theory remain mostly open in this context. Based on the survey [1], I will discuss the development of non-associative universal enveloping algebras from their recent origin to our days.

[1] J. Mostovoy, J.M. Pérez-Izquierdo, I.P. Shestakov: Hopf algebras in non-associative Lie theory, *Bull. Math. Sci.* (2014) 4:129-173. (Received January 28, 2015)

Session 8

1111-17-207 **Hoel Queffelec*** (hoel.queffelec@anu.edu.au) and **Antonio Sartori**. *Homfly-Pt and Alexander polynomials from a doubled Schur algebra.*

The Homfly-Pt polynomial is a two-variable knot invariant, that can be specialized to both the Alexander and the Jones polynomials. However, the quantum groups based constructions yielding these latter invariants do not lift to the Homfly-Pt polynomial. Using ideas from Howe duality, we introduce a doubled version of the quantum Schur algebra, which allows us to define in a unified quantum setting the Homfly-Pt, Reshetikhin-Turaev, and Alexander polynomials. (Received February 02, 2015)

Session 42

1111-17-216 **J. M. Casas*** (jmcasas@uvigo.es), E. E. Forestal, Campus Universitario A Xunqueira, 36005 Pontevedra, Pontevedra, Spain, and **E. Khmaladze**, A. Razmadze Math. Inst., Tamarashvili Str. 6, 0177 Tbilisi, Rep of Georgia. *Central extensions of Leibniz algebras relative to the Liezation functor.* Preliminary report.

The goal of the talk is to consider the notions of central extension and commutator relative to the Liezation functor $(-)_{\mathsf{Lie}} : \mathsf{Leib} \to \mathsf{Lie}$ in order to study properties of Leibniz algebras relative to this functor.

Firstly we recall the concepts of Lie-perfect Leibniz algebra, Lie-trivial and Lie-central extension. We construct an explicit complex which allow to compute the homology of a Leibniz algebra relative to the Liezation functor and we relate it with the usual Leibniz homology by means of a long exact sequence.

We introduce the notions of Lie-trivial, Lie-stem and Lie-stem cover of Leibniz algebras and we characterize them by means of a six-term exact sequence.

We introduce the notions of Lie-unicentral, Lie-capable and precise Lie-center of Leibniz algebras and prove that Lie-capability is equivalent to the vanishing of the precise Lie-center and Lie-unicentrality is equivalent to the vanishing of a map in a six-term exact sequence.

We introduce and characterize Lie-solvable and Lie-nilpotent Leibniz algebras by means of relative commutators. A homological characterization of Lie-nilpotence is obtained.

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Session 11

1111-17-272 **Jan E Grabowski*** (j.grabowski@lancaster.ac.uk), Department of Mathematics and Statistics, Lancaster University, Lancaster, LA1 4YF, United Kingdom. *Recovering automorphisms of quantum spaces.*

It has long been expected and is now proved in many important cases that quantum algebras are more rigid than their classical limits. That is, they have much smaller automorphism groups. This begs the question of whether this broken symmetry can be recovered.

I will outline an approach to this question involving groupoids and functors on them induced by 2-cocycle twists, focussing on the example of quantum projective space.

This is joint work with Nicholas Cooney (Lancaster). (Received February 04, 2015)

Session 2

1111-17-273 **Mitja Mastnak*** (mmastnak@cs.smu.ca), Department of Math. and C.S., Saint Mary's University, 923 Robie Street, Halifax, NS B3N1Z9, Canada. *Quantum Lie algebras and formal graded deformations of Nichols algebras.*

The talk is about a deformation theory for bialgebras in braided linear monoidal categories. It is well-known that Lie algebra structures on a vector space V are in bijective correspondence with deformations of the symmetric algebra S(V). In joint work with I. Angiono and M. Kotchetov we study a braided analogue of this correspondence. The braided analogue of the symmetric algebras are Nichols algebras. I will present some of our joint results regarding the rigidity of certain Nichols algebras. These results can be interpreted as non-existence of braided Lie algebras with non-trivial bracket. Some connections with the famous Andruskiewitsch-Schneider lifting method will also be discussed. (Received February 04, 2015)

Session 42 1111-17-383 **Consuelo Martínez López*** (cmartinez@uniovi.es), Department of Mathematics, Faculty of Sciences, C/ Calvo Sotelo s/n, 33007 Oviedo, Asturias, Spain. *Some Infinite dimensional (super)algebras and their representations.*

The aim of this talk is to give a general view of what is known about the structure of some interesting infinite dimensional Lie algebras and superalgebras, comparing the results and placing them in relation with well known results in the finite dimensional case. We will consider also relations with Jordan structures and will pay attention to the representation theory of the considered algebras and superalgebras. (Received February 06, 2015)

Session 42 1111-17-461 **Fernando Montaner*** (fmontane@unizar.es), Departamento de Matemáticas, Universidad de Zaragoza, Zaragoza, Spain. *Local Goldie conditions on Jordan Algebras and the socle of their algebras of quotients.* Preliminary report.

We report on joint work with I. Paniello which on the application of the notion of maximal algebra of quotients of a Jordan algebra, as introcuced by Montaner, to the study of local algebras of quotients of Jordan algebras in the spirit of the version of Fernández-López and García-Rus' on the works of Fountain and Gould and of Ahn and Márki on (associative) orders in rings with minimal conditions. (Received February 08, 2015)

Session 2 1111-17-487 **Ivan Shestakov*** (shestak@ime.usp.br), Rua do Matão, 1010, Sao Paulo, 05586-080, Brazil. *Non-associative Hopf algebras of formal diffeomorphisms.* Preliminary report.

We give an introduction to non-associative Hopf algebras and their relations. In particular, a non-associative version of the Faàa Di Bruno bialgebra will be considered. (Received February 08, 2015)

Session 42 1111-17-491 **Pavel S. Kolesnikov**, **Leonid G. Makar Limanov** and **Ivan P. Shestakov*** (shestak@ime.usp.br), rua do Matão, 1010, São Paulo, 05586-080, Brazil. *The Freiheitssatz for generic Poisson algebras.*

A generic Poisson algebra is an associative commutative algebra with an anticommutative product (a bracket) which, in general, is not a Lie one but satisfies the Leibnitz identity. We prove that the Freiheitssatz is true for the variety of generic Poisson algebras. More exactly, let $P = P[x_1, \ldots, x_n]$ be the free generic Poisson algebra on free generators $x_1, \ldots, x_n$, and let an element $f \in P$ involves x_n. Then the images of the elements $x_1, \ldots, x_{n-1}$ generates the free subalgebra in the quotient algebra $P/(f)$. For ordinary Poisson algebras (i.e., when the bracket is a Lie one), the Freiheitssatz was proved earlier by L. Makar Limanov and U. Umirbaev.
(Received February 08, 2015)

Session 42 1111-17-523 **Seidon Alsaody***, Uppsala University, Department of Mathematics, P. O. Box 480, 75106 Uppsala, Sweden. *Composition Algebras, Triality, and Automorphisms of Algebraic Groups.*

A composition algebra over a field is a (not necessarily associative) algebra endowed with a strictly non-degenerate quadratic form which is multiplicative. Classical examples include quaternion and octonion algebras, and it is known that any finite-dimensional composition algebra is of dimension 1, 2, 4 or 8. In dimension eight, the classification problem is yet unsolved, and is related to a phenomenon known as triality.

Recently, Chernousov, Elduque, Knus and Tignol established a correspondence between so called symmetric composition algebras and certain automorphisms of an algebraic group G. This was done using triality of symmetric composition algebras. Under this correspondence, isomorphism classes of algebras correspond to conjugacy classes of automorphisms, and a classification of either was obtained from the other.

We will give a generalization of this result over any field of characteristic not 2. Namely, by extending the notion of triality, we establish an equivalence between the category of all eight-dimensional composition algebras with a given quadratic form, and a category arising from the action of G on certain pairs of automorphisms of G by simultaneous conjugation. We then show how previous isomorphism conditions follow from this equivalence.
(Received February 09, 2015)

Session 42 1111-17-537 **Xabier García-Martínez**, **Emzar Khamaladze** and **Manuel Ladra*** (manuel.ladra@usc.es), 15782 Santiago de Composte, Spain. *Non-abelian tensor product and homology of Lie Superalgebras.*

We introduce the non-abelian tensor product of Lie superalgebras, study some of its properties including nilpotency, solvability and Engel, and we use it to describe the universal central extensions of Lie superalgebras. We present the low-dimensional non-abelian homology of Lie superalgebras and establish its relationship with

the cyclic homology of associative superalgebras. We also define the non-abelian exterior product and give an analogue of Miller's theorem, Hopf formula and a six-term exact sequence for the homology of Lie superalgebras. (Received February 09, 2015)

Session 42

1111-17-538 **Jose Luis Castiglioni** and **Xabier García-Martínez*** (xabier.garcia@usc.es), Santiago de Comp., Spain, and **Manuel Ladra**. *Universal central extensions of Lie–Rinehart algebras.*

In this work we study central extensions of Lie–Rinehart algebras. They do an algebraic codification of Lie algebroids. The concept of Lie–Rinehart A-algebra generalizes the concept of Lie A-algebra and A-module and the main example of Lie–Rinehart algebra is the set $\mathtt{Der}_K(\mathrm{A})$ of all K-derivations of A.

We study central extensions of Lie–Rinehart algebras and we prove that if L is A-projective then the second cohomology group $H^2_{\mathrm{Rin}}(L, I)$ classifies central extensions of L by I. Then we build a non-abelian tensor product of Lie–Rinehart algebras extending the non-abelian tensor product of Lie algebras and we obtain the existence of the universal central extension when the Lie–Rinehart algebra is perfect and we characterize it with the non-abelian tensor product. (Received February 09, 2015)

Session 42

1111-17-620 **Lina Oliveira*** (linaoliv@math.tecnico.ulisboa.pt), Department of Mathematics, Instituto Superior Técnico, Av. Rovisco Pais, 1049-001 Lisbon, Portugal. *On the geometry of the unit ball in a JB^*-triple.*

The purpose of this talk is to address the problem of identifying the norm-exposed faces of the unit ball A_1 in a JB*-triple A. This problem has a local counterpart since each tripotent u in the bidual A^{**} of a JB*-triple A, compact relative to A, gives rise to a complex Banach space $P_2(u)A$ with bidual the JBW*-algebra $A_2^{**}(u)$ that is a weak*-closed subtriple of A^{**}. It will be shown that both locally and globally the norm-exposed faces of A_1 are those corresponding to compact support tripotents of elements of norm one in the dual space A^* of A.

This is a joint work with C. Martin Edwards (The Queen's College, Oxford). (Received February 09, 2015)

Session 42

1111-17-622 **Irene Paniello*** (irene.paniello@unavarra.es), Dept. of Statistics and Operative Research, Edificio Los Magnolios, Campus Arrosadia, 31006 Pamplona, Navarre, Spain. *Genetic coalgebras and cubic stochastic matrices.*

Coalgebras with genetic realization were introduced in [J. P. Tian, B-L. Li, Coalgebraic structure of genetic inheritance, Math. Biosciences and Engineering, 1 (2), 243-266 (2004)] in an attempt to model the backwards genetic inheritance in Mendelian genetic systems and later revisited in [I. Paniello, Stochastic matrices arising from genetic inheritance, Linear Algebra and its Applications 434, 791-800 (2011)] to be endowed with a matrix realization in terms of cubic stochastic matrices. Indeed, the probabilistic significance of the comultiplication constants, as transition probabilities ruling the genetic transference through generations, requires cubic matrices to comprise all the transition probabilities between the different genetical individuals of a population space.

The aim of this talk is to briefly describe some of the stochastic processes that arise related to genetic coalgebras and their cubic stochastic matrices and turn to be useful to study the asymptotic behavior of the genetic systems under consideration, stressing on bivariate Markov chains defined by the marginal distributions of genetic coalgebras [I. Paniello, Marginal distributions of genetic coalgebras, Journal of Mathematical Biology 68, 1071-1087 (2014)]. (Received February 09, 2015)

Session 51

1111-17-645 **Anthony Giaquinto*** (agiaqui@luc.edu). *Some Properties of Frobenius Lie Algebras.*

A Lie algebra is Frobenius if there exists a linear functional $F \in L^*$ such that the bilinear form $F([x, y])$ is non-degenerate. The relation between Frobenius Lie algebras and the classical Yang-Baxter equation (CYBE) is well-studied. In this talk I will show how to explicitly construct solutions to the CYBE from certain graphs associated to the linear functional F. I will also report on the principal element, the Ooms Spectrum, and other interesting properties of Frobenius Lie algebras. (Received February 09, 2015)

Session 42

1111-17-659 **Efim Zelmanov*** (ezelmano@math.ucsd.edu), Department of Mathematics, University of, California - San Diego, 9500 Gilman Drive, La Jolla, CA 92093-0112. *On Jordan and Lie Superalgebras.*

We will discuss connections between Jordan and Lie superalgebras defined by brackets. (Received February 09, 2015)

Contr.Session

1111-17-664 **Andrew Douglas*** (afdouglas@gmail.com), 277 Gold Street, Apartment 8D, Brooklyn, NY 11201. *Subalgebras of Semisimple Lie Algebra.*

We will review what is known about semisimple subalgebras of semisimple Lie algebras. Then, we'll outline some of our results on non-semisimple subalgebras of semisimple Lie algebras. Finally, we will describe an application of our techniques to a problem in physics.

All Lie algebras and representations in this talk are (almost always) finite-dimensional and over the complex numbers. The results presented are joint work with Repka. (Received February 09, 2015)

Session 42

1111-17-719 **Carlos Soneira Calvo*** (carlos.soneira@udc.es), Depto. Pedagoxía e Didáctica, Campus Universitario de Elviña, 15007 A Coruña, A Coruña, Spain, and **Nicanor Alonso Álvarez**. *About the splitting of exact sequences of Hopf triples in a non associative setting.*

This work is devoted to the study of Maschke type theorems in a non associative setting, extending previous results given by Doi about the splitting of exact sequences of (A,B)-Hopf modules for A a Hopf algebra and B a A-comodule algebra. In this line, but allowing A to be a non associative Hopf algebra with (right)left division, we give a version of Maschke's Theorem for (A, B)-Hopf triples that relies on the notion of total integral $\phi : A \to B$ and its relation with relative injectivity. Technical conditions for A and ϕ introduced in this setting are illustrated with natural examples where they are satisfied, and result to be equivalent to those introduced by Doi in the associative context when restricting to this case. (Received February 10, 2015)

Session 42

1111-17-775 **Liudmila Sabinina*** (liudmila@uaem.mx), Facultad de Cienacias, UAEM, av.Universidad 1001, 62209 Cuernavaca, Morelos, Mexico. *On some class of Malcev algebras.* Preliminary report.

We will discuss the properties of tangent algebras of smooth left automorphic Moufang loops. In particular we treat the speciality of these algebras. The talk is based on joint work with A. Grishkov and M Rasskazova. (Received February 10, 2015)

18 ► Category theory; homological algebra

Session 2

1111-18-14 **R. González Rodríguez*** (rgon@dma.uvigo.es), Campus Universitario Lagoas-Marcosende, E.E Telecomunicación, Departamento de Matemática Aplicada II, 36310 Vigo, Pontevedra, Spain. *Weak Hopf quasigroups.*

The purpose of this talk is to present the notion of weak Hopf quasigroup as a new Hopf algebra generalization that encompass weak Hopf algebras and Hopf quasigroups, and to prove that some relevant properties of these algebraic structures can be obtained under a unified approach. Also, we construct a family of examples of weak Hopf quasigroups working with bigroupoids, i.e. bicategories where every 1-cell is an equivalence and every 2-cell is an isomorphism. Finally, we obtain the fundamental theorem of Hopf modules in the weak Hopf quasigroup setting, extending the results proved by Larson and Sweedler, for Hopf algebras, by Böhm, Nill and Szlachányi for weak Hopf algebras, and by Brzeziński for Hopf quasigroups.

This talk is based on a joint work with José Nicanor Alonso Álvarez and José Manuel Fernández Vilaboa. (Received January 14, 2015)

Session 41

1111-18-27 **Volodymyr Mazorchuk*** (mazor@math.uu.se), SE75106 Uppsala, Sweden. *Finitary 2-categories and their 2-representations.*

The aim of this talk is to survey recent developments in the structure and 2-representation theory of finitary 2-categories.

This is a report on a joint project with Vanessa Miemietz. (Received January 03, 2015)

Session 28

1111-18-107 **Friedrich Wagemann*** (wagemann@math.univ-nantes.fr), Laboratoire de Mathématiques Jean Leray, Université de Nantes, 2, rue de la Houssinière, 44322 Nantes, France. *On the string Lie algebra.*

This is joint work with Salim Rivière. We interprete the equivalence class of crossed modules corresponding to the Cartan cocycle for a semi-simple finite dimensional complex Lie algebra as the "string Lie algebra". We exhibit in this equivalence class a so-called "abelian representative" which is meant to simplify applications of the string Lie algebra in representation theory. As an illustration, we show that Cirio-Martins' construction of a categorification of the infinitesimal braiding in a category of modules corresponding to the string Lie algebra for sl_2 extends to all finite dimensional metric Lie algebras. (Received January 23, 2015)

Session 2

1111-18-118 **B. Mesablishvili*** (bachi@rmi.ge), 6, Tamarashvili Str. Tbilisi 0177, Georgia. *On descent cohomology.*

The zeroth and first descent cohomology sets for a comonad on arbitrary base category with coefficients in a coalgebra are introduced. The first cohomology set is related with isomorphism classes of twisted forms and torsors. It is shown that when the comonad is generated by the free-forgetful adjunction for some monad, one can compute the first cohomology set in terms of a certain Amitsur cohomology associated to the monad. (Received January 26, 2015)

Session 41

1111-18-126 **Marco Mackaay*** (mmackaay@ualg.pt) and **Ben Webster** (btw4e@virginia.edu). *Web-bimodules over Webster's cyclotomic tensor algebras and comparison of knot homologies in type A.* Preliminary report.

In type A, there are essentially five different categorifications of the Reshetikhin-Turaev knot invariants using: matrix factorizations (Khovanov-Lauda, Wu, Yonezawa); foams (Khovanov, M.-Stosic-Vaz, Queffelec-Rose); geometry (Cautis-Kamnitzer); category O (Mazorchuk-Stroppel, Sussan); cyclotomic tensor diagrams (Webster).

All these knot homologies were conjectured to be equivalent, but proving that turned out to be hard in most cases. Cautis showed (based on previous work with Kamnitzer) that categorical skew Howe duality provides a general framework for proving that a type A knot homology is equivalent to a universal one. This implies that the first three knot homologies above are equivalent. In my talk, I will show how Webster's knot homology can be fit into Cautis's framework. By Webster's earlier work, it can also be seen that his knot homology is equivalent to the ones constructed using the representation theory of category O. Therefore, all five knot homologies are now known to be equivalent. (Received January 27, 2015)

Session 7

1111-18-219 **Tim Van der Linden*** (tim.vanderlinden@uclouvain.be), IRMP UCL, chemin du cyclotron 2 bte L7.01.02, 1348 Louvain-la-Neuve, Belgium. *When is a double central extension* universal*?*

It is easy to prove that a double central extension over an object X which is initial amongst such is necessarily the zero double extension over $X = 0$. This explains why it does not make sense to define universality of higher central extensions in the way done classically for one-fold central extensions.

The aim of my talk is to introduce an appropriate notion of universality for higher central extensions which does extend the theory of one-fold central extensions and prefect objects to higher degrees in a non-trivial way. This work is done in semi-abelian categories, but the results are new even for groups.

We shall see that a universal double central extension of X by $H_3(X)$ exists as soon as $H_2(X) = H_1(X) = 0$. I will also describe a simple construction for such universal extensions.

This is joint work with George Peschke. (Received February 03, 2015)

Session 8

1111-18-234 **Benjamin Cooper*** (ben-cooper@uiowa.edu), University of Iowa, Department of Mathematics, 14 MacLean Hall, Iowa City, IA 52242-1419, and **Amey Kaloti**. *Categorification from localization contruction.*

I will discuss an extension of the Toen localization construction along the type $\mathrm{A_n}$ family. Focus will be on applications to low dimensional topology and categorification. (Received February 03, 2015)

Session 7

1111-18-278 **Julia Goedecke*** (julia.goedecke@cantab.net). *Semi-abelian homology: an overview.*

Semi-abelian categories give a very nice context for homological algebra, extending that of abelian categories to include the categories of groups, Lie algebras, and many more. There are many different ways of computing the homology of an object in a semi-abelian category, such as classical methods using simplicial resolutions, Hopf formulae using projective presentations, computing a group of automorphisms of a suitable Galois groupoid, and homology as a Kan extension. In this talk I will present several of these methods and compare the ingredients and conditions going into each one. (Received February 04, 2015)

Session 8

1111-18-365 **Radmila Sazdanovic*** (rsazdanovic@math.ncsu.edu), Department of Mathematics, North Carolina State University, POBox 8205 SAS Hall 2311 Stinson drive, Raleigh, NC 27695, and **Mikhail Khovanov**. *Bernstein–Gelfand–Gelfand reciprocity property in categorification of orthogonal polynomials.* Preliminary report.

Bernstein–Gelfand–Gelfand reciprocity property originally appears in infinite-dimensional representation theory of simple Lie algebras. We describe a new emanation of the Bernstein–Gelfand–Gelfand reciprocity in diagrammatic categorifications of orthogonal polynomials. (Received February 06, 2015)

Session 7

1111-18-428 **Walter P Tholen*** (tholen@mathstat.yorku.ca), 4700 Keele Street, Toronto, Ontario M3J1P3, Canada. *Lax-algebraic structures without the unit law.*

Ordered sets, metric spaces, topological spaces and approach spaces are uniformly described as lax algebras with respect to a suitable quantale and a Set-monad; see D. Hofmann, G. Seal and W. Tholen (editors), "Monoidal Topology", Cambridge University Press, 2014. As is well known, choosing the monad trivially but allowing the quantale to be a quantaloid (i.e. a "multi-object quantale"), in this setting one may also capture ordered or metric structures that are not required to be reflexive or zero on the diagonal of the ambient set. In this talk we report on on-going work with D. Hofmann and L. Shen that explores the emerging theory and examples for non-identical monads. (Received February 07, 2015)

Session 41

1111-18-462 **Raquel Coelho Simoes*** (rcoelhosimoes@campus.ul.pt). *Negative Calabi-Yau triangulated categories.*

Calabi-Yau (CY) triangulated categories are those satisfying a useful and important duality, characterised by a number called the CY dimension. Much work has been carried out on understanding positive CY triangulated categories, especially in the context of cluster-tilting theory. Even though CY dimension is usually considered to be a positive (or fractional) number, there are natural examples of CY triangulated categories where this "dimension" or parameter is negative, for example, stable module categories of selfinjective algebras. Therefore, negative CY triangulated categories constitute a class of categories that warrant further systematic study. In this talk, we will give a brief survey regarding what is so far known about the structure of negative CY triangulated categories. (Received February 10, 2015)

Session 2

1111-18-502 **Marcelo Aguiar*** (maguiar@math.cornell.edu), **Mariana Haim** and **Ignacio Lopez-Franco**. *Monads on higher monoidal categories.*

McCrudden, Moerdijk, and Szlachányi (independently) studied monads acting on monoidal categories. When the monad and the monoidal structure are compatible, the category of algebras inherits the monoidal structure. This generalizes the analogous property of the category of modules over a bialgebra. A different but related situation had been considered earlier by Kock; this abstracts the fact that the category of modules over a commutative ring A carries the product $\otimes_A$. Kock's work has been recently expanded by Seal.

In ongoing work with Mariana Haim and Ignacio López-Franco, we consider monads acting on higher monoidal categories. The latter categories are equipped with several monoidal structures with any two of them related by an interchange law:

$$(A \star B) \diamond (C \star D) \to (A \diamond C) \star (B \diamond D).$$

This setting allows us to generalize and unify the case studied by Moerdijk with that studied by Kock. We will discuss when the category of algebras inherits the higher monoidal structure and illustrate the result with a few examples. (Received February 09, 2015)

Session 8

1111-18-521 **Krzysztof Karol Putyra***, ETHZ Institute for Theoretical Studies, Clausiusstrasse 47, 8092 Zurich, Switzerland, and **Alexander Shumakovitch** (shurik@gwu.edu). *Homological operations coming from odd Khovanov homology.* Preliminary report.

We construct an infinite algebra of homological operations on Khovanov homology with coefficients in $\mathbb{Z}_2$ generated by two Bockstein operations, and its lift to integers. The integral operations, when of odd degree, go between the ordinary Khovanov homology and its odd variant. We provide examples of knots that have same Khovanov and odd Khovanov homology, but the operations acts differently. In particular, it implies that the

unified Khovanov homology constructed by one of the authors is a finer invariant than the Khovanov and odd Khovanov homology taken together. (Received February 09, 2015)

Session 7

1111-18-556 **Lurdes Sousa*** (sousa@estv.ipv.pt). *On injectivity of locales and spaces.*
Two well-known important facts are the characterization of the continuous lattices as the spaces injective with respect to embeddings in the category Top_0 of T_0 topological spaces (D. Scott, 1972), and the characterization of the stably locally compact locales as the locales injective with respect to flat embeddings in the category Loc of locales (P. T. Johnstone, 1981). We show that in Loc flat embeddings are precisely those morphisms with respect to which the quotient map from the three-element chain to the two-element one which merges the two upper elements is Kan-injective. As a consequence, the category of stably locally compact locales (with convenient morphisms) is the Kan-injective hull of a finite subcategory of Loc. More generally, we characterize n-flat embeddings in Loc for each cardinal n by means of Kan-injectivity of finite subcategories and, as a corollary, we obtain analogous characterizations of the n-flat embeddings in Top_0. Furthermore, several well-known subcategories of Loc and Top_0 are Kan-injective hulls of finite subcategories, and Loc is the Kan-injective hull of a subcategory of spatial locales. This is joint work with Margarida Carvalho. (Received February 09, 2015)

Session 28

1111-18-564 **Yaël Frégier*** (yael.fregier@math.mit.edu) and **Marco Zambon**. *L_∞ algebras governing simultaneous deformations in algebra and geometry.*
We will explain how simultaneous deformations problems are naturally governed by non quadratic L_∞ algebras and how such algebras can be constructed by resolutions of operads in the algebraic case or by supergeometry in a geometric setting.

This will be illustrated with examples in algebra such as simultaneous deformations of algebras/morphisms in the Lie and associative categories. In geometry we will consider simultaneous deformations of pairs such as coisotropic/Poisson, Dirac/Courant, generalized complex/Courant. (Received February 09, 2015)

Session 28

1111-18-576 **Jeffrey C Morton*** (jeffrey.c.morton@gmail.com), , Canada. *Transformation Double Groupoids in Higher Gauge Theory.* Preliminary report.
Transformation groupoids associated to 2-group actions capture the interplay between global and local symmetries of "categorified" structures. This is expressed as the action of a 2-group (categorical group) G on a category C, and determines a transformation double groupoid C//G. We consider an example arising in Higher Gauge Theory, a categorified analog of the construction of a groupoid from the moduli space of G-bundles with connection on a manifold M in gauge theory. This double groupoid turns out to have a second construction, analogous to the situation for ordinary groups, in which it arises as a double category of pseudofunctors by treating connections in terms of holonomies: that is, as representations in G of the fundamental 2-groupoid of M. The two directions of this double category therefore have two interpretations: in the transformation groupoid, they distinguish symmetries arising from the actions of the 2-group G from those which are intrinsic to the category C. In the directions distinguish strict natural transformations from a class of "costrict" pseudonatural transformations called ICONs, which we can now interpret geometrically. (Received February 09, 2015)

Session 28

1111-18-592 **John Huerta*** (jhuerta@math.tecnico.ulisboa.pt). *Trigroups and M-theory.*
A trigroup is a tricategory with one object and all 1-, 2- and 3-morphisms invertible. M-theory is a mysterious branch of physics believed to unify the five 10D string theories and 11D supergravity. Without assuming any knowledge of physics, we will describe how the mathematics of M-theory leads naturally to a certain trigroup. (Received February 09, 2015)

Session 7

1111-18-612 **Marino Gran*** (marino.gran@uclouvain.be), I.R.M.P., Université catholique de Louvain, 2, Chemin du Cyclotron, Louvain-la-Neuve, 1348. *Star-regularity and regular completions.*
In this work in collaboration with Zurab Janelidze [1] we give a new characterisation of star-regular categories, by using a property of internal reflexive graphs. As an application we obtain a characterisation of star-regularity for multi-pointed categories which are the regular completion of a category with weak finite limits. It follows that star-regularity is invariant by regular completion and, in particular, that a regular category is normal if and only its regular completion is normal.

[1] M. Gran and Z. Janelidze, Star-regularity and regular completions, J. Pure Appl. Algebra 214, 2014, 1771-1782. (Received February 09, 2015)

Session 7

1111-18-680 **Isar Stubbe*** (isar.stubbe@lmpa.univ-littoral.fr). *Partial metric spaces as enriched categories.*

Let $Q = ([0,\infty]^{\mathrm{op}}, +, 0)$ be Lawvere's quantale of extended positive real numbers, then a Q-enriched category is precisely a generalised metric space. A *partial* metric space (X,p) is "a metric space in which self-distance is not necessarily zero"; that is, we no longer require that $p(x,x)=0$, but we do need to adapt the triangular inequality: $p(x,y)+p(y,z)-p(y,y) \geq p(x,z)$. In this talk I shall show how also partial metric spaces are enriched categories—but, crucially, now enriched in a quantaloid. Indeed, I shall construct a quantaloid $D(Q)$ from the quantale Q and show that $D(Q)$-enriched categories are precisely (generalised) partial metric spaces. I shall indicate some advantages of this categorical approach to partial metrics, more precisely when considering "completions"; I shall give other examples of the phenomena described here, notably in sheaf theory; and - time permitting - I shall comment on the abstract construction of the quantaloid $D(Q)$ from any quantale Q, showing in particular the relation with divisible quantales, BL-algebras and t-norms. (Received February 10, 2015)

Session 7

1111-18-682 **Dirk Hofmann** (dirk@ua.pt) and **Gavin J. Seal*** (gavin.seal@epfl.ch). *An adjunction between lax extensions and presheaf monads.*

While topological spaces can be equivalently described via convergence of ultrafilters or neighborhood systems, the corresponding ultrafilter and filter monads yield quite difference categories of algebras: the category of Hausdorff spaces and that of continuous lattices, respectively. In this talk, we will show that such algebras are in fact part of an adjunction that highlights certain structures of the monads. (Received February 10, 2015)

Session 51

1111-18-733 **Peter Schauenburg***, Institut de Mathématiques de Bourgogne, Faculté des Sciences Mirande, 9 avenue Alain Savary, BP 47870, 21078 Dijon, France. *Frobenius-Schur indicators in group-theoretical fusion categories.* Preliminary report.

Higher Frobenius-Schur indicators are invariants of (objects in) pivotal fusion categories, generalizing invariants for group representations. Group-theoretical fusion categories form a particularly accessible class of fusion categories, constructed from "classical" data, namely finite groups, subgroups, and cohomological information. We report on formulas for the indicators of objects in group-theoretical categories, and on concrete results obtained with these formulas. (Received February 10, 2015)

Session 7

1111-18-782 **Luke Wolcott*** (luke.wolcott@lawrence.edu). *Bousfield lattice invariants of triangulated symmetric monoidal categories.*

If T is a well generated triangulated category with a symmetric monoidal structure, or any localizing subcategory of such a category, the Bousfield class of an object X is the collection of Y such that $X \otimes Y = 0$. In such a category, the collection of Bousfield classes is a set and has the structure of a lattice. We discuss recent work in analyzing the structure of this lattice, in particular when considering a localizing subcategory that does not include the tensor unit. (Received February 10, 2015)

Session 7

1111-18-818 **Francisco Abreu Faro Mota*** (fmota@cs.cornell.edu), Department of Computer Science, Bill and Melinda Gates Hall, 343 Campus Rd, Ithaca, NY 14853. *Coinduction and Categorical Reflection.* Preliminary report.

We explore the interaction between categorical reflections and final F-coalgebras. In particular, we present a proof that if D is a full reflective subcategory of C, and F preserves D, then any final F-coalgebra must be isomorphic to its reflection in D. This gives us alternative proofs of compactness of several topological spaces, and completeness of metric spaces, and it has an application in programming languages: a coinductive type is exhaustively searchable if and only if its defining functor preserves exhaustive searchability. (Received February 10, 2015)

20 ► Group theory and generalizations

Session 41

1111-20-54 **Maud De Visscher*** (m.devisscher@city.ac.uk). *Representation theory of the partition algebra.*

The partition algebra was originally defined by Paul Martin. Over the complex numbers, it satisfies a double centraliser property with the symmetric group via their actions on a tensor space. In this talk I will discuss the representation theory of the partition algebra both over the complex numbers (due to P. Martin) and over a field of positive characteristic (joint work with C. Bowman and O. King), and present some applications to the representation theory of the symmetric group (joint with C. Bowman and R. Orellana). (Received January 14, 2015)

Session 1

1111-20-74 **Lisa Bromberg** and **Vladimir Shpilrain***, shpil@groups.sci.ccny.cuny.edu, and **Alina Vdovina**. *Navigating in the Cayley graph of $SL_2(F_p)$ and applications to hashing.*

Cayley hash functions are based on a simple idea of using a pair of (semi)group elements, A and B, to hash the 0 and 1 bit, respectively, and then to hash an arbitrary bit string in the natural way, by using multiplication of elements in the (semi)group. In this talk, we focus on hashing with 2×2 matrices over F_p. In particular, we give explicit lower bounds on the length of collisions for hash functions corresponding to some specific pairs of matrices from $SL_2(F_p)$. (Received January 19, 2015)

Session 40

1111-20-109 **Matthieu Picantin*** (picantin@liafa.univ-paris-diderot.fr). *From automatic semigroups to automaton semigroups.*

We develop an effective and natural approach to interpret any cancellative semigroup admitting a special language of greedy normal forms as an automaton semigroup, namely the semigroup generated by a Mealy automaton encoding the behavior of such a language of greedy normal forms under one-sided multiplication. The framework embraces many of the well-known classes of (automatic) semigroups: free semigroups, free commutative semigroups, trace or divisibility monoids, braid or Artin-Tits monoids, as well as some variations of the bicyclic monoid, etc. It provides what appears to be the first known connection from a class of automatic semigroups to a class of automaton semigroups. Like plactic monoids or Chinese monoids, some non-cancellative automatic semigroups are also investigated. (Received January 24, 2015)

Session 13

1111-20-114 **Winfried Bruns***, Universität Osnabrück, Institut für Mathematik, 48069 Osnabrück, Germany. *Recent developments in Normaliz.*

Normaliz is a computer program for the computation of Hilbert bases of the monoids of lattice points in rational cones, their Hilbert series and related data. In the last year several algorithmic improvements have been implemented, for example in the parallelization of Fourier-Motzkin elimination and pyramid decomposition, in the computation of lattice points in rational polytopes and in the treatment of large simplicial cones. More importantly, the functionality has been extended by the computation of lattice points polyhedra in general and Hilbert series of "semi-open" monoids. (Received January 25, 2015)

Session 4

1111-20-134 **Itamar Stein*** (steinita@gmail.com). *The ordinary quiver of the algebra of the monoid of all partial functions on a set.*

One of the goals of the study of monoid representations, is to relate them to the modern representation theory of associative algebras. An important invariant of an associative algebra A is its (ordinary) quiver, a graph that contains information about the algebra's representations. Hence, given a monoid M it is of interest to find the quiver of its algebra $\mathbb{C}M$. We will give a description of the quiver of PT_n, the monoid of all partial functions on n elements. Our description uses an isomorphism between $\mathbb{C}PT_n$ and a certain category algebra, which is an extension of a well known isomorphism of the algebra of IS_n (the monoid of all partial 1-1 maps on a set) and the algebra of the groupoid of all bijections between subsets of a set. The quiver of the category algebra is described using results of Stuart Margolis, Ben Steinberg and Liping Li on the quiver of EI-categories. (Received February 10, 2015)

Session 1

1111-20-145 **Pascal Weil***, LaBRI, bâtiment A30, 351 cours de la Libŕation, 33400 Talence, France. *Generic properties of randomly chosen subgroups of free groups and group presentations.* Preliminary report.

Let F be a finitely generated free group. For each $k \geq 1$, generically, a k-tuple of words of length at most n chosen uniformly at random forms a basis of the subgroup it generates, and this subgroup is malnormal and Whitehead minimal (Arzhantseva, Bassino, Jitsukawa, Nicaud, Ol'shanskiĭ, Weil). Let R_n be the number of words in F of length at most n. Then a R_n^d-tuple of cyclically reduced words of length at most n chosen uniformly at random, generically has the small cancellation property $C'(\frac{1}{6})$ if $d < \frac{1}{12}$, the group it presents is generically infinite and hyperbolic if $d < \frac{1}{2}$, and it is generically trivial for $d > \frac{1}{2}$ (Champetier, Gromov, Ollivier, Ol'shanskiĭ).

We discuss extensions of these results to tuples where the number and the length of the words is set more freely, and where the probability law on words of a given length is given by a Markovian process (instead of the uniform distribution). The genericity of the free basis and the malnormality properties for subgroups is extended to exponential size tuples of generators. The small cancellation properties and the degeneracy results for finite presentations are preserved under reasonable assumptions, with phase transitions that depend on the Markovian process. (Received January 29, 2015)

Session 4

1111-20-158 **Emanuele Rodaro*** (emanuele.rodaro@fc.up.pt), Departamento de Matemática, Universidade do Porto, Rua do Campo Alegre, 687, 4169-007 Porto, Portugal. *Decidability vs Undecidability in HNN-extensions of Inverse Semigroups.* Preliminary report.

The concept of HNN-extension was originally introduced for groups by Higman, Neumann and Neumann, who showed that if A_1 and A_2 are isomorphic subgroups of a group G, then it is possible to find a group H such that A_1 and A_2 are conjugate to each other in H and such that G is embeddable in H. There are two main approaches to generalize this construction to the class of inverse semigroups; one proposed by Gilbert and the other by Yamamura. In this communication we consider HNN-extensions $[S; A_1, A_2; \varphi]$ in the sense of Yamamura. Using a recent result regarding the undecidability of the word problem for amalgams of inverse semigroups under certain conditions, we show that, contrary to the group case, the word problem for an HNN-extension $[S; A_1, A_2; \varphi]$ is undecidable even if we consider S to have finite $\mathcal{R}$-classes, A_1 and A_2 to be free inverse subsemigroups of finite rank with zero, and φ, φ^{-1} to be computable functions. Finally, we try to define the "boundary" conditions for which the word problem for $[S; A_1, A_2; \varphi]$ becomes decidable. (Received January 30, 2015)

Session 4

1111-20-162 **Igor Dolinka*** (dockie@dmi.uns.ac.rs), Department of Mathematics and Informatics, University of Novi Sad, Trg Dositeja Obradovića 4, 21101 Novi Sad, Serbia, **Robert Duncan Gray** (robert.d.gray@uea.ac.uk), School of Mathematics, University of East Anglia, Norwich, NR4 7TJ, United Kingdom, and **Nik Ruškuc** (nik@mcs.st-and.ac.uk), School of Mathematics and Statistics, University of St Andrews, St Andrews, KY16 9SS, United Kingdom. *On regularity and the word problem for free idempotent generated semigroups. Part II.*

The category of all idempotent generated semigroups S with a prescribed structure $\mathcal{E}$ of their idempotents $E = E(S)$ (called the biordered set) has an initial object called the *free idempotent generated semigroup over* $\mathcal{E}$, defined by a presentation over alphabet E, and denoted by $\mathsf{IG}(\mathcal{E})$. In this two-part talk we focus on issues related to the word problem of semigroups of this form. In Part I it was discussed that the set of words representing regular elements of $\mathsf{IG}(\mathcal{E})$ is recursive; furthermore, if one assumes that all maximal subgroups of $\mathsf{IG}(\mathcal{E})$ have decidable word problems, then the word problem in $\mathsf{IG}(\mathcal{E})$ restricted to these regular words is decidable, too.

In this part, we exhibit a biordered set $\mathcal{E}$ arising from a finite idempotent semigroup (band) S, such that the word problem for $\mathsf{IG}(\mathcal{E})$ is undecidable, even though all the maximal subgroups have decidable word problems. This is achieved by relating the word problem of $\mathsf{IG}(\mathcal{E})$ to the subgroup membership problem in finitely presented groups. (Received January 30, 2015)

Session 4

1111-20-165 **Karl Auinger*** (karl.auinger@univie.ac.at), Fakultät für Mathematik, Universität Wien, Oskar-Morgenstern-Platz 1, Wien, A-1090. *The Ribes–Zalesskii-Theorem revisited.* Preliminary report.

A new approach to the Ribes–Zalesskii product theorem will be discussed. It can be applied to the pro-$\mathfrak{F}$-topology on a free group F whenever $\mathfrak{F}$ is a formation of finite groups for which the free pro-$\mathfrak{F}$-groups have tree-like Cayley graphs. We find new examples of (relatively free) profinite groups having such Cayley graphs — among them some which do not have any non-trivial solvable quotients. This also leads to new examples of profinite topologies on F for which the Ribes–Zalesskii-Theorem holds. (Received January 31, 2015)

Session 1

1111-20-182 **Laura I Ciobanu***, Rue Emile-Argand 11, 2000 Neuchâtel, Switzerland, **Volker Diekert**, Stuttgart, Germany, and **Murray Elder**, Newcastle, Australia. *The language complexity of algebraic sets in free groups and monoids.* Preliminary report.

We show that, given a word equation over a finitely generated free group, the set of all solutions in reduced words forms an EDT0L language. In particular, it is an indexed language in the sense of Aho. (Received February 02, 2015)

Session 40

1111-20-189 **Enric Ventura*** (enric.ventura@upc.edu), Av. Bases de Manresa 61-73, 08242 Manresa, Barcelona, Spain, and **Zoran Sunic**. *Automaton groups with unsolvable conjugacy problem.*

In this talk we construct a family of examples of self-similar groups generated by finite self-similar sets of automorphisms of infinite regular trees. And among them, we prove there are some with unsolvable conjugacy problem. Along the way, orbit undecidable, free subgroups of $GL_d(Z)$ for $d > 5$, and of $Aut(F_d)$ for $d > 4$, are constructed as well. (Received February 02, 2015)

Session 1

1111-20-191 **Enric Ventura*** (enric.ventura@upc.edu), Av. Bases de Manresa 61-73, 08242 Manresa, Barcelona, Spain. *Membership in the BNS invariant.*

Given a finitely generated group G, $\Sigma^1(G)$ denotes the Bieri–Neumann–Strebel invariant of G, a certain open subset of the unit sphere which has some interesting information about abelian quotients of G and their kernels.

By analyzing semidirect products of the form $G_\alpha = G \rtimes_\alpha Z$, specially with defining automorphisms α with no non-trivial fixed points at the abelianization level, we obtain the following unsolvability result: there exists no algorithm to decide, given a finite presentation of a group G and given a rational point in the sphere, whether the point belongs to $\Sigma^1(G)$. (Received February 02, 2015)

Session 51 1111-20-196 **Alberto Hernandez*** (ahernandeza079@gmail.com), F.C.U.P., Departamento de Matematica, Rua Campo Alegre, 687, 4169-007 Porto, Portugal, and **Lars Kadison** (lkadison@broadpark.no), **Marcin Szamotulski** (mszamot@gmail.com) and **Christopher J. Young** (booloon_b457@hotmail.com). *Subgroup depth, algebraic modules and twisted coefficients.*

Morita equivalence of two ring extensions is definable by a commutative square of functors between module categories with arrows consisting of two equivalences and two induction (or restriction) functors. For example, the inclusion matrix of a semisimple C-subalgebra pair, and subring depth in general, are Morita invariants. After this introduction, we talk somewhat independently about the subring depth of a Hopf subalgebra pair, which may be determined by the degree of a minimal polynomial (perhaps infinite) of the right quotient module in either Green ring. By passing to corings and entwinings, this theory extends to subalgebra pairs of crossed products, which shows that subgroup depth is an upper bound for depth of the same group algebra pair with twisted coefficients. (Received February 02, 2015)

Session 40 1111-20-199 **Rostislav Grigorchuk*** (grigorch@math.tamu.edu), Department of Mathematics, Mailstop 3368, College Station, TX 77845, and **Artem Dudko**. *On diagonal actions of branch groups and the corresponding characters.*

In 2014 L.Bartholdi and speaker showed that weakly branch groups act completely nonfree on the boundary of associated rooted tree. A corollary of this result is the fact that every weakly branch group has at least one continuous ergodic invariant random subgroup (IRS). In 2014 A.Dudko and speaker introduced a notion of absolute non-free action and showed that every weakly branch group acts absolutely non-freely on the boundary of the associated rooted tree. Using this result and the symmetrized diagonal actions it is shown that every branch group has at least countably many different ergodic totally non-free actions and therefore at least countably many ergodic IRS and II1 factor representations.

This result is applicable to many groups generated by finite automata. (Received February 02, 2015)

Contr.Session 1111-20-211 **Muhammad Inam*** (s-minam1@math.unl.edu), University of Nebraska-Lincoln, Department of mathematics, 203 Avery Hall, P. O. Box 880130, Lincoln, NE 68588-0130, **John C. Meakin** (jmeakin@unl.edu), University of Nebraka-Lincoln, Department of mathematics, 203 Avery Hall, P. O. Box 880130, Lincoln, NE 68588-0130, and **Robert Ruyle** (rruyle3@unl.edu), University of Nebraska-Lincoln, Department of mathematics, 203 Avery Hall, P. O. Box 880130, Lincoln, NE 68588-0130. *A structural property of Adian inverse semigroups.*

We show that an inverse semigroup given by an Adian presentation is $E-$unitary. Moreover, an inverse semigroup given by a presentation $Inv\langle X|u_iv_i^{-1} = 1\rangle$, where $\langle X|u_i = v_i\rangle$ is Adian, is also $E-$unitary. (Received February 02, 2015)

Session 4 1111-20-213 **John Rhodes***, rhodes@math.berkeley.edu, and **Edmond Lee**, elee1@nova.edu. *A survey of finite join irreducible (ji) semigroups.*

A survey of finite join irreducible (ji) semigroups in which all semigroups considered are finite. Direct product is denoted x and division S < T means S is an surmorphism of a subsemigroup of T. S is ji if S < A x B implies there exist an n so S divides an nth power of A or an n power of B, where nth power means direct product n times. Equivalently, S is ji if the pseudovariety (S) generated by S is ji in the complete lattice of all pseudovarieties of finite semigroups.

We will probably never know all the ji semigroups. We do not know if S being ji is decidable. In this talk we give a survey of all known ji semigroups to date, including some infinite families. We define 4 operations on finite semigroups that preserve ji. We know all the ji semigroups of order 5 or less, using the aid of known computer-generated tables, known results and some new results. We present some conjectures.

This is joint work with Edmond Lee and Benjamin Steinberg. (Received February 03, 2015)

Session 40 1111-20-214 **Ines Klimann*** (klimann@liafa.univ-paris-diderot.fr), LIAFA, Université Paris Diderot - Paris 7, CNRS UMR 7089, Case 7014, 75205 Paris Cedex 13, France. *On torsion elements in a (semi)group generated by a reversible automaton.*

(join works with Thibault Godin, Matthieu Picantin, and Dmytro Savchuk)

We introduce a labeling of the orbit tree of an invertible Mealy automaton in order to give a characterization of torsion elements in the semigroup generated by the dual automaton, in terms of a path property in this tree. This leads to new results for invertible-reversible Mealy automata: (i) a connected 3-state automaton cannot generate an infinite Burnside group; (ii) a semigroup generated by an automaton with no bireversible component is torsion-free. (Received February 03, 2015)

Session 4

1111-20-259 **Mark Kambites***, School of Mathematics, University of Manchester, Manchester, M13 9PL, United Kingdom. *Anisimov's Theorem for Inverse Semigroups.*

The idempotent problem of a finitely generated inverse semigroup is the formal language of all words over the generators which represent idempotent elements; it was introduced by Gilbert and Noonan Heale as a natural generalisation to inverse semigroups of the word problem for groups. We show that a finitely generated inverse semigroup with regular idempotent problem is necessarily finite; this answers a question of Gilbert and Noonan Heale, and establishes a generalisation to inverse semigroups of Anisimov's Theorem for groups. The main tool is a structure theorem of Billhardt, which embeds an inverse semigroup into a λ-semidirect product of any idempotent-pure quotient with a semilattice. (An alternative, somewhat orthogonal but equally interesting, generalisation of Anisimov's Theorem to inverse semigroups has recently been obtained by Tara Brough.) (Received February 04, 2015)

Session 4

1111-20-268 **Nóra Szakács*** (szakacsn@math.u-szeged.hu), Aradi vertanuk tere 1., Szeged, 6721, Hungary. *On the graph condition regarding the F-inverse cover problem.*

The topic of the talk is the so-called F-inverse cover problem proposed by Henckell and Rhodes about 25 years ago, asking whether or not every finite inverse monoid admits an F-inverse cover. In [1], Auinger and Szendrei have shown that the answer is positive if and only if each finite graph admits a locally finite group variety with a certain property. As presented in [2], we study this property and prove that the class of graphs for which a given group variety suffices is closed downwards in the minor ordering, and can therefore be described by forbidden minors. We find these forbidden minors for all varieties of Abelian groups, thus describing the graphs for which such a group variety satisfies the above mentioned condition.

References

[1] K. Auinger and M. B. Szendrei, On F-inverse covers of inverse monoids, *J. Pure Appl. Algebra* **204** (2006), 493–506.

[2] N. Szakács, On the graph condition regarding the F-inverse cover problem, submitted. ArXiv:1501.06466

(Received February 04, 2015)

Session 40

1111-20-286 **Tatiana Nagnibeda***, University of Geneva, Department of mathematics, 2-4, rue du Lievre, c.p, 64, 1211 Geneva, Switzerland. *De Brujin graphs, lamplighter groups and spectral computations.*

We will explore a connection between two well-known notions, one from combonatorics, the other from group theory: de Brujin graphs and lamplighter groups. The talk is based on a joint work with Paul-Henry Leemann. (Received February 04, 2015)

Session 4

1111-20-308 **Boris M. Vernikov*** (bvernikov@gmail.com), Lenina 51, Institute of Mathematics and Computer Science, Ekaterinburg, 620000, Russia. *Special elements of lattices of semigroup varieties.* Preliminary report.

An examination of special elements of different types in the lattice **SEM** of all semigroup varieties and the lattice **Com** of commutative semigroup varieties is a subject of a number of articles published several last years. I am going to give a brief survey of these results including several new and non-published of them. It turns out that there are both a number of surprising analogues and several significant differences between properties of special elements in **SEM** and **Com**. I plan to emphasize on these similarities and differences between behaviour of special elements in two varietal lattices. (Received February 05, 2015)

Session 4

1111-20-353 **Alan J. Cain*** (a.cain@fct.unl.pt), Centro de Matemática e Aplicações, Departamento de Matemática, Universidade Nova de Lisboa, 2829-516 Caparica, Portugal, and **Robert D. Gray** and **António Malheiro**. *Crystal bases, finite convergent presentations, and automaticity for plactic monoids.*

The elements of the plactic monoid are Young tableaux, and index representations of the semisimple Lie algebras of type A_n (that is, the special linear algebras $\mathfrak{sl}_{n+1}$). Crystal bases are powerful combinatorial tools for working with the representations of quantum groups and semisimple Lie algebras. They are the natural setting for studying analogues of plactic monoids corresponding to the Lie algebras of types B_n, C_n, D_n, and G_2. This talk will describe how crystal basis theory and analogues of Young tableaux can be used to construct, in a uniform way, finite convergent presentations and automatic structures (in the sense of Epstein et al.) for plactic monoids of types A_n (the classical plactic monoid), B_n, C_n, D_n, and G_2. (Received February 06, 2015)

Session 4

1111-20-422 **Victoria Gould*** (victoria.gould@york.ac.uk), Department of Mathematics, University of York, York, YO10 5DD, United Kingdom. *Free idempotent generated semigroups and the endomorphism monoid of a free G-act.*

The study of the free idempotent generated semigroup IG(E) over a biordered set E began with the seminal work of Nambooripad and has seen a recent revival with a number of new approaches. A particular focus, which this talk explores, has been on the maximal subgroups of IG(E). A long-standing conjecture that all such subgroups were free was shown to be false, first by a counterexample of Brittenham, Margolis and Meakin, and later by a proof by Gray and Ruškuc that *any* group arises in this way.

Here we consider IG(E) in the case E is the biordered set of the endomorphism monoid of the free G-act $F_n(G)$ on n generators. We say that the *rank* of an element of End $F_n(G)$ is the minimal number of (free) generators in its image.

Let $\epsilon = \epsilon^2 \in$ End $F_n(G)$. We show that if rank $\epsilon = r$ where $1 \leq r \leq n-2$ then $H_{\overline{\epsilon}}$ (the maximal subgroup of ϵ in IG(E)) is isomorphic to H_ϵ (the corresponding subgroup of End $F_n(G)$) and hence to $G \wr \mathcal{S}_r$. This provides in particular an alternative approach to the result of Gray and Ruškuc.

This is joint work with Yang Dandan and Igor Dolinka. (Received February 07, 2015)

Session 40

1111-20-446 **Pedro V. Silva*** (pvsilva@fc.up.pt), Department of Mathematics, Rua do Campo Alegre, 687, 4169-007 Porto, Portugal. *Compact completions: from hyperbolic to self-similar groups.* Preliminary report.

The (compact) completion $\widehat{G}$ of a hyperbolic group G, defined by means of the Gromov product, has played an important role in my recent research, from which I select two examples:

- If G is virtually free and φ is a nontrivial endomorphism of G, then φ admits a continuous extension $\widehat{\varphi}$ to $\widehat{G}$ if and only if it is virtually injective; in this case, the subspace of fixed points Fix($\widehat{\varphi}$) is in some precise sense finitely generated and all the regular fixed points are either atractors or repellers (from the dynamical viewpoint) (Silva'13).
- If G is hyperbolic and φ is a nontrivial endomorphism of G, then φ satisfies a Hölder condition with respect to some (any) visual metric if and only if it is virtually injective and $G\varphi$ is a quasiconvex subgroup of G (Araújo and Silva'14).

Given a self-similar group, we can also define a (compact) completion using the (metrizable) topology of pointwise convergence: the tree completion. Which concepts and results involving the completion of hyperbolic groups find counterparts in this setting? This talk will report on recent results involving particular subclasses of self-similar groups. (Received February 08, 2015)

Session 40

1111-20-451 **Said Najati Sidki*** (ssidki@gmail.com), Departamento de Matematica, Universidade de Brasilia, Brasilia, Brazil. *Virtual Endomorphisms and Lamplighter Groups.* Preliminary report.

We approach the problem of faithful self-similar representations of groups of type $C_p wreath C^d$ (or, lamplighter groups) through their virtual endomorphisms. This leads to existence and nonexistence results of such representations on the p-adic tree. (Received February 08, 2015)

Session 4

1111-20-457 **Pedro V. Silva*** (pvsilva@fc.up.pt), Department of Mathematics, Rua do Campo Alegre, 687, 4169-007 Porto, Portugal. *Complexity advances in equations over semigroups.*

In 1977, Makanin proved that finite systems of equations over free monoids are decidable, but the complexity of the original algorithm turns out to be a tower of exponentials. In 1983, Makanin proved decidability for finite systems of equations over free groups, but in this case the algorithm is not even primitive recursive.

On the other hand, equations over free inverse monoids were shown to be undecidable in general by Rozenblat in 1985. But the important particular case of idempotent variable equations was solved in 2007 by Deis, Meakin and Sénizergues. However, the algorithm depended on Rabin's tree theorem and has therefore very high complexity.

Over the years, several improvements were achieved for free monoid and free group equations. Recently, advances were made on the complexity of algorithms for all the above problems.

In 2013, Jeż used data compression to lower complexity of (finite systems of) equations on free monoids to NTIME($n \log n$). In 2014, these techniques were adapted by Diekert, Jeż and Plandowski to cover equations over free groups with rational constraints, with PSPACE complexity. Also in 2014, Diekert, Martin, Sénizergues and the speaker improved the complexity of idempotent variable equations over free inverse monoids to EXPTIME. (Received February 08, 2015)

Session 4

1111-20-474 **Peter R. Jones*** (peter.jones@mu.edu). *Strict restriction semigroups and Tilson's 'Categories as Algebra'.*

The variety of restriction semigroups may be most simply described as that generated from inverse semigroups $(S, \cdot, ^{-1})$ by forgetting the inverse operation and retaining the two induced operations $x^+ = xx^{-1}$ and $x^* = x^{-1}x$. The subvariety $\mathbf{B}$ of *strict* restriction semigroups is that generated by the Brandt semigroups. At the top of its lattice of subvarieties are the two intervals $[\mathbf{B_2}, \mathbf{B_2M} = \mathbf{B}]$ and $[\mathbf{B_0}, \mathbf{B_0M}]$. Here $\mathbf{B_2}$ and $\mathbf{B_0}$ are respectively generated by the five-element Brandt semigroup and that obtained by removing one of its nonidempotents. The other two varieties are their joins with the variety of all monoids. It is shown here that the interval $[\mathbf{B_2}, \mathbf{B}]$ is isomorphic to the lattice of varieties of categories, as introduced by Tilson in the seminal paper of the title. Important concepts, such as the local and global varieties associated with monoids, are readily identified under this isomorphism. Two of Tilson's major theorems have natural interpretations and application to the interval $[\mathbf{B_2}, \mathbf{B}]$ and, with modification, to the interval $[\mathbf{B_0}, \mathbf{B_0M}]$ that lies below it. Further exploration may lead to applications in the reverse direction. (Received February 08, 2015)

Session 1

1111-20-478 **Attila Egri-Nagy** (a.egri-nagy@uws.edu.au), Centre for Research in Mathematics, University of Western Sydney, Parramatta Campus, Locked Bag 1797, Penrith, NSW 2751, Australia, and **Chrystopher L. Nehaniv*** (c.l.nehaniv@herts.ac.uk), School of Computer Science, University of Hertfordshire, College Lane, Hatfield, AL10 9AB, United Kingdom. *Holonomy Decomposition and Skeleton of Finite Transformation Semigroups: Improved Proofs for Computer Implementations.*

We present an understandable, efficient, and streamlined proof of the Holonomy Decomposition for finite transformation semigroups and automata. In Krohn-Rhodes theory, the holonomy method for cascade decomposition was originally developed by H. Paul Zeiger, and subsequently improved by S. Eilenberg, and later by several others. The holonomy decomposition approach has turned out to be the most amenable to feasible realization using computer algebra. We give a constructive proof revealing new insights, and also show new results on how the skeleton construction used in the course of the proof is related to the Green's J-classes ordering. These methods are illustrated with computational examples computed using our SgpDec package for the GAP computer algebra system. (Received February 09, 2015)

Session 1

1111-20-488 **Yago Antolin*** (yago.anpi@gmail.com), 1326 Stevenson Center, Vanderbilt University, Nashville, TN 37240. *Conjugacy languages of hyperbolic groups.*

In this talk I will present some recent results on the geometry of the conjugacy problem in hyperbolic and relatively hyperbolic groups. I will discuss some applications to the complexity of the conjugacy problem and conjugacy languages. The talk will be based on joint works with L. Ciobanu and A. Sale. (Received February 08, 2015)

Session 4

1111-20-489 **Gracinda M.S. Gomes*** (gmcunha@fc.ul.pt), Departamento de Matemática, Faculdade de Ciências, Universidade de Lisboa, 1749-016 Lisboa, Portugal. *Takahashi semigroups.*

This talk is based on joint work with Mário J. J. Branco and Pedro V. Silva.

Recently, Araújo, Silva and Sykiotis defined a *Takahashi group* as one in which every ascending chain of subgroups of bounded group rank is stationary. Takahashi, in 1950, proved that any free group has this property.

We generalise this concept to an algebra in an arbitrary variety. Takahashi's condition in the context of various varieties of semigroups is discussed. In particular, Takahashi completely simple [Clifford] semigroups are described.

We look at the class of semigroups **UE**, where the rank of the semigroup of all fixed points of any endomorphism is bounded. Putting together a number of results, we show that in a finitely generated completely simple [Clifford] semigroup whose $\mathcal{H}$-classes are Takahashi groups in **UE**, the semigroup of periodic points of any endomorphism is finitely generated and its periodic orbits are bounded. Similar results hold for monoids defined by finite balanced one-relator presentations of length 2.

This work was developed within the activities of CAUL, CMUP and CEMAT with the support of FCT. (Received February 08, 2015)

Session 1

1111-20-495 **Ariane Masuda*** (amasuda@citytech.cuny.edu), New York City College of Technology, CUNY, Department of Mathematics, 300 Jay St., Brooklyn, NY 11201, and **Luciane Quoos** and **Benjamin Steinberg**. *Character Theory of Monoids over an Arbitrary Field.*

The basic character theory of finite monoids over the complex numbers was developed in the sixties and seventies based on work of Munn, Ponizovsky, McAlister, Rhodes and Zalcstein. In particular, McAlister determined the space of functions spanned by the irreducible characters of a finite monoid over $\mathbb{C}$ and the ring of virtual characters. We present the corresponding results over an arbitrary field. (Received February 08, 2015)

Session 4

1111-20-499 **Benjamin Steinberg*** (bsteinberg@ccny.cuny.edu), Department of Mathematics, City College of New York, New York City, NY 10031. *The representation theory of the full transformation monoid.*

The representation theory of the symmetric group S_n (over $\mathbb{C}$) is one of the gems of modern mathematics. In this talk I survey what is known about the representation theory (over $\mathbb{C}$) of the full transformation monoid T_n (the monoid of all self-maps on an n-element set), including Putcha's construction of the irreducible representations, Ponizovskii, Putcha and Ringel's determination of the representation type and my recent computation of the global dimension. (Received February 08, 2015)

Session 40

1111-20-501 **Benjamin Steinberg*** (bsteinberg@ccny.cuny.edu), Department of Mathematics, City College of New York, New York City, NY 10031. *Algorithms for invertible transducers and automaton groups: a retrospective and problems.*

In this talk I survey some results on algorithmic problems associated to invertible transducers and automaton groups and discuss some open problems. (Received February 08, 2015)

Session 40

1111-20-503 **Volodymyr Nekrashevych** and **Zoran Sunic*** (sunic@math.tamu.edu). *Grigorchuk group as the iterated monodromy group of the Ulam - von Neumann map.*

We show that the limit dynamical system of a contracting group G is topologically conjugate to the Ulam - von Neumann map (the tent map) if and only if G is equivalent, as a self-similar group, to the group $G_{p(x)}$ for some nonconstant polynomial $p(x)$ with nonzero constant term over the two-element field. In this context the infinite dihedral group is G_{x+1} and the first Grigorchuk group is G_{x^2+x+1}. All groups obtained in this way, except the infinite dihedral group, have intermediate growth. If $p(x)$ is not divisible by $x+1$, then $G_{p(x)}$ is finitely generated, infinite 2-group. Higher degree maps on the unit interval and self-similar groups acting on trees of higher degree may be considered in analogous way. (Received February 09, 2015)

Session 40

1111-20-509 **Robert Gray** (robert.d.gray@uea.ac.uk), School of Mathematics, University of East Anglia, Norwich, NR4 7TJ, United Kingdom, and **Mark Kambites*** (mark.kambites@manchester.ac.uk), School of Mathematics, University of Manchester, Manchester, M13 9PL, United Kingdom. *Amenability of finitely generated semigroups.* Preliminary report.

I will discuss some recent research on amenability and Følner set conditions for finitely generated semigroups. (Received February 09, 2015)

Session 4

1111-20-512 **Ondřej Klíma*** (klima@math.muni.cz), Department of Mathematics and Statistics, Faculty of Science, Masaryk University, Kotlářská 2, 611 37 Brno, Czech Rep. *Overview of New Results on Piecewise Testable Languages.*

The class of piecewise testable languages is a prominent one in the algebraic theory of regular languages. During the last 40 years a lot of papers concerning these languages were published. Surprisingly, new results still arise, and in this talk we overview some of them. In particular, we mention our new results concerning complexity aspects of deciding k-piecewise testability of a regular language given by its minimal deterministic automaton or by its syntactic monoid. (Received February 09, 2015)

Contr.Session

1111-20-528 **Pedro V. Silva** (pvsilva@fc.up.pt), CMUP, Faculdade de Ciências, Rua Campo Alegre, 687, 4169-007 Porto, Portugal, and **Filipa Soares*** (falmeida@adm.isel.pt), Área Departamental de Matemática, Instituto Superior de Engenharia de Lisboa, Rua Conselheiro Emídio Navarro, 1, 1959-007 Lisboa, Portugal. *Howson's property for semidirect products of semilattices by groups.*

The famous Howson's Theorem (1954) states that the intersection of two finitely generated subgroups of a free group is a finitely generated subgroup. Jones and Trotter (1989) showed that is not the case for any free inverse semigroup with more than one generator. In our work, we considered this problem in the important class of inverse semigroups which are semidirect products of semilattices by groups and showned that, for a group G acting on a semilattice E by means of a locally finite action, the semidirect product $E * G$ satisfies the Howson property (with respect to inverse subsemigrups) if and only if so does G (with respect to subgroups) and that the equivalence fails for arbitrary actions. Some conclusions can also be drawn on the size of a minimal set of generators. (Received February 09, 2015)

Session 4

1111-20-534 **João Jorge Araújo*** (jaraujo@uab.pt), Av Gama Pinto, 2, 1649-003 Lisboa, Lisbon, Portugal. *Conjugation in Semigroups.*

There have been several attempts to extend the notion of conjugacy from groups to semigroups. One notion was originally introduced for free semigroups and popularized by Lallement's book. In a general semigroup, this one is reflexive and symmetric, but not transitive. Another notion of conjugacy was introduced by Otto for monoids presented by finite Thue systems. This relation is an equivalence relation in any semigroup, but it reduces to the universal relation if a semigroup has a zero; since there is a precise sense in which almost all finite semigroups have a zero, it follows that this notion is not useful for almost all finite semigroups.

Recentely a new notion of conjugation was introduced, which is an equivalence relation in any semigroup, coincides with Otto's if the semigroup has no zero, but does not reduce to the universal relation when a semigroup has a zero. In this talk we will briefly compare the behaviour of these different notions. (Received February 09, 2015)

Session 13

1111-20-552 **Alfred Geroldinger*** (alfred.geroldinger@uni-graz.at), University of Graz, Institute for Mathematics and Scientific Comp, Heinrichstrasse 36, 8010 Graz, Austria. *Sets of lengths in Krull monoids.*

Let H be a Krull monoid with finite class group G and suppose that each class contains a prime divisor (rings of integers in algebraic number fields share this property). For each element $a \in H$, its set of lengths $\mathsf{L}(a)$ consists of all $k \in \mathbb{N}_0$ such that a can be written as a product of irreducible elements. Sets of lengths of H are finite nonempty, and they depend just on the class group G. We consider the system $\mathcal{L}(G) = \{\mathsf{L}(a) \mid a \in H\}$ of all sets of lengths. It is classical that H is factorial if and only if $|G| = 1$, and that $|G| \leq 2$ if and only if $|L| = 1$ for each $L \in \mathcal{L}(G)$.

The present talk is devoted to the inverse problem whether or not the class group G is determined by the system of sets of lengths. Thus, let G' be a finite abelian group with $|G'| \geq 4$ and $\mathcal{L}(G) = \mathcal{L}(G')$. Does it follow that G and G' are isomorphic ? This question has been answered in the affirmative for cyclic groups, elementary 2-groups, and others. In the present talk we present the result that the answer to the above problem is positive for groups G having rank at most two. The proof is based on methods from Additive Combinatorics. This is joint work with Wolfgang A. Schmid. (Received February 09, 2015)

Session 4

1111-20-572 **Wolfram Bentz*** (wfbentz@fc.ul.pt). *Synchronizating automata, graphs, and transformation monoids.*

Synchronization is a property of automata and can be understood as a method of error recovery. Translated into semigroup theory, synchronization asks if a transition semigroup given by a set of generators contains a constant map. An important case is the situation where this generating set consists of a permutation group G together with a singular transformation t.

Recently, we have derived several new synchronization results for this particular situation, both negative and positive. They were obtained with the help of connection between transformation monoids and graphs of a particular type.

In this talk, we will give an overview of our new results. We close by raising various questions on synchronization motivated by our work.

This is a joint work with João Araújo (CEMAT, Universidade de Lisboa), Peter J. Cameron (Mathematical Institute, University of St Andrews), Gordon Royle (Centre for the Mathematics of Symmetry and Computation, University of Western Australia), and Artur Schaefer (Mathematical Institute, University of St Andrews). (Received February 09, 2015)

Contr.Session

1111-20-579 **T. M. Quinteiro*** (tmelo@adm.isel.pt), Área Departamental de Matemática, Instituto Superior de Engenharia de Lisboa, R. Conselheiro Emídio Navarro, 1, 1950-062 Lisboa, Lisboa, Portugal, and **V. H. Fernandes**. *On monoids of finite partial isometries.*

The study of semigroups of finite partial isometries was initiated by Al-Kharousi et al. in [1, 2]. The first of these two papers is dedicated to investigate some combinatorial properties of the monoid $\mathcal{DP}_n$ of all partial isometries on $\{1, \ldots, n\}$ and of its submonoid $\mathcal{ODP}_n$ of all order-preserving (considering the usual order of $\mathbb{N}$) partial isometries, in particular, their cardinalities. The second one presents the study of some of their algebraic properties, namely Green's structure and ranks.

In this talk we will exhibit presentations for the monoids $\mathcal{DP}_n$ and $\mathcal{ODP}_n$.

References

[1] F. Al-Kharousi, R. Kehinde and A. Umar, Combinatorial results for certain semigroups of partial isometries of a finite chain, Australas. J. Combin. 58(3) (2014), 365–375.

[2] F. Al-Kharousi, R. Kehinde and A. Umar, On the semigroup of partial isometries of a finite chain, Communications in Algebra. To appear.

(Received February 09, 2015)

Session 4

1111-20-586 **Igor Dolinka**, **Robert D. Gray*** (robert.d.gray@uea.ac.uk) and **Nik Ruškuc**. *On regularity and the word problem for free idempotent generated semigroups. Part I.*

The category of all idempotent generated semigroups S with a prescribed structure $\mathcal{E}$ of their idempotents $E = E(S)$ (called the biordered set) has an initial object called the *free idempotent generated semigroup over* $\mathcal{E}$, defined by a presentation over alphabet E, and denoted by $\mathsf{IG}(\mathcal{E})$. Recently, much effort has been put into investigating the structure of semigroups of the form $\mathsf{IG}(\mathcal{E})$, especially regarding their maximal subgroups.

In this two-part talk we focus on decision problems regarding semigroups of the form $\mathsf{IG}(\mathcal{E})$, more specifically, on their word problem. In the first part, I will give an account of our positive results. Specifically I will explain how an old lemma of Howie and Lallement can be used to show that the action of idempotents on $\mathcal{H}$-classes in an idempotent generated semigroup is encoded in the biorder. Then I will explain how this leads to results about the decidability of regularity, and of the word problem for regular elements, in $\mathsf{IG}(\mathcal{E})$. (Received February 09, 2015)

Session 1

1111-20-599 **Laura Ciobanu**, Mathematics Department, University of Neuchâtel, Rue Emile-Argand 11, CH-2000 Neuchâtel, Switzerland, **Susan Hermiller***, Department of Mathematics, University of Nebraska, Lincoln, NE 68588-0130, **Derek Holt**, Mathematics Institute, Zeeman Building, University of Warwick, Coventry, CV4 7AL, United Kingdom, and **Sarah Rees**, Department of Mathematics, University of Newcastle, Newcastle, NE1 7RU, United Kingdom. *Conjugacy languages in groups.*

Rationality of growth series derived from conjugacy classes of groups is implied by regularity of associated languages. In this talk I will discuss conjugacy regularity for languages of normal forms for conjugacy classes and for minimal length elements up to conjugacy, and languages of conjugacy geodesics, for a variety of examples. (Received February 09, 2015)

Session 4

1111-20-624 **Jon M Corson** and **Veny Liu*** (vliu@crimson.ua.edu), Tuscaloosa, AL 35487-0350. *Free Inverse Semigroupoids and Their Inverse Subsemigroups.*

Semigroupoids are generalizations of semigroups and of small categories. However, the quotient of a semigroupoid in general is not a semigroupoid and the homomorphisms of semigroupoids can also behave badly. We define such congruence and homomorphism to form the first isomorphism theorem for semigroupoid homomorphisms for this special type. Hence, we can investigate inverse semigroupoid which is a semigroupoid in which each element has a unique inverse. Using Stalling's folding and Munn tree, this will lead us to free inverse semigroupoids and their inverse subsemigroup. (Received February 09, 2015)

Session 40

1111-20-630 **Tullio Ceccherini-Silberstein*** (tceccher@mat.uniroma3.it), Dipartimento di Ingegneria, Universita' del Sannio, Corso Garibaldi 107, 82100 Benevento, Italy. *On soficity and surjunctivity for monoids.*

We introduce and investigate the notions of soficity and surjunctivity for monoids.

All finite monoids, all commutative monoids, all free monoids, all cancellative one-sided amenable monoids, all multiplicative monoids of matrices over a field, and all monoids obtained by adjoining an identity element to a semigroup without identity element are sofic. On the other hand, although the question of the existence of a non-sofic group remains open, the bicyclic monoid is not sofic.

A monoid M is called surjunctive if every injective cellular automaton with finite alphabet over M is surjective. All finite monoids, all finitely generated commutative monoids, all cancellative commutative monoids, all residually finite monoids, all finitely generated linear monoids, and all cancellative one-sided amenable monoids are surjunctive. On the other hand, the bicyclic monoid is non-surjunctive.

Finally, if M is a monoid and A a finite set with more than one element, then the residual finiteness of M is equivalent to that of the monoid $\mathrm{CA}(M; A)$ consisting of all cellular automata over M with alphabet A. (Received February 09, 2015)

Session 40

1111-20-633 **Volodymyr Nekrashevych*** (nekrash@math.tamu.edu). *Automata groups and automatic sequences.*

We will talk about connections between different notions of automaticity: automata groups, automatic sequences, matrices, maps between self-similar spaces, and symbolic dynamics. This is a joint work with R. Grigorchuk, Y. Leonov, and V. Sushchansky. (Received February 09, 2015)

Contr.Session

1111-20-641 **Fariba Karimi** (f.karimi2@herts.ac.uk), School of Computer Science, University of Hertfordshire, College Lane, Hatfield, AL10 9AB, United Kingdom, and **Chrystopher L. Nehaniv*** (c.l.nehaniv@herts.ac.uk), School of Computer Science, University of Hertfordshire, College Lane, Hatfield, AL10 9AB, United Kingdom. *Coproducts for Pointed Transformation Semigroups, Pointed Transformation Monoids, Pointed Permutation Groups and for Partial Transformation Semigroups.*

We show the existence and give the structure of coproducts in the categories of pointed transformation semigroups, pointed transformation monoids and pointed permutation groups. In addition the existence and very different structure of coproducts in the category of partial transformation semigroups is demonstrated. These coproducts have links with related constructions in automata theory and for labelled directed multigraphs, which are explored. (Received February 09, 2015)

Contr.Session

1111-20-669 **Worachead Sommanee*** (worachead_som@cmru.ac.th), 239 Huay Kaew Road, Muang District, Department of Mathematics, Faculty of Science, Chiang Mai University, Chiang Mai 50200, Thailand, and **Jintana Sanwong** (jintana.s@cmu.ac.th), 239 Huay Kaew Road, Muang District, Department of Mathematics, Faculty of Science, Chiang Mai University, Chiang Mai 50200, Thailand. *Rank and idempotent rank of order-preserving transformation semigroups with restricted range.*

The rank of a semigroup S is the smallest number of elements needed to generate S. If S is generated by its set of idempotents, then the idempotent rank of S defined as the smallest number of idempotents generating S.

Let X be a chain and $OT(X)$ the full order-preserving transformation semigroup on X. Let Y be a nonempty subset of X and let $OT(X,Y)$ be the subsemigroup of $OT(X)$ of all transformations with ranges contained in Y. In this paper, we calculate the rank and idempotent rank of the order-preserving transformation semigroup

$$OF(X,Y) = \{\alpha \in OT(X,Y) : X\alpha = Y\alpha\}$$

when Y is a finite subset of X. (Received February 09, 2015)

Contr.Session

1111-20-670 **Kritsada Sangkhanan*** (kritsada.s@cmu.ac.th), Department of Mathematics, Faculty of Science, Chiang Mai University, 239 Huay Kaew Road, Muang District, Chiang Mai, Chiang Mai 50200, Thailand. *The regular part of a semigroup of linear transformations with restricted range.*

Let V be a vector space and let $T(V)$ denote the semigroup (under composition) of all linear transformations from V into V. For a fixed subspace W of V, let $T(V,W)$ be the semigroup consisting of all linear transformations from V into W. It is known that

$$F(V,W) = \{\alpha \in T(V,W) : V\alpha \subseteq W\alpha\},$$

is the largest regular subsemigroup of $T(V,W)$ and determines Green's relations on $T(V,W)$. In this paper, we show that $F(V,W) \cong T(U)$ for some vector space U if and only if $V = W$ and there is a semilinear transformation from W onto U; or $|W| = 1 = |U|$. Moreover, we describe the maximal regular subsemigroups when W is a finite dimensional subspace of V over a finite field. (Received February 10, 2015)

Session 4

1111-20-671 **Mikhail V. Volkov*** (mikhail.volkov@usu.ru), Institute of Mathematics and Computer Science, Ural Federal University, Lenina 51, Ekaterinburg, 620000, Russia. *The finite basis problem for matrix semigroups.* Preliminary report.

The finite basis problem for an algebraic structure A asks whether or not the identities holding in A admit a finite basis. We briefly survey recent results and open questions on the finite basis problem for algebraic structures, both finite and infinite, that are formed of matrices over a (semi)ring under the usual matrix multiplication and, possibly, some additional unary operations. As a sample of our results, we mention the absence of a finite identity basis for the set of all upper triangular real 3×3-matrices with 0s and/or 1s on the main diagonal considered either as a plain semigroup or as an involution semigroup under the reflection with respect to the secondary diagonal. (Received February 10, 2015)

Contr.Session

1111-20-675 **E. Cosme-Llópez*** (enric.cosme@uv.es), Departament d'Àlgebra, Universitat de València, Dr. Moliner, 50, 46100 Burjassot, Spain. *Faithful and Transitive Monoid Actions.*

Let M be a monoid and Ω a non-empty set. An action of M on Ω is a monoid homomorphism $\phi : M \to T_\Omega$, from M to the monoid T_Ω of all total transformations of Ω. We say that the action ϕ is *transitive* if for any $a, b \in \Omega$, there exists $m \in M$ such that $\phi(m)(a) = b$, and is *faithful* when ϕ is injective.

According to Cayley's theorem every finite monoid M admits a faithful action on a finite set, and if M is a group this action is also transitive. Futhermore, every faithful and transitive action of a finite group on a finite set is equivalent to the action on the cosets of a core-free subgroup. Although monoid actions are essentially different, the transitive and faithful case can be satisfactorily reduced to a situation closely related to the group case. Our main result confirms this and gives a complete description of all faithful and transitive actions of a finite monoid on finite sets.

This is joint work with A. Ballester-Bolinches, Universitat de València, and P. Jiménez-Seral, Universidad de Zaragoza. (Received February 10, 2015)

Contr.Session

1111-20-694 **Vicente Pérez-Calabuig*** (vicente.perez-calabuig@uv.es), C/ Dr Moliner, 50, 46100 Burjassot, València, Spain. *On the $\mathfrak{F}$-kernel of a finite semigroup.*

The problem of computing kernels of finite semigroups goes back to the early seventies and became popular among semigroup theorists through the Rhodes Type II conjecture which proposed an algorithm to compute the kernel of a finite monoid with respect to the class of all finite groups. Proofs of this conjecture were given in independent and deep works by Ash and Ribes and Zalesskiĭ, and the results of these authors that led to its proof have been extended in several directions.

Our interest in this subject was motivated by the description of the intersection of the kernel of a finite semigroup S with a regular $\mathcal{J}$-class given by Rhodes and Tilson in 1972, which is underneath Rhodes Type II conjecture. Our principal aim here is to present a reduction theorem concerning the description of the intersection of the kernel of a finite semigroup with respect to a variety of finite groups with a regular $\mathcal{J}$-class. Many earlier related results appear as a consequences of our study.

This is joint work with the professor Adolfo Ballester-Bolinches, Universitat de València. (Received February 10, 2015)

Session 41

1111-20-702 **Stephen Donkin*** (sd510@york.ac.uk), Department of Mathematics, University of York, York, Yorkshire YO10 5DD, United Kingdom. *Composition factors of symmetric powers.*

This is joint work with H. Geranios. It concerns a problem in the polynomial representation theory of general linear groups. Let G be a general linear group over an infinite field of positive characteristic. I will report on the problem of determining the composition factors of a tensor product of symmetric powers of the natural G-module. The problem in the case of a single symmetric power is solved by a theorem of Krop and Sullivan. We approach the problem of a general m-fold tensor product by considering tensor product of copies of the "reduced" symmetric algebra (which also appears in the work of Doty). For this algebra we give a complete solution, i.e., a description of the highest weights of the irreducible modules that occur as composition factors. We then describe the relationship with this problem and the corresponding problem for the symmetric powers. We do not have a complete solution in the general case but have enough information to settle the problem for a tensor product of two symmetric powers (the case m=2). The result is a Krop-Sullivan type of tensor theorem giving a composition factor as a tensor product of Frobenius twists of certain modules. (Received February 10, 2015)

Session 13

1111-20-710 **J. I. García-García*** (ignacio.garcia@uca.es), Dpto. Matemáticas, Facultad de Ciencias, Campus Universitario Río San Pedro s/n, 11510 Puerto Real, Cádiz, Spain, and **A. Vigneron-Tenorio** (alberto.vigneron@uca.es), Dpto. Matemáticas, Facultad de Ciencias Sociales, y de la Comunicació, 11405 Jerez de la Fra., Cádiz, Spain. *Affine convex body semigroups of $\mathbb{N}^3$*. Preliminary report.

Let F be a subset of $\mathbb{R}^k$ with non-empty interior, $\mathcal{F} = \cup_{i=0}^{\infty} F_i \cap \mathbb{N}^k$, where $F_i = \{iX \mid X \in F\}$ with $i \in \mathbb{N}$. A convex body of $\mathbb{R}^n$ is a compact convex subset of $\mathbb{R}^n$ with non-empty interior. If F is a convex body, then the set $\mathcal{F}$ is a semigroup of $\mathbb{N}^k$, the convex body semigroup generated by F. This kind of semigroups generalize to arbitrary dimension the concept of proportionally modular numerical semigroup.

In general, these semigroups are not finitely generated. If $\mathcal{F}$ is a finitely generated semigroup we say that $\mathcal{F}$ is an affine convex body semigroup. In previous works, convex body semigroups generated by polygons of $\mathbb{N}^2$ have been studied. We have characterizations to check if a convex body semigroup is finitely generated. It must be noted that these semigroups provides us with instances of families of Cohen-Macaulay semigroups and examples of Gorenstein semigroups.

In our work we study convex body semigroups when F is a convex polyhedron of $\mathbb{R}^3$, characterizing affine convex body semigroups of $\mathbb{N}^3$ and giving some results concerning the Cohen-Macaulay property. (Received February 10, 2015)

Contr.Session

1111-20-720 **Camille Laurent-Gengoux*** (`camille.laurent-gengoux@univ-lorraine.fr`), 16 rue des Huiliers, 57000 Metz, France. *About resolutions of Poisson singularities.*

I shall expose some new technics involving higher structures that allow to lift singularities of Poisson structures and singularities of the underlying variety on which it is defined altogether (Received February 10, 2015)

Session 4

1111-20-730 **Jorge Almeida** (`jalmeida@fc.up.pt`), Centro de Matematica, Departamento de, Matematica, Faculdade de Ciencias, Universidade do Porto Rua do Campo Alegre,687, 4169-007 Porto, Porto, Portugal, **M. Hossein Shahzamanian C.*** (`m.h.shahzamanian@fc.up.pt`), Centro de Matematica, Departamento de, Matematica, Faculdade de Ciencias, Universidade do Porto Rua do Campo Alegre,687, 4169-007 Porto, Porto, Portugal, and **Benjamin Steinberg** (`bsteinberg@ccny.cuny.edu`), Department of Mathematics, City College of New York, NAC 8/133, Convent Ave at 138th Street, New York, NY NY 10031. *The pro-nilpotent group topology on a free group.* Preliminary report.

In this paper, we work on the pro-nilpotent group topology of a free group. First we investigate the closure of the product of finitely many subgroups of a free group in the pro-nilpotent group. Then we present an algorithm for the calculation of the closure in the pro-nilpotent group topology of rational subsets of a free group. (Received February 10, 2015)

Session 40

1111-20-747 **Collin P Bleak*** (`collin@mcs.st-andrews.ac.uk`), Mathematical Institute, North Haugh, St Andrews, KY16 9SS, United Kingdom, and **James Belk**. *On the semi-decidability of the periodicity problem for elements of various groups.*

We prove that both the Higman-Thompson group $2V$ and the rational group $\mathcal{R}_n$ of Grigorchuk, Nekrashevych, and Suschanskiĭ have semi-decidable periodicity problems. That is, there are algorithms which can confirm, given an element of one of these groups, that the element has finite order. However, there is no algorithm which can always confirm in finite time whether a general element of one of these groups has infinite order. Joint with Jim Belk. (Received February 10, 2015)

Session 40 1111-20-773 **Tara Brough*** (tara@mcs.st-and.ac.uk) and **Alan J Cain**. *Automaton semigroup constructions.*

We investigate whether the class of automaton semigroups is closed under certain semigroup constructions. We prove that the free product of two automaton semigroups that contain left identities is again an automaton semigroup. We also show that the class of automaton semigroups is closed under the combined operation of 'free product followed by adjoining an identity'. We present an example of a free product of finite semigroups that we conjecture is not an automaton semigroup. Turning to wreath products, we consider two slight generalizations of the concept of an automaton semigroup, and show that a wreath product of an automaton monoid and a finite monoid arises as a generalized automaton semigroup in both senses. We also suggest a potential counterexample that would show that a wreath product of an automaton monoid and a finite monoid is not necessarily an automaton monoid in the usual sense. (Received February 10, 2015)

Session 40 1111-20-786 **Rostyslav Kravchenko*** (rkchenko@gmail.com), 2515 Speedway, Austin, TX 78712. *Self-similar actions of Lamplighter groups.*

Let $L_p = \mathbb{Z}/p\mathbb{Z} \wr \mathbb{Z}$. We study self-similar actions of L_p on trees. For particular actions, we determine the stabilizers of all points on the boundary of a tree. We show that the profinite completion $\hat{L}_p$ of L_p is a self-similar group generated by finite automaton. We also describe the structure of portraits of elements of L_p and $\hat{L}_p$. This is a joint work with R. Grigorchuk. (Received February 10, 2015)

Session 4 1111-20-811 **Jorge Almeida*** (jalmeida@fc.up.pt), CMUP, Departamento de Matemática, Faculdade de Ciências, Univ. do Porto, Rua do Campo Alegre 687, 4169-007 Porto, Portugal, and **M. Hossein Shahzamanian C.**, CMUP, Departamento de Matemática, Faculdade de Ciências, Univ. do Porto, Rua do Campo Alegre 687, 4169-007 Porto, Portugal. *The finite basis and finite rank properties for pseudovarieties of semigroups.* Preliminary report.

The finite basis property is often connected with the finite rank property. For varieties and finitely generated pseudovarieties, the two properties are in fact equivalent. In this talk, we address their relationship in the context of pseudovarieties of semigroups. We also show that the classes defined by several of the variants of nilpotent semigroups in the sense of Mal'cev that have been considered in the literature are finitely based pseudovarieties. (Received February 10, 2015)

22 ► Topological groups, Lie groups

Session 8

1111-22-140 **Anna Beliakova***, University of Zurich, Institute of Mathematics, Winterthurerstrasse 190, 8057 Zurich, Switzerland, and **Zaur Guliyev**, **Kazuo Habiro**, **Aaron Lauda** and **Ben Webster**. *Trace of the categorified quantum groups.*

Abstract: In this talk I will give a gentle introduction to the categorified quantum groups and show that the trace (or 0th Hochschild homology) of the Khovanov-Lauda 2-category is isomorphic to the current algebra. Then I'll discuss some applications of this fact to link homology theories. (Received January 28, 2015)

Session 16

1111-22-265 **Sílvia Anjos*** (sanjos@math.ist.utl.pt), Instituto Superior Técnico, Departamento de Matemática, Av. Rovisco Pais, 1, 1049-001 Lisboa, Portugal. *Seidel's morphism of toric 4–manifolds.*

We explain how to calculate, in some particular cases, the Seidel representation of $\pi_1(\mathrm{Ham}(M,\omega))$ in the units of the quantum homology ring, where $\mathrm{Ham}(M,\omega)$ denotes the group of Hamiltonian symplectomorphisms of a closed symplectic manifold (M,ω). This is very difficult to calculate in general. However, following the work of D. McDuff and S. Tolman, we make some progress by computing explicit expressions of the Seidel elements in the case of 4-dimensional NEF toric manifolds. From these expressions we can obtain the quantum homology ring of these manifolds. We also give explicit formulas for the Seidel elements in some non-NEF cases. These results are closely related to recent work by Fukaya, Oh, Ohta, and Ono, González and Iritani, and Chan, Lau, Leung, and Tseng. The main difference is that in the 4–dimensional case the methods we use are more elementary: they do not rely on open Gromov–Witten invariants nor mirror maps. We only use the definition of Seidel's elements and specific closed Gromov–Witten invariants which we compute via localization. This makes the resulting formulas directly readable from the moment polytope. This is joint work with Rémi Leclercq. (Received February 04, 2015)

Session 11

1111-22-655 **Thomas H Lenagan** (t.lenagan@ed.ac.uk), Maxwell Institute for Mathematical Sciences, School of Mathematics, University of Edinburgh, Edinburgh, Scotland EH9 3JZ, United Kingdom, and **Milen T Yakimov*** (yakimov@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803. *Prime factors of quantum Schubert cell algebras and clusters for quantum Richardson varieties.*

To every symmetrizable Kac-Moody algebra and Weyl group element w, one associates a quantum Schubert cell algebra which is a deformation of the universal enveloping algebra of $\mathfrak{n}_+ \cap w(\mathfrak{n}_-)$. We will describe explicit formulas for the Cauchon generators for all prime factors of the quantum Schubert cell algebras (by torus invariant prime ideals) in terms of sequences of normal elements for chains of subalgebras. The quantized coordinate rings of all open Richardson varieties can be realized as normal localizations of such prime factors. Based on the first result, we will construct large families of toric frames for quantum Richardson varieties associated to arbitrary symmetrizable Kac-Moody algebras. (Received February 09, 2015)

Session 28

1111-22-726 **Christoph Wockel*** (christoph@wockel.eu), christoph@wockel.eu. *Bisections of Lie groupoids as a link between infinite-dimensional and higher geometry.* Preliminary report.

Lie groupoids and infinite-dimensional Lie groups are both generalisations of finite-dimensional Lie groups. However, these two subjects have in the past been studied mostly independently. The aim of this talk is to present the Lie group of bisections of a Lie groupoid as a tool to link these two subjects closer together. Motivations for this are to understand better the relation of string structures to lifts of spin structures to string group models and to get access to low-dimensional homotopy groups of diffeomorphism groups.

One crucial observation is that one can view each Lie groupoid as a quotient of an action groupoid for the natural action of the bisections on the objects. The question that we will address is to what extend the bisections "know" about the geometry and the topology of the Lie groupoid (in the sense that certain cohomology classes descend from the bisections to their Lie groupoids or that certain elements of homotopy groups lift from their Lie groupoids to the bisections). (Received February 10, 2015)

26 ► Real functions

Session 21

1111-26-29 **M. Cristina Caputo**, Department of Mathematics, The University of Texas at Austin, Austin, TX 12-1202, and **Delfim F. M. Torres*** (delfim@ua.pt), CIDMA, Department of Mathematics, University of Aveiro, 3810-193 Aveiro, Portugal. *Duality of left and right fractional operators.*

We prove duality between the left and right fractional derivatives, independently on the type of fractional operator. Main result asserts that the right derivative of a function is the dual of the left derivative of the dual function or, equivalently, the left derivative of a function is the dual of the right derivative of the dual function. Such duality between left and right fractional operators is useful to obtain results for the left operators from analogous results on the right operators and vice versa. We illustrate the usefulness of our duality theory by proving a fractional integration by parts formula for the right Caputo derivative and by proving a Tonelli-type theorem that ensures the existence of minimizer for fractional variational problems with right fractional operators.

Reference

M. Cristina Caputo and Delfim F. M. Torres, Duality for the left and right fractional derivatives, Signal Process. 107 (2015), 265–271. (Received January 06, 2015)

Session 23

1111-26-171 **Stefan Steinerberger*** (stefan.steinerberger@yale.edu), Department of Mathematics, Yale University, New Haven, CT 06520-8283. *A Rigidity Phenomenon for the Hardy-Littlewood Maximal Function.*

We present a curious connection between the Hardy-Littlewood maximal function on the real line and the trigonometric function: if the computation of the maximal function is so simple that it suffices to check two intervals, then the function is f(x) = a+bsin(cx + d) for some real numbers a,b,c,d. This characterization seems to be unrelated to the classical properties of sin(x) and our proof requires a nontrivial fact from number theory: tan(x) maps nonzero algebraic numbers to transcendental numbers. (Received January 31, 2015)

Session 23

1111-26-230 **Alexander Volberg*** (volberg@math.msu.edu), Dept. Mathematics, Michigan State University, 619 Red Cedar Road, East Lansing, MI 48824. *Integrating non-linear PDE to prove some sharp weak type estimates in harmonic analysis.* Preliminary report.

We will show how certain weak and strong sharp estimates in harmonic analysis give rise to a special type of non-linear PDE. By some mystic reason they can be integrated (they are not of pure Monge–Ampère type). This automatically ives the estimate we are searching after. (Received February 03, 2015)

28 ► Measure and integration

Contr.Session

1111-28-520 **Jayrold Provendido Arcede*** (jparcede@carsu.edu.ph), Mathematics Department, College of Arts and Sciences, Caraga State University, 8600 Butuan City, ADN, Philippines. *On the SDE differential form for backwards Itô integral.*

Consider the following differential form

$$df(B_t) = f'(B_t)dB_t + \frac{1}{2}f''(B_t)dt, \tag{1}$$

along with its integral form:

$$f(B_T) - f(B_0) = \int_\xi^T f'(B_u)dB_u + \frac{1}{2}\int_\xi^T f''(B_u)du. \tag{2}$$

In the classical stochastic integration there is no solid definition for the terms $df(B_t)$, dB_t, and dt. Although, these terms has an intuitive meaning, still they remain a notation.

Using Henstock approach, we introduce differentiation as a reverse process of integration in the stochastic backwards Itô setting. Here, we obtained our version of Itô Formula. Along with our notion of Itô differential, we will give examples on the reversibility process as an application. (Received February 11, 2015)

30 ► Functions of a complex variable

Session 49

1111-30-76 **Gerardo R Chacon*** (grchacon@gmail.com), 800 Florida Avenue NE, Dpt. Science, Technology and Mathematics, HMB S340G, Washington, DC 20002, and **Humberto Rafeiro**. *Carleson Measures and variable exponent Bergman spaces.*

Let $\mathbb{D}$ denote the open unit disk in the complex plane and dA the normalized Lebesgue measure on $\mathbb{D}$. For a given $1 \leqslant p < \infty$ define the *Bergman space* $A^p(\mathbb{D})$ as the space of all analytic functions on $\mathbb{D}$ that satisfy:

$$\|f\|_{A^p}^p := \int_{\mathbb{D}} |f(z)|^p dA(z) < \infty.$$

The theory of Bergman spaces were introduced by S. Bergman and since the 1990s it has gained a lot of attention mainly due to some major breakthroughs at the time.

In this talk we will define variable exponent Bergman spaces and show some fundamental properties. We introduce to notion of Carleson measures on this spaces and study a characterization. We consider this to be an interesting topic since the classical approach to Bergman spaces seems to fail in the variable framework. To circumvent this problem, we rely on techniques from real harmonic analysis, variable exponent spaces and complex function theory. (Received January 19, 2015)

Session 15

1111-30-111 **Carl M. Bender*** (cmb@wustl.edu), Physics Department, Washington University, St. Louis, MO 63130. *Nonlinear eigenvalue problems and PT symmetry.*

We discuss new kinds of nonlinear eigenvalue problems, which are associated with instabilities, separatrix behavior, and hyperasymptotics. First, we consider the toy differential equation $y'(x) = \cos[\pi x y(x)]$, which arises in several physical contexts. We show that the initial condition $y(0)$ falls into discrete classes: $a_{n-1} < y(0) < a_n$ $(n = 1, 2, 3, ...)$. If $y(0)$ is in the nth class, $y(x)$ exhibits n oscillations. The boundaries a_n of these classes are analogous to quantum-mechanical eigenvalues and finding the large-n behavior of a_n is analogous to a semiclassical (WKB) approximation in quantum mechanics. For large n, $a_n \sim A\sqrt{n}$, where $A = 2^{5/6}$. The constant A is numerically close to the lower bound on the power-series constant P, which is fundamental in the theory of complex variables and which is associated with the asymptotic behavior of zeros of partial sums of Taylor series.

The Painlevé transcendents P_1 and P_2 have a remarkable eigenvalue behavior. As $n \to \infty$, the nth eigenvalue for P_1 grows like $Bn^{3/5}$ and the nth eigenvalue for P_2 grows like $Cn^{2/3}$. We calculate B and C analytically by reducing the Painlevé transcendents to linear eigenvalue problems in PT-symmetric quantum mechanics. (Received January 24, 2015)

Session 9

1111-30-132 **L. Cnudde*** (lander.cnudde@ugent.be) and **H. De Bie** (hendrik.debie@ugent.be). *Slice Fourier transform: definition, properties and corresponding convolutions.* Preliminary report.

In this talk, a Fourier transform is constructed in the context of slice monogenic functions. Based on an appropriate extension of the Dirac operator and a corresponding inner product, an orthogonal set of Clifford-Hermite functions is defined and imposed as the basis of eigenfunctions of the integral transform. Inspired by the differential properties of these Clifford-Hermite functions, suitable eigenvalues are chosen in order to fix the slice Fourier transform completely. Using the Mehler formula, the kernel function of the integral transform could be written in a closed form which corresponds to this set of eigenfunctions and their respective eigenvalues. This closed form allows for a closer study of the properties of the slice Fourier transform and the definition of three slice convolutions. By introducing the concept of generalized translation operators, one of these could be defined such that it mirrors the convolution property of the classical Fourier transform. Given the clear structure of the method leading to the slice Fourier transform, it is explored as an algorithm to define generalized Fourier transforms in some other algebraic settings too. (Received February 09, 2015)

Contr.Session

1111-30-133 **Kenier Castillo***, Centre for Mathematics, University of Coimbra, 3001-501 Coimbra, Coimbra, Portugal. *On polynomials with all their zeros on the unit circle.*

We prove that for any two monic polynomials whose zeros are simple and strictly interlacing on the unit circle, there exists a sequence of para-orthogonal polynomials such that these polynomials belong to it. (Received January 27, 2015)

Session 9

1111-30-139 **Fabrizio Colombo**, **Irene Sabadini** and **Franciscus Sommen*** (fs@cage.ugent.be), Department of Mathematical Analysis, Ghent University, Galglaan 2, 9000 Ghent, Belgium. *On the Szegő-Radon projection of monogenic functions.*

In this talk, we define a version of the Radon transform for monogenic functions which is based on Szegő kernels. The corresponding Szegő-Radon projection is abstractly defined as the orthogonal projection of a Hilbert module of left monogenic functions onto a suitable closed submodule of functions depending only on two variables. We conclude by establishing the inversion formula based on the dual transform. (Received January 28, 2015)

Session 47

1111-30-159 **Alexander I. Aptekarev*** (aptekaa@keldysh.ru), Miusskaya Pl. 4, Keldysh Institute of Applied Mathematics, Moscow, 125047, Russia. *Multiple orthogonal polynomials and Schrodinger operators on the d-lattice.*

Let $\mu(x) := (\mu_1(x), \ldots, \mu_d(x))$ be a vector of positive measures. For a given multiindex $n = (n_1, \ldots, n_d)$ we consider a polynomial $P_n(x)$ of degree $|n| := n_1 + \cdots + n_p$, which satisfies n_j orthogonality relations to the degrees of the scalar variable x with respect to the measure μ_j, $j = 1, \ldots, p$. Such polynomials always exist and they are called multiple orthogonal polynomials. For $p = 1$ we have usual orthogonal polynomials, which satisfy to the three term recurrence relations. For $p > 1$ the multiple orthogonal polynomials possess a $d+1$ recurrence relations, which relate polynomials with neighboring multiindices. We shall discuss a multiple orthogonal polynomials approach to the spectral theory of $d > 1$ discrete Schrodinger operator and corresponding discrete integrable systems.

It is a joint work with Walter Van Assche and Maxim Derevyagin. (Received January 30, 2015)

Session 14

1111-30-276 **Nataliya Goncharuk*** (natasha@urkud.name), 7 Vavilova Str., Moscow, 117312, Russia, and **Yury Kudryashov** (urkud@urkud.name), 7 Vavilova Str., Moscow, 117312, Russia. *Genera of non-algebraic leaves of polynomial foliations of $\mathbb{C}P^2$.*

We consider the space $\mathcal{A}_n$ of polynomial foliations of $\mathbb{C}P^2$ given by

$$\begin{cases} \dot{x} = p(x, y) \\ \dot{y} = q(x, y) \end{cases}$$

in a fixed affine chart, $\deg p = \deg q = n$. It is well-known that each leaf of a generic foliation from $\mathcal{A}_n$ is dense in $\mathbb{C}P^2$.

We prove that in a dense subset of $\mathcal{A}_n$ any foliation has a (non-algebraic) leaf with at least $\frac{(n+1)(n+2)}{2} - 4$ handles. This result is motivated by an earlier result of D.Volk: in a dense subset of $\mathcal{A}_n$, any foliation has a separatrix connection.

We also prove that all non-algebraic leaves of any foliation given by

$$\begin{cases} \dot{x} = p(x^2, y) \\ \dot{y} = xq(x^2, y) \end{cases}$$

have infinite genus. (Received February 07, 2015)

Session 47

1111-30-297 **Laurent Baratchart*** (laurent.baratchart@inria.fr), 2004, route des lucioles, Sophia-Antipolis, 06902 Valbonne, France, and **Nikos Stylianopoulos** (nikos@ucy.ac.cy), University of Cyprus,P.O. Box 20537, CY 1678 Nicosia, Cyprus. *Exterior asymptotics for weighted Bergman polynomials on the disk.*

For $\mathbb{D}$ the unit disk and $w \in L^1(\mathbb{D})$ a non-negative weight, we consider the orthonormal polynomials P_n:

$$\int_{\mathbb{D}} P_n \overline{P}_k w dm = \delta_{n,k},$$

where m is Lebesgue measure and the leading coefficient κ_n of P_n is positive. Put $w_r(\xi) := w(r\xi)$ for $\xi \in \mathbb{T}$ with $\mathbb{T}$ the unit circle. We show that if w_r converges to a function h in $L^p(\mathbb{T})$ for some $p > 1$, and if $\log^- w_r$ is bounded in the real Hardy space $H^1(\mathbb{T})$, then

$$\lim_{n\to\infty} \frac{\kappa_n}{\sqrt{n+1}} = (\pi \mathcal{G}_h)^{-1/2}$$

where $\mathcal{G}_h$ is the geometric mean of h, and moreover

$$P_n(z) = \left(\frac{n+1}{\pi}\right)^{1/2} z^n S_h(z)\{1 + o(1)\}$$

locally uniformly in the complement of $\overline{\mathbb{D}}$, where S_h is the Szegő function of h. We will discuss generalizations to analytic domains, and also cases where the assumptions are not satisfied and there is no limit for $\kappa_n/\sqrt{n+1}$. Previous asymptotics by P. Suetin and P. Korovkin required w to be Hölder-smooth and strictly positive in $|z| > 1 - \varepsilon$. (Received February 05, 2015)

Session 9

1111-30-359 **Matvei Libine*** (mlibine@indiana.edu). *Anti De Sitter Deformation of Quaternionic Analysis.*

I will describe a one-parameter deformation of quaternionic analysis. This deformation of quaternions preserves conformal invariance and has a geometric realization as anti de Sitter space sitting inside the five-dimensional

Euclidean space. Many results of classical quaternionic analysis - including the Cauchy-Fueter formula - extend to this new setting. This is a joint work with Igor Frenkel from Yale University. (Received February 06, 2015)

Session 30

1111-30-396 **Monica Moreno Rocha*** (`mmoreno@cimat.mx`), CIMAT, Callejon Jalisco s/n, 36240 Guanajuato, GTO, Mexico, and **Pablo Perez Lucas**. *Connectivity of Julia sets for elliptic functions.*

It has been conjectured that the Julia set of the Weierstrass P elliptic function is always connected over any given lattice. Although some results have been obtained by Hawkins and Koss over certain type of lattices, this question remains open. In fact, very little is known about connectivity of Julia sets for other elliptic maps. In this talk, I will present a dynamical study of the elliptic function 1/P over real square lattices and discuss two results. Namely, there are no cycles of Herman rings while the Julia set may be either connected or totally disconnected. (Received February 06, 2015)

Session 9

1111-30-444 **Swanhild Bernstein***, TU Bergakademie Freiberg, Department of Mathematics and Informatics, Prüferstr. 9, D-09599 Freiberg, Germany. *Fractional Hilbert transforms and fractional monogenic signals.* Preliminary report.

The fractional Fourier transform and Hilbert transform play an important role in applications in optics and signal processing. A higher dimensional analog can be given in Clifford analysis by an Hilbert operator based on the Riesz transforms. We will define sveral fractional Hilbert transforms in Clifford analysis, prove that this transforms have the semigroup properties and a fractional monogenic signal can be built up. (Received February 08, 2015)

Session 9

1111-30-691 **Sorin G. Gal** and **Irene Sabadini*** (`irene.sabadini@polimi.it`), Dipartimento di Matematica, Politecnico di Milano, 20133 Milano, Italy. *On some approximation properties for slice regular functions of a quaternionic variable.*

In this talk we discuss some approximation properties of slice hyperholomorphic functions of one quaternionic variable. As it is well known, this class of functions contains converging power series of the variable. We show that an almost universal property holds (a weaker version of the universality property of a power series). We also discuss the validity of Mergelyan-type results, by showing uniform approximation results of slice hyperholomorphic functions by polynomials, in the case of starlike sets and axially symmetric sets. Finally we discuss expansions in Faber series of functions continuous on a compact K and slice regular in the interior of K. (Received February 10, 2015)

Session 30

1111-30-698 **Phil Rippon*** (`phil.rippon@open.ac.uk`), Department of Mathematics and Statistics, The Open University, Milton Keynes, MK7 6AA, United Kingdom, and **Gwyneth Stallard**. *Escaping boundary points of Baker domains.*

A Baker domain of a transcendental entire function is a periodic component of the Fatou set within which all points are escaping to infinity under iteration of the function. It is an open question whether the boundary of a Baker domain must contain at least one escaping point.

We prove that for any univalent Baker domain the set of escaping boundary points forms a set of full harmonic measure with respect to the domain, and we deduce that for any transcendental entire function the escaping set is either connected or has infinitely many unbounded components. We also describe various ways to construct examples of univalent Baker domains. (Received February 10, 2015)

Session 30

1111-30-700 **Gwyneth Stallard*** (gwyneth.stallard@open.ac.uk), Department of Mathematics and Statistics, The Open University, Milton Keynes, MK7 6AA, United Kingdom, and **Phil Rippon** and **Anna Miriam Benini**. *Commuting functions and multiply connected wandering domains.*

Let f and g be meromorphic functions such that f and g commute. It has been known since Fatou and Julia that, if f and g are both rational, then their Julia sets must be equal. For transcendental entire functions, however, this is still an open question. Previously, the strongest result was obtained by Bergweiler and Hinkkanen who showed that this is true, provided that neither f nor g has any fast escaping wandering domains. We strengthen this to show that the Julia sets are equal, provided that neither f nor g has any fast escaping simply connected wandering domains. Our proof uses recent results on the properties of multiply connected wandering domains. (Received February 10, 2015)

Session 9

1111-30-794 **Dixan Peña Peña*** (dixanpena@gmail.com), Dipartimento di Matematica, Politecnico di Milano, Via E. Bonardi 9, Milano, Italy, and **Frank Sommen** (fs@cage.ugent.be). *Biaxial monogenic functions from Funk-Hecke's formula combined with Fueter's theorem.*

Fueter's theorem is a fundamental result in Clifford analysis. It transforms holomorphic functions in the plane into axial monogenics. The aim of our talk is to present a method for constructing biaxial monogenics from holomorphic functions, which uses Fueter's theorem and Funk-Hecke's formula. (Received February 10, 2015)

31 ► Potential theory

32 ► Several complex variables and analytic spaces

Session 9

1111-32-392 **Chao Ding*** (dchao@uark.edu) and **John Ryan** (jryan@uark.edu). *Alternative proofs of some properties of the Rarita-Schwinger operator and the fundamental solution of the higher spin Laplace operator.*

In this talk we first show a counter-example, which illustrates that the Dirac operator D_x is not conformally invariant in the Rarita-Schwinger setting. Then, proofs of the conformal invariance and the interwining operator of the Rarita-Schwinger operator are provided. This corrects arguments given in a paper of Dunkl, Li, Ryan and Van Lancker. This also implies that the Laplace operator Δ_x is not conformally invariant in the Rarita-Schwinger setting either. So, what is the second order conformally invariant operator in the Rarita-Schwinger setting? The answer can be found in a recent paper of De Bie, Eelbode and Roel. In that paper, they showed the higher spin Laplace operator $\mathcal{D}_k$ is conformally invariant and its fundamental solution was also found. In this talk we will present an alternative construction of the fundamental solution. There are many interesting open problems in this area. I will conclude by discussing some of them. (Received February 06, 2015)

33 ► Special functions

Contr.Session

1111-33-151 **Amílcar Branquinho*** (ajplb@mat.uc.pt), Departamento de Matemática, Universidade de Coimbra, Apartado 3008, EC Santa Cruz, 3001-501 Coimbra, Portugal. *Deformed semi-classical discrete orthogonal polynomials.*

In this talk a study families of discrete orthogonal polynomials on the real line whose Stieltjes functions satisfy a linear type difference equation with polynomial coefficients is presented.

The discrete dynamical systems, obtained as a result of deformations of the recurrence relation coefficients of the orthogonal polynomials related to the above referred Stieltjes functions is derived. (Received January 29, 2015)

Session 47

1111-33-318 **Renato Alvarez-Nodarse*** (ran@us.es), Departamento de Análisis Matemático, Universidad de Sevilla, Apto. 1160, 41080 Sevilla, Spain. *Generating recurrence and ladder-type relations for Orthogonal Polynomials and Special Functions with applications to Quantum Systems.*

Almost all Special Functions (SF) of Mathematical-Physics are solutions of the so-called hypergeometric-type equation

$$(*) \qquad \sigma(z)y''(z) + \tau(z)y'(z) + \lambda y(z) = 0\,,$$

where σ and τ are polynomials with degrees not higher than two and one, respectively, and λ is a constant.

An application of the aforesaid functions is the fact that the Schrödinger equation for a wide class of potentials can be transformed into the equation (*) by an appropriate change of variables and so, a deep knowledge of the Special Function Theory allow us to obtain new relations for the wave functions. Our main aim in this talk is to present a constructive approach for generating recurrence relations and ladder-type operators for the SF. This method is also extensive to the discrete case when the equation (*) is changed by the second-order difference equation of hypergeometric type on linear and q-linear lattices.

The recurrence relations for the SF are interesting not only from the theoretical point of view but also they can be used to numerically compute the values of the functions as well as their derivatives. We will show this with some examples related with quantum mechanical systems. (Received February 05, 2015)

Session 47

1111-33-328 **Erik Koelink*** (e.koelink@math.ru.nl). *Matrix-valued orthogonal polynomials and spectral decompositions.*

The link between the spectral decomposition of a Jacobi operator acting on $\ell^2(\mathbf{N})$ and orthogonal polynomials is well-known, and goes under the name of Favard's theorem. We discuss the relation between matrix-valued orthogonal polynomials and self-adjoint operators, such as differential operators, which can be realised as higher-order recurrence relations in a suitable basis. In case we can obtain the spectral decomposition of the self-adjoint operator involved we obtain highly non-trivial examples of 2×2-matrix-valued orthogonal polynomials with explicit weight function and explicit matrix-valued three-term recurrence relation. We discuss in particular an example of an explicit simple second-order differential operator leading to 2×2-matrix-valued orthogonal polynomials, which can be considered as a matrix-valued extension of (a subclass of) Wilson polynomials.

The presentation is based on two papers. One of the papers is a joint paper with Mourad Ismail and Wolter Groenevelt (Advances in Math. 44 (2013), 91–105), and the other paper is a joint paper with Wolter Groenevelt (Constructive Approx. 38 (2013), 277–309). (Received February 05, 2015)

Session 47

1111-33-344 **Antonio J Duran*** (duran@us.es), Facultad de Matematicas, Universidad de Sevilla, Av. Reina Mercedes s/n, 41012 Sevilla, Sevilla, Spain. *Some conjectures on Wronskian determinants of orthogonal polynomials.*

In this talk we present some conjectures on regularity properties for the zeros of Wronskian determinants whose entries are orthogonal polynomials. These determinants are formed by choosing orthogonal polynomials whose degrees run on a finite set F of nonnegative integers. The case when F is formed by consecutive integers was studied by S. Karlin and G. Szegő in 1961. (Received February 06, 2015)

Session 47

1111-33-356 **Peter A Clarkson*** (p.a.clarkson@kent.ac.uk), SMSAS, University of Kent, Canterbury, CT2 7NF, United Kingdom. *Semi-classical Orthogonal Polynomials and the Painleve Equations.*

In this talk I shall discuss semi-classical orthogonal polynomials arising from perturbations of classical weights. It is shown that the coefficients of the three-term recurrence relation satisfied by the polynomials can be expressed in terms of Wronskians which involve special functions. These Wronskians are related to special function solutions of the Painlevé equations. Using this relationship recurrence relation coefficients can be explicitly written in terms of exact solutions of Painlevé equations. (Received February 06, 2015)

Session 47

1111-33-674 **Alfredo Deaño***, Avda. de la universidad 30, 28911 Leganés, Madrid, Spain. *Asymptotics of kissing polynomials.*

We present several recent results on the asymptotic behaviour of polynomials $p_n(x)$ that are orthogonal with respect to the complex weight function $w(x) = e^{i\omega x}$ on $[-1,1]$, where $\omega > 0$ is a real (and possibly large) parameter. In this setting, we study the properties of $p_n(x)$ and associated quantities such as the Hankel determinants constructed from moments of $w(x)$, as ω, n or both parameters tend to infinity. The techniques used include multivariate oscillatory integrals, the Riemann–Hilbert formulation of the problem in the complex plane, potential theory and the Deift–Zhou method of steepest descent.

This is a joint work with Daan Huybrechs (KU Leuven, Belgium), Arieh Iserles (University of Cambridge, UK) and Pablo Román (Universidad Nacional de Córdoba, Argentina) (Received February 10, 2015)

Session 47

1111-33-791 **P Gochhayat**, **K Jordaan*** (kjordaan@up.ac.za), **K Raghavendar** and **A Swaminathan**. *Interlacing properties and bounds for zeros of ${}_2\phi_1$ hypergeometric and little q-Jacobi polynomials.*

We use a consequence of a generalised version of Markov's monotonicity results to investigate interlacing properties of zeros of contiguous basic hypergeometric polynomials associated with little q-Jacobi polynomials and determine inequalities for extreme zeros of the above two polynomials. It is observed that the new bounds which are obtained in this paper give more precise upper bounds for the smallest zero of little q-Jacobi polynomials, improving previously known results by Driver and Jordaan [1], and in some cases, those by Gupta and Muldoon [2]. Numerical examples are given in order to illustrate the accuracy of our bounds.

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(Received February 10, 2015)

34 ► Ordinary differential equations

Contr.Session

1111-34-78 **Helena Sofia Rodrigues***, sofiarodrigues@esce.ipvc.pt, and **Manuel Fonseca**. *Could commercial information be spread like a virus? Epidemiological model in a viral marketing context.*

In epidemiology, an epidemic is defined as the spread of an infectious disease to a large number of people in a given population within a short period of time. In the marketing context, the recommendations from others are important sources of information for those who consume different types of commercial information online. This is the basis of a specific marketing communication strategy commonly referred as viral marketing: a message is viral when it is broadly sent and received by the target market through person-to-person transmission. Due to this similarity between an epidemic and the viral marketing process and because the understanding of the critical factors to this communications strategy effectiveness remain largely unknown, the mathematical models in epidemiology are presented in this marketing specific field. In this paper, an epidemiological model SIR (Susceptible-Infected-Recovered) to study the effects of a viral marketing strategy is presented. It is made a comparison between the disease parameters and the marketing application. The basic reproduction number is calculated and a sensibility analysis is performed in order to determine the relative importance of model parameters. Finally, some conclusions are given and their marketing implications are exposed. (Received January 20, 2015)

Session 44

1111-34-146 **Nadir Sari*** (`nsari@univ-lr.fr`), Département de Mathématiques, Université de La Rochelle, Avenue Michel Crépeau, 17000 La Rochelle, France. *Periodic orbits of a seasonal SIS epidemic model with migration.*

We consider a SIS epidemic model with a constant population divided into susceptibles and infectives and spatially divided into two patches: susceptibles S_i with migration rates a_i, infectives I_i with migration rates b_i. Contact rates $\beta_i(\tau)$ are supposed periodic and switched signals.
We prove the existence of an invariant domain D with at least one periodic solution in D.
Assuming that *mortality* $<<$ *migration dynamics* $<<$ *epidemic dynamics*, we write the system as a slow-fast system. Using an averaging method, we prove the existence of a closed curve which is an attractor, denoted Γ_m, and the existence, in a small neighborhood of Γ_m, of at least one periodic solution. We conclude by a numerical illustration of our results. (Received January 29, 2015)

Session 43

1111-34-180 **Christos Sourdis*** (`csourdis@tem.uoc.gr`), 33 Velestinou, 11523 Athens, Greece. *Analysis of the irregular boundary layer for the flow of a Boussinesq fluid.*

Using a perturbation approach, we make rigorous the formal boundary layer asymptotic analysis of Turcotte, Spence and Bau from 1982 for the vertical flow of an internally heated Boussinesq fluid in a vertical channel with viscous dissipation and pressure work. The key step in our proof is to establish the nondegeneracy of a special solution to the first Painlevé transcendent. For this purpose, we adapt some arguments from the corresponding problem of positive ground states of the focusing, nonlinear Schrödinger equation in an annulus. We will also relate our result to a special case of the superlinear Lazer-McKenna conjecture for elliptic equations. (Received February 01, 2015)

Session 21

1111-34-236 **Carla M Pinto*** (`cap@isep.ipp.pt`), Rua Dr António Bernardino de Almeida, 431, 4200-072 Porto, Portugal, and **Ana R Carvalho**, Rua do Campo Alegre s/n, 4440-452 Porto, Portugal. *Fractional model of typical stages in HV epidemics.*

In this paper it is studied a model for the three stages of HIV epidemics with drug-resistance. We consider the integer-order model and its fractional complex-order counterpart. The model includes $CD4^+$ T cells, CTLs, macrophages, and the virus populations. We simulate the model for different values of the fractional derivative of complex order $D^{\alpha \pm \jmath\beta}$, where $\alpha, \beta \in R^+$. The fractional derivative of complex order is a generalization of the integer order derivative where $\alpha = 1$ and $\beta = 0$. The fractional complex-order system untangles generous dynamical characteristics, such as faster transients and slower evolutions as time increases. These traits are not seen in the integer-order model, since they are customary of memory-preserving systems. (Received February 03, 2015)

Session 37

1111-34-325 **Carlota Rebelo*** (`mcgoncalves@fc.ul.pt`), Departamento de Matemática, Faculdade de Ciências, Universidade de Lisboa, P-1749-016 Lisboa, Portugal. *Persistence in seasonally forced epidemiological models.*

To prove persistence of infectious in an epidemiological model is an important step to understand the dynamics of the disease. In what concerns autonomous epidemiological models there is a vast literature in which it is proved that when the basic reproduction number R_0 is larger than one the disease persists and when it is less than one it dies out.

In the case of seasonally forced epidemiological models, it is not always possible to give an explicit formula for R_0. In this way to prove persistence can be harder. In a recent paper [RMB1] we gave general conditions to have persistence for a large class of epidemiological models. In [RMB2] persistence for periodic models with infection age or constant periods of infection was studied.

In this seminar we aim to give a glimpse on the results obtained in [RMB1] and [RMB2].

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(Received February 05, 2015)

Session 44 1111-34-377 **Tewfik Sari*** (tewfik.sari@irstea.fr), Irstea, UMR ITAP, 361 rue Jean-François Breton, 34196 Montpellier, France. *MacArthur's Consumer-Resource Model.*

The model of MacArthur starts with an explicit representation of the dynamics of consumers and resources interactions, assuming that resources have logistic growth in the absence of consumers and consumers have simple linear functional responses. MacArthur made the additional assumption that resources have much faster dynamics than consumers. The quasi steady state approximation consists in solving the steady states of the dynamics of the resources as functions of the consumers, which can be substituted into the equations of the consumers the consumers, provided it is positive. The system then reduces to a classical Lotka–Volterra competition model for consumers. The reduction of the consumers-resource model to a Lotka-Volterra competition model is valid only when the resources have positive densities. We propose to revisit the theory and clarify this assumption that all resources must have positive densities. Canards are central to understand the dynamics of the slow-fast resource-consumer model. (Received February 06, 2015)

Contr.Session 1111-34-463 **Codruta Simona Stoica*** (codruta.stoica@uav.ro), Aurel Vlaicu University of Arad, 2 Elena Dragoi Str., 310330 Arad, Romania. *On the property of exponential splitting for skew-evolution cocycles in Banach spaces.*

As the state space of the dynamical systems that describe processes from engineering, physics, biology is of infinite dimension, the study is more appropriate by means of associated operator families. The notion of skew-evolution cocycle arises naturally when considering the linearization along an invariant manifold of a dynamical system generated by a nonlinear differential equation. It generalizes the classic concepts of evolution operators and skew-product semiflows, and enables a unitary study in a non-uniform setting.

In this paper, we develop a framework for the study of the exponential splitting induced on a Banach space by a skew-evolution cocycle defined over a generalized multivalued non-autonomous dynamical system. The splitting is characterized in terms of existence and uniqueness of bounded, continuous mild solutions of non-homogeneous variational equations.

We prove that the concept of exponential splitting is stronger than the exponential dichotomy, but they are equivalent under suitable conditions.

As applications, we propose necessary and sufficient conditions of input-output type for the exponential stability of autonomous systems, which allow establishing connections between stability, detectability and exponential expansivity of control systems. (Received February 08, 2015)

Session 26 1111-34-517 **Alexander Lohse*** (alexander.lohse@math.uni-hamburg.de) and **Sofia Castro**. *Existence and stability of elementary heteroclinic networks in $\mathbb{R}^4$.*

In this talk we look at constructions of heteroclinic networks from simple robust cycles in $\mathbb{R}^4$: considering only non-homolinic cycles and assuming that there are no critical elements (i.e. equilibria, periodic orbits or heteroclinic cycles) other than the origin and the network itself, we are able to show that only very few ways exist by which cycles can be joined together in a network. We call such networks *elementary* and provide a complete list of them for $\mathbb{R}^4$. Some of these networks have been previously studied in great detail by other authors, while others, especially those of type A, are so far absent from the literature. Using the stability index from Podvigina and Ashwin (*Nonlinearity* 24, 887–929, 2011), we describe the non-asymptotic stability properties of individual cycles and, where possible, derive information about stability of the entire network, which is strongly dependent on the types of the cycles. (Received February 09, 2015)

Session 10

1111-34-542 **Rafael Sasportes*** (rafael@uab.pt), CAMGSD, Departamento de Matematica, Av. Rovisco Pais, 1, 1049-001 Lisboa, Portugal. *Self-similar behaviour in an island growth model with constant monomer input.* Preliminary report.

In recent work Grinfeld et al. [2], considered a model for island growth in which islands of size $\geqslant$ n are stable, while smaller islands are unstable. This model generalizes the case $n = 2$ of da Costa et al. [1]. The resulting system of equations is

$$\begin{cases} \dot{c_1} = \alpha - nc_1^n - c_1 \sum_{j=n}^{\infty} c_j, \\ \dot{c_n} = c_1^n - c_1 c_n, \\ \dot{c_j} = c_1 c_{j-1} - c_1 c_j, \ j > n, \end{cases}$$

where $\alpha > 0$ represents the constant input rate of monomers. Grinfeld et al. [2] prove the existence of a self-similar solution with a discontinuity along the characteristic direction $j = \tau$.

For monomeric initial data we show that there is also a self-similar solution along the critical direction, given by

$$\Phi_{2,n}(\xi) = e^{-\frac{\xi^2}{2}} \int_0^{\infty} e^{-\xi w^n - \frac{w^{2n}}{2}} dw, n \geqslant 2.$$

References

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[2] O. Costin, M. Grinfeld, K. P. O'Neill, H. Park, Long-time behaviour of point islands under fixed rate deposition, *Commun. Inf. Syst.*, **13** (2013).

(Received February 09, 2015)

Session 26

1111-34-545 **S. Ibáñez*** (mesa@uniovi.es) and **A. Rodrigues** (alexandre.rodrigues@fc.up.pt). *Dynamics around a network of bifocal homoclinic orbits.*

In a homoclinic network associated to a non-resonant hyperbolic bifocus, we prove that the rotation combined with a non-degeneracy condition concerning the intersection of the two-dimensional invariant manifolds of the equilibrium, creates switching behaviour, that is, close to the network, there are trajectories that visit the neighbourhood of the bifocus following the connections in any prescribed order. These trajectories lie on suspended hyperbolic horseshoes that accumulate on the network. (Received February 09, 2015)

Session 26

1111-34-551 **Manuela A. D. Aguiar*** (maguiar@fep.up.pt), Manuela A.D. Aguiar, Faculdade de Economia, Rua Dr. Roberto Frias, 4200-464 Porto, Portugal. *Heteroclinic cycles and networks in coupled cell systems.*

As it is well known, flow-invariant subspaces favour the existence of robust heteroclinic cycles and networks. One of the novelties introduced by the theory of coupled cell systems (CCS) is the existence of synchrony subspaces, subspaces defined by equalities of some cell coordinates that are flow-invariant by all CCS associated with the given network structure and that are independent of the specific dynamics at the cells. There is a vast work on heteroclinic cycles and networks in symmetric systems, induced by the lattice of fixed point subspaces. The study of heteroclinic cycles and networks in CCS, induced by the lattice of synchrony subspaces, is new and of current interest. I will start by showing how flow-invariant subspaces in CCS can support robust heteroclinic attractors, assuming asymmetric inputs and no global or local symmetries in the network (joint work with Peter Ashwin (Exeter, UK), Ana Dias (Porto, Portugal) and Mike Field (Houston, USA)). Next,I will focus on how to combine, through binary network operations, such as the join and the product, small networks whose dynamics supports robust heteroclinic cycles to build larger networks with dynamics supporting robust heteroclinic networks (joint work with Ana Dias (Porto, Portugal)). (Received February 09, 2015)

Session 18

1111-34-575 **Martin Golubitsky*** (mg@mbi.osu.edu). *Homeostasis As a Network Invariant.* Preliminary report.

The simplest mathematical definition of homeostasis is as follows. Suppose a system $\dot{X} = F(X)$ has a stable equilibrium X_0 and the system depends on an input parameter I. Homeostasis occurs when one of the variables of $X_0(I)$ — say the jth — is approximately constant over a broad range of I. We translate finding homeostasis to finding singular points $\frac{\partial X_0}{\partial I}(I_0) = 0$. We discuss the question: When are homeostasis singularities invariants of the system when viewed as a network? (Received February 09, 2015)

Session 14

1111-34-643 **Emmanuel Paul*** (emmanuel.paul@math.univ-toulouse.fr), Institut de Mathematiques de Toulouse, France. *Dynamics on wild character varieties.*

Every linear fuchsian connection over a Riemann surface X gives rise to a (monodromy) representation of the fundamental group of X punctured at finitely many points corresponding to the singular locus. The character variety corresponds to the variety arising from these representations up to a natural equivalence relation. The character variety is acted upon by and the group of exterior automorphisms of the fundamental group in question. The resulting dynamics is directly related to the Schlesinger foliation induced by the isomonodromic deformations by means of the Riemann-Hilbert correspondence. In order to extend this description to the context of irregular differential equations, we need to consider fundamental groupoids whose representations take into account the Stokes phenomenon. Nonetheless, by studying one example to be presented here, we will see that the natural dynamics on these wild character varieties cannot be completely described by the action of braids on the objects of the groupoid. This is joint work with Jean-Pierre Ramis and Julio Rebelo. (Received February 09, 2015)

Session 14

1111-34-644 **Yulij Il'yashenko*** (yulij@math.cornell.edu), Cornell University and Independent University. *New Phragmen-Lindelef theorems for functional cochains.*

Phragmen-Lindelef theorems hold not only for holomorphic functions, but rather for functional cochains. This property is a key point in the proof of the finiteness theorem for limit cycles. In its previous form (1991), the Phragmen-Lindelef theorems for functional cochains was proved only for the cochains that occur in the study of monodromy mappings of polycycles. We present a general theorem for cochains not necessary related to the monodromy mappings. It looks more transparent and implies the previous one. (Received February 09, 2015)

Session 18

1111-34-697 **Philipp Pade**, Berlin, Berlin, Germany, and **Tiago Periera*** (tiago.pereira@imperial.ac.uk), Exhibition Road, London, London SW7 2AZ, United Kingdom. *Improving the Network Structure can lead to Functional Failures.*

In many real-world networks the ability to synchronize is a key property for their performance. Recent work on undirected networks with diffusive interaction revealed that improvements in the network connectivity such as making the network more connected and homogeneous enhances synchronization. However, real-world networks have directed and weighted connections. In such directed networks, understanding the impact of structural changes on the network performance remains a major challenge. Here, we show that improving the structure of a directed network can lead to a failure in the network function. For instance, introducing new links to reduce the minimum distance between nodes can lead to instabilities in the synchronized motion. This effect only occurs in directed networks. Our results allow to identify the dynamical importance of a link and thereby have a major impact on the design and control of directed networks. (Received February 10, 2015)

Session 18

1111-34-713 **Fatihcan Atay** and **Haibo Ruan***, Bundesstrasse 55, 20146 Hamburg, Hamburg, Germany. *Symmetry Analysis of Coupled Scalar Systems under Time Delay.*

We study systems of coupled units in a general network configuration with a coupling delay. We show that the destabilizing bifurcations from an equilibrium are governed by the extreme eigenvalues of the coupling matrix of the network. Based on the equivariant degree method and its computational packages, we perform a symmetry classification of destabilizing bifurcations in bidirectional rings of coupled units. Both stationary and oscillatory bifurcations are discussed. We also introduce the concept of secondary dominating orbit types to capture bifurcating solutions of submaximal nature. (Received February 10, 2015)

Session 26

1111-34-731 **Jens D.M. Rademacher*** (rademach@math.uni-bremen.de). *Pathwise unfolding of heteroclinic networks with periodic orbits.*

This talk reviews results from unfolding heteroclinic networks involving periodic orbits by a Lyapunov-Schmidt reduction approach akin to Lin's method. Tangencies in the heteroclinic connections and higher codimensions are allowed. In this approach bifurcating orbits are organized by their itinerary in the network, giving a pathwise unfolding. This perspective is particularly suitable when seeking travelling waves in evolution equations posed on the real line.

The reduction gives analytic bifurcation equations, whose solutions are in one-to-one correspondence with orbits passing sufficiently close to the network along the itinerary. A leading order expansion is given in terms of the times spent near vertices and, if applicable, the location on the non-trivial tangent directions. Here the time parameters are discrete for vertices that are periodic orbits and continuous for equilibria. Analysing the reduced equations provides insight into the loci of selected solution types and the geometry of the solution branches and, e.g., one may find homoclinic snaking without reversible symmetry. (Received February 10, 2015)

Session 43

1111-34-749 **Isabel Coelho*** (icoelho@adm.isel.pt), Área Científica de Matemática, Instituto Superior de Engenharia de Lisboa, Rua Conselheiro Emídio Navarro, 1, 1950-062 Lisboa, Portugal. *Positive solutions of a singular Minkowski-curvature equation.*

We discuss the existence of positive solutions for the quasilinear equation

$$-\left(\frac{u'}{\sqrt{1-|u'|^2}}\right)' - \frac{N-1}{r}\frac{u'}{\sqrt{1-|u'|^2}} + a(r)u = b(r)g(u)$$

satisfying the initial condition $u'(0)=0$ in bounded intervals of the form $[0,R]$ and in $[0,+\infty[$. We consider the space dimension $N \geq 2$ and that the functions a, b and g are smooth.

In our approach, we combine a shooting argument of Beresticky, Lions and Peletier with variational and topological methods. Contrary to the semilinear case, the structure of the equation prevents the appearance of critical exponents.

This is a joint work with Denis Bonheure and Colette De Coster. (Received February 10, 2015)

Session 44

1111-34-767 **Claude E Lobry*** (lobrinria@wanadoo.fr), Le grand palais Bt 6, 2 Bd de Cimiez, 06000 NICE, France. *Switched dynamical systems and persistence in certain models of trophic interaction.* Preliminary report.

Consider two models of consumer-resource interaction M_1 and M_2 representing two possible environmental conditions E_1 and E_2. We suppose that environment can switch from E_1 to E_2 or vive versa. We say that the system is *unconditionaly persistent* if for any possible succession of environments and any initial condition the corresponding solution never approach zero or infinity. It is well known that for suitable values of the papameters the Rosenzweig-MacArthur (RMA) model has a stable equilibrium or limit cycle which is globally attracting and by the way is persistent. Assume that M_1 and M_2 are both persistent. Is it true that the system is *unconditionnally persistent* ? The answer is yes but unfortunately is not completely suitable for applicacations. Actually the RMA model is a slow fasrt-system in dimension 2 with solutions which might be exponentially small, too small to represent any actual process even in the case where the switched system is persistent. We analyse this feature within the N.S.A. framework of E. Nelson and show the role of "canard" solutions. (Received February 10, 2015)

35 ► Partial differential equations

Session 21

1111-35-21 **Sanja Konjik*** (sanja.konjik@dmi.uns.ac.rs), Trg D. Obradovica 4, 21000 Novi Sad, Serbia. *Fractional models of the wave equation.*

Fractional differential and integral operators have become an indispensable tool for describing certain phenomena in physics, mechanics, engineering, economics, medicine, etc. For instance, viscoelasticity or diffusion and heat conduction processes are more accurately modeled by the use of derivatives of noninteger order. This is achieved by the so-called direct fractionalization, where integer order derivatives in the corresponding equations are replaced by fractional ones in a way that basic physical principles remain preserved.

Over the past few year there has been going an extensive study of wave propagation in viscoelastic materials within the fractional framework. Generalizations of the classical wave equation include fractionalization with respect to both time and spatial variables, and use of real but also complex order fractional derivatives. In this talk we give an overview of some recent results about various fractional models of the wave equation. We discuss different topics, such as well-posedness, thermodynamical restrictions, real valued compatibility constraints, existence and uniqueness of solutions, numerical verifications.

This talk is based on joint work with Teodor M. Atanackovic, Ljubica Oparnica, Stevan Pilipović and Dušan Zorica. (Received December 29, 2014)

Session 36

1111-35-24 **Giovanni Leoni*** (giovanni@andrew.cmu.edu), Carnegie Mellon University, Department of Mathematical Sciences, 5000 Forbes Avenue, Pittsburgh, PA 15213. *On slow motion for phase transitions.*

We discuss slow motion for phase transitions in higher dimensions through asymptotic development by Gamma convergence. (Received January 02, 2015)

Session 46

1111-35-31 **Anatoli E Merzon*** (anatolimx@gmail.com), 58066 Morelia, Mexico. *Sobolev's and Keller-Blank's formulas in scattering of plane waves by a wedge.*

We consider nonstationary scattering of plane waves $F(t-n\cdot y),\ y\in\mathbb{R}^2\ (F\in L^1(\mathbb{R}),\ \text{supp}\, F\in[0,\infty))$ by DD, NN and DN-wedges of an arbitrary magnitude. Mathematically, this problem is reduced to Cauchy problem for the wave equation with DD, NN and DN-boundary conditions. Using the Method of Complex Characteristics, we prove the existence and uniqueness of solution in a class of distributions [2]. We present a simple explicit formula in the form of the Sommerdeld-Malyuzhinetz integral for the wave diffracted by the edge of the wedge. This formula allows to prove the Limiting amplitude principle, to find long time asymptotics, asymptotics near the front of the scattered wave, and to establish the stability of solution. Finally, we prove that our solution for the pulse incident wave coincides with the Sobolev (1934) and Keller-Blank's (1951) solutions and thus we prove the uniqueness of these solutions in our functional class.

[1] Komech A, Merzon A, De la Paz Mendez J.E. Time-dependent scattering of generalized plane waves by a wedge *Mathematical methods in the Applied Sciences* (to appear). (Received February 03, 2015)

Session 43 1111-35-42 **Sergio H. M. Soares*** (monari@icmc.usp.br), Universidade de São Paulo, Campus de São Carlos, Caixa Postal 668, São Carlos, SP 13560-970, Brazil, and **Liliane A. Maia** and **Olimpio H. Miyagaki**. *A sign-changing solution for an asymptotically linear Schrödinger equation.*

The aim of this talk is to present a sign-changing solution for a class of radially symmetric asymptotically linear Schrödinger equations. The proof is variational and the Ekeland variational principle is employed as well as a deformation lemma combined with Miranda's Theorem. (Received January 09, 2015)

Contr.Session 1111-35-49 **Ozgur Yildirim*** (ozgury@yildiz.edu.tr), Science Faculty, Department of Mathematics, Davutpasa Campus, E2038, 34210 Istanbul, Turkey, and **Meltem Uzun** (meltemu@yildiz.edu.tr), Science Faculty, Department of Mathematics, Davurpasa Campus, 34210 Istanbul, Turkey. *On stability of high order difference schemes for hyperbolic multipoint nonlocal boundary value problem.*

This paper presents third and fourth order of accuracy stable difference schemes for the approximate solutions of multipoint nonlocal boundary value problem of the hyperbolic type in a Hilbert space H with self-adjoint positive definite operator A. Stability estimates for solutions of these difference schemes are obtained. Some results of numerical experiments are presented using finite difference method in order to support theoretical statements. (Received January 13, 2015)

Session 31 1111-35-50 **José Matias** (jose.c.matias@tecnico.ulisboa.pt), Av. Rovisco Pais, 1, 1049-001 Lisboa, Portugal, **Marco Morandotti*** (morandot@sissa.it), Via Bonomea, 265, 34136 Trieste, Italy, and **Pedro M. Santos** (pmsantos@math.ist.utl.pt), Av. Rovisco Pais, 1, Lisboa, Portugal. *Homogenization of functionals with linear growth in the context of $\mathcal{A}$-quasiconvexity.* Preliminary report.

This work deals with the homogenization of functionals with linear growth in the context of $\mathcal{A}$-quasiconvexity. A representation theorem is proved, where the new integrand function is obtained by solving a cell problem where the coupling between homogenization and the $\mathcal{A}$-free condition plays a crucial role. This result extends some previous work to the linear case, thus allowing for concentration effects. (Received January 13, 2015)

Session 31 1111-35-58 **Alexei Novikov***, Math Department, State College, PA 16802. *Homogenization in stationary fluid flows.*

I will discuss recent results related to analysis of effective behavior of a passive scalar in incompressible stationary fluid flows in two dimensions. The particle is driven either by the classical Brownian motion or by the fractional Brownian motion. (Received January 15, 2015)

Session 35 1111-35-66 **Francesco Toppan*** (toppan@cbpf.br), Rua Dr. Xavier Sigaud 150, Urca, Rio de Janeiro, RJ 22090-180, Brazil. *Conformal Galilei Invariant Dynamics.*

Second-order, linear PDEs invariant under the centrally extended Conformal Galilei Algebra are constructed. They induce pseudo-hermitian Hamiltonians with a positive and discrete spectrum, determined by the spectrum-generating subalgebras. This new class of systems, determined by a half-integer parameter l (a spin variable), generalizes the harmonic oscillator (recovered at l=1/2). The construction of the PDEs from an on-shell invariant condition and their physical applications are discussed. (Received January 17, 2015)

Inv.Adresses 1111-35-82 **Gigliola Staffilani***, MIT, Room E17 330, 77 Massachusetts Avenue, Cambridge, MA 02139. *Recent developments on certain dispersive equations as infinite dimensional Hamiltonian systems.*

In this talk I will present some recent developments in the study of dispersive differential equations on compact manifolds that can also be viewed as infinite dimensional Hamiltonian systems. I will talk about Strichartz estimates, weak turbulence, Gibbs measures, symplectic structures and non-squeezing theorems. A list of open problems will conclude the talk. (Received January 20, 2015)

Inv.Adresses

1111-35-87 **Irene Fonseca*** (fonseca@andrew.cmu.edu), Department of Mathematical Sciences, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213. *Quantum Dots and Dislocations: Dynamics of Materials Defects.*

The formation and assembly patterns of quantum dots have a significant impact on the optoelectronic properties of semiconductors. We will discuss shapes of quantum dots and short time existence for a surface diffusion evolution equation with curvature regularization in the context of epitaxially strained three-dimensional films. Further, short time existence, uniqueness, and qualitative properties of solutions to an evolution law for systems of screw dislocations under the assumption of antiplane shear will be obtained. (Received January 20, 2015)

Session 33

1111-35-94 **Paulo Amorim***, Instituto de Matemática, Universidade Federal do Rio de Janeiro, Cidade Universitária - Ilha do Fundão, Rio de Janeiro, RJ 21941-909. *The obstacle-mass constraint problem for hyperbolic conservation laws. Solvability.*

In this work we introduce the obstacle-mass constraint problem for a multidimensional scalar hyperbolic conservation law. We prove existence of an entropy solution to this problem by a penalization/viscosity method. The mass constraint introduces a nonlocal Lagrange multiplier in the penalized equation, giving rise to a nonlocal parabolic problem. We determine conditions on the initial data and on the obstacle function which ensure global in time existence of solution. These are not smoothness conditions, but relate to the propagation of the support of the initial data. (Received January 21, 2015)

Session 33

1111-35-129 **Athanasios Tzavaras*** (athanasios.tzavaras@kaust.edu.sa), Computer, Electical, Math Sci & Eng Division, King Abdullah University of Science and Tech, (KAUST), Thuwal, Saudi Arabia. *Coherent localized structures emerging from a parabolic regularization of an ill-posed intilal-value problem in materials.*

Shear localization occurs in various instances of material instability in solid mechanics and is typically associated with Hadamard-instability for an underlying model. While Hadamard instability indicates the catastrophic growth of oscillations around a mean state, it does not by itself explain the formation of coherent structures typically observed in localization. The latter is a nonlinear effect and its analysis is the main objective of this talk. We consider a model that captures the main mechanisms observed in high strain-rate deformation of metals, and describes shear motions of temperature dependent non-Newtonian fluids. We show that the mechanism associated to localization at the linearized level is that of Turing instability. Then, we turn to the nonlinear model, and construct localized states - in the form of similarity solutions - that emerge as coherent structures in the localization process. (Received January 27, 2015)

Session 48

1111-35-138 **Francesco Fanelli*** (francesco.fanelli@sns.it), CRM "Ennio De Giorgi", Scuola Normale Superiore, Collegio Puteano - Piazza dei Cavalieri, 3, I-56126 Pisa, Italy. *A singular limit problem for viscous compressible fluids in presence of capillarity.*

In the present talk we are interested in a singular limit problem for a compressible Navier-Stokes-Korteweg system under the action of fast rotation of the Earth.

We suppose both the Mach and Rossby numbers to be proportional to a small parameter ε: letting $\varepsilon \to 0$, we study the incompressible and high rotation limits simultaneously. Moreover, we are interested in both the constant capillarity and the vanishing capillarity regimes: namely, the capillarity coefficient is supposed to be proportional to $\varepsilon^{2\alpha}$, for some $\alpha \in [0, 1]$.

Then, in these cases we investigate the asymptotic behavior of a family of weak solutions to our system for $\varepsilon \to 0$, and we completely characterize the limit equations.

The results are based on suitable applications of the RAGE theorem. (Received January 28, 2015)

Session 10

1111-35-144 **Marco A Fontelos***, Nicolas Cabrera, n 13-15, Campus de Cantoblanco, UAM, 28049 Madrid, Spain, and **Giancarlo Breschi**. *Selfsimilar solutions for coagulation and fragmentation processes.*

Concerning Smoluchowski equation for coagulation with multiplicative kernel, we propose the problem of self-similar solutions of the second kind for kernels that do produce gelation in finite time. The results consist in the construction of global solutions matching asymptotic expansions and intermediate behaviors. The exponents of self-similarity are computed by solving a suitable nonlinear eigenvalue problem. We then consider the problem of self-similar solutions to the linear equation of irreversible fragmentation. We rigorously determine an explicit formula in the form of infinite product for the self-similar solutions through a Wiener-Hopf method for the calculation of residues in the complex plane; this is done for both the case of fragmentation which allows infinitesimal fragments and for fragmentation which bounds from below the mínimum fragments. This study leads us to accurately determine the asymptotic behaviors of the solutions in both cases. (Received January 28, 2015)

Session 47

1111-35-149 **Ana Foulquié*** (foulquie@ua.pt), Departamento de Matemática, Universidade de Aveiro, Campus de Santiago, 3810-193 Aveiro, Portugal, and **Iván Area**, **Amílcar Branquinho** and **Eduardo Godoy**. *Orthogonal polynomial interpretation of Δ-Toda and Volterra lattices.*

The correspondence between dynamics of Δ-Toda and Δ-Volterra lattices for the coefficients of the Jacobi operator and its resolvent function is established. A method to solve inverse problem –integration of Δ–Toda and Δ-Volterra lattices – based on Padé approximants and continued fractions for the resolvent function is proposed. The main ingredient are orthogonal polynomials which satisfy an Appell condition, with respect to the forward difference operator Δ.

It is shown that the measure of orthogonality associated to these systems of orthogonal polynomials evolve in t like $(1+x^p)^{1-t}\mu(x)$, $p=1,2$, where $\mu(x)$ is a given positive Borel measure.

Moreover, the Δ-Volterra lattice is related to the Δ-Toda lattice from Miura or Bäcklund transformations.

Examples related with Jacobi and Laguerre orthogonal polynomials and Δ-Toda equations are given, as well as explicit solutions of Δ-Volterra and Δ-Toda lattices. (Received January 29, 2015)

Session 43

1111-35-170 **Serena Dipierro*** (serena.dipierro@ed.ac.uk), Edinburgh, EH165EJ. *All functions are locally s-harmonic (up to a small error).*

We show that we can approximate every C^k function with a s-harmonic function in a ball that vanishes outside a compact set.

That is, s-harmonic functions are locally dense in C^k.

This result is clearly in contrast with the rigidity of harmonic functions in the classical case and can be viewed as a purely nonlocal feature.

This is a joint work with O. Savin and E. Valdinoci. (Received January 31, 2015)

Session 10

1111-35-178 **Robert L Pego*** (rpego@cmu.edu), Department of Mathematical Sciences, Carnegie Mellon University, Pittsburgh, PA 15213. *An analysis of merging-splitting group dynamics by Bernstein function theory.* Preliminary report.

We study coagulation-fragmentation equations inspired by a simple model derived in fisheries science to explain data on the size distribution of schools of pelagic fish. Although the equations lack detailed balance and admit no H-theorem, we are able to develop a rather complete description of equilibrium profiles and large-time behavior, based on complex function theory for Bernstein and Pick functions. The structure of discrete equilibrium profiles and other related sequences is explained through a new and elegant characterization of the generating functions of completely monotone sequences as those Pick functions analytic and nonnegative on $(-\infty, 1)$. This is joint work with Jian-Guo Liu and Pierre Degond. (Received February 01, 2015)

Session 48

1111-35-186 **mehmet ersoy***, avenue de l'université BP 20132, 83957 La Garde, France. *Block-Based Adaptive Mesh Refinement scheme based on numerical density of entropy production for conservation laws and applications.*

In this work, we present a new parallel finite volume scheme on unstructured meshes applied to fluid flow for hyperbolic system of conservation laws. It is based on a block-based adaptive mesh refinement strategy which allows quick meshing and easy parallelisation. Following the previous one dimensional framework, we use the useful numerical density of entropy production as mesh refinement criterion. Combining with a local time stepping method, we preserve the computational time. In particular, we numerically investigate its efficiency through 1D, 2D and 3D test cases with a confrontation with exact solution or experimental data. (Received February 02, 2015)

Session 46

1111-35-198 **Roland Duduchava*** (roldud@gmail.com), Andrea Razmadze Mathematical Institute, Tbilisi, 0177, **Medea Caava** (m.caava@yahoo.com), A.Razmadze Mathematical Institute, Tbilisi, 0177, and **Tamta Tsutsunava** (tamta.wuwunava@mail.ru), A.Razmadze Mathematical Institute, Tbilisi, 0177. *MIXED BOUNDARY VALUE PROBLEMS FOR THE LAPLACE-BELTRAMI EQUATION.*

We investigate mixed Dirichlet-Neumann boundary value problems for the Laplace-Beltrami equation on a smooth hypersurface $\mathcal{C}$ with the smooth boundary in non-classical setting, in the Bessel potential spaces $\mathbb{H}^1_p(\mathcal{C})$ for $1<p<\infty$, $s>1/p$. To the initial BVP we apply quasilocalization and obtain model BVPs for the Laplacian. The model mixed BVP on the half plane is investigated by potential method and is reduced to an equivalent system of Mellin convolution equations in Bessel potential and Besov spaces. The symbol of the obtained system is written explicitly, which provides Fredholm properties and the index of the system. Criteria of unique solvability of the initial mixed BVP in non-classical setting is found. (Received February 02, 2015)

Session 43

1111-35-212 **Alberto Farina***, LAMFA, CNRS 7352, Amiens, France. *Some results on entire solutions to a family of nonlinear elliptic systems.*

We prove symmetry results and Liouville-type theorems for, possibly sign changing, entire distributional solutions to a family of nonlinear elliptic systems encompassing models arising in Bose-Einstein condensation and in nonlinear optics. (Received February 03, 2015)

Session 44

1111-35-305 **João Paulo Teixeira*** (jteix@math.tecnico.ulisboa.pt), Av. Rovisco Pais, 1049-001 Lisboa, Portugal. *Global existence and regularity of periodic and stationary solutions of the n-dimensional Navier-Stokes equations via discretizations.*

Consider the equations:

$$u_t = \nu\Delta u - (u\cdot\nabla)u - \nabla p + f$$

$$\operatorname{div} u = 0$$

for $x \in [0,1]^n$ and $t \in (0,\infty)$, together with periodic boundary conditions and initial condition $u(x,0) = g(x)$ (with $\operatorname{div} g = 0$).

We present a proof of local-in-time existence of the smooth solution of a initial and boundary value problem for the Navier-Stokes equations based on a finite-difference discretization by an Euler scheme. The incompressibility condition is treated by a fixed point argument.

This proof does not use the theory of weak solutions, nor the Galerkin aproximation. We show regularity of the standard part of a hiperfinite solution of the Euler scheme from estimates of the Lipshitz norms of these hiperfinite-difference solutions. We use these estimates to show that there exists a solution in an interval $[0,T]$, where T depends on n, f and g.

If f is T-periodic, then our existence result implies the global existence and regularity of T-periodic solutions. If f is independent of t, then global existence and regularity of stationary solutions is obtained. (Received February 05, 2015)

Session 9

1111-35-306 **Vladimir Soucek*** (soucek@karlin.mff.cuni.cz), Sokolovska 83, 18675 Praha, Czech Rep, and **Fred Brackx**, **David Eelbode**, **Hennie De Schepper** and **Roman Lavicka**. *Basic equations of quaternionic Clifford analysis.*

Quaternionic Clifford analysis is a recent new branch of Clifford analysis, a higher dimensional function theory which refines harmonic analysis and generalizes holomorphic function theory in the complex plane to higher dimension. So-called quaternionic monogenic functions satisfy a system of first order linear differential equations expressed in terms of four interrelated Dirac operators. The corresponding systems can be defined on an abstract level by a suitable vision of the Stein-Weiss construction. In the lecture, both the abstract definition and its explicit realization will be discussed. (Received February 05, 2015)

Session 9

1111-35-327 **Fred Brackx**, **Hennie De Schepper**, **David Eelbode** and **Roman Lavicka*** (lavicka@karlin.mff.cuni.cz), Faculty of Mathematics and Physics, Charles University in Prague, Sokolovska 83, 186 75 Praha, Czech Rep, and **Vladimir Soucek**. *Fischer decomposition and Howe duality in quaternionic Clifford analysis.*

In the talk, we describe Fischer decomposition and Howe duality in quaternionic Clifford analysis. This is a new branch of Clifford analysis, a higher dimensional function theory where the underlying symmetry is given by the symplectic group Sp(p). In particular, we decompose spaces of spinor-valued homogeneous harmonic polynomials into irreducible representations of the symplectic group Sp(p). These Fischer decompositions involve spaces of homogeneous, so-called osp(4,2)- monogenic polynomials, the Lie super algebra osp(4,2) being the Howe dual to the symplectic group Sp(p). (Received February 05, 2015)

Session 33

1111-35-345 **Eduard Feireisl*** (feireisl@math.cas.cz), Institute of Mathematics AVCR, Zitna 25, 115 67 Praha, Czech Rep. *Weak and strong solutions to problems arising in dynamics of inviscid fluids.*

We discuss solvability of certain problems arising in the dynamics of inviscid fluids in the framework of weak and strong solutions. In particular, the following topics will be addressed:

1. The property of weak-strong uniqueness
2. Uniqueness/multiplicity of weak solutions for given data
3. Admissibility criteria, relative energy functionals (Received February 06, 2015)

Session 33 1111-35-346 **Evgeny Yu. Panov*** (eugeny.panov@novsu.ru), Novgorod State University, B. Sankt-Peterburgskaya str., 41, Veliky Novgorod, 173003, Russia. *On one operator criterion of the uniqueness of generalized solutions to a linear transport equation with rough coefficients.*

We consider a transport equation

$$u_t + a(x) \cdot \nabla_x u = 0, \tag{1}$$

$u = u(t,x)$, $t > 0$, $x \in \mathbb{R}^n$, with a general field of coefficients $a(x) = (a_1(x), \dots, a_n(x)) \in L^\infty(\mathbb{R}^n, \mathbb{R}^n)$ satisfying the solenoidality condition $\nabla \cdot a(x) = 0$ in $\mathcal{D}'(\mathbb{R}^n)$. The latter allows to rewrite (1) in the conservative form $u_t + \nabla_x \cdot (au) = 0$ and introduce the notion of a generalized solution (g.s.) of the Cauchy problem with initial data

$$u(0,x) = u_0(x) \in L^\infty(\mathbb{R}^n) \tag{2}$$

on the base of the standard integral identity. It is known that a g.s. of (1), (2) always exists but can be nonunique. We introduce the operator $Au = a(x) \cdot \nabla u(x)$, $u(x) \in C_0^1(\mathbb{R}^n)$. It is a skew-symmetric operator on $L^2 = L^2(\mathbb{R}^n)$. The main our result is the following criterion of the uniqueness.

Theorem. *A g.s. $u(t,x)$ of (1), (2) is unique if and only if the operator A is essentially skew-adjoint on L^2. Moreover, in this case $g(u(t,x))$ is a g.s. for every $g(u) \in C(\mathbb{R})$ (the renormalization property).*

This research was carried out with the financial support of the RFBR (grant no. 15-01-07650-a) and the Ministry of Education and Science of RF, project 1.857.2014/K. (Received February 06, 2015)

Contr.Session 1111-35-351 **Piotr MichałBies*** (biesp@mini.pw.edu.pl), Warsaw, Poland. *Linear elliptic equations in variable Hölder spaces.*

We study partial differential equations of second order with the right side in variable Hölder space. We show that solutions of this problem are in variable Hölder space and that they are uniqueness. We will also conclude from Campanato Theorem and Morrey Theorem for variable Hölder spaces, that weak solutions of elliptic equations are in Hölder spaces with variable exponent. (Received February 06, 2015)

Session 38 1111-35-354 **João L. Costa*** (jlca@iscte.pt), Mathematics Department, ISCTE-IUL, Av$^{\text{a}}$das Forças Armadas, 1649-026 Lisboa, Portugal. *Cosmic "No-hair" for a self-gravitating scalar field.*

We present some new ideas on how to improve previous results concerning the asymptotic behavior of the Einstein-scalar field system with a positive cosmological constant in spherical symmetry. A natural framework for such analysis is provided by the celebrated Cosmic "No-hair" Conjecture. (Received February 06, 2015)

Session 43 1111-35-363 **Philippe P. Souplet*** (souplet@math.univ-paris13.fr), Université Paris 13, Sorbonne Paris Cité, CNRS UMR 7539, Laboratoire, Analyse Géométrie et Applications, 93430 Villetaneuse, France. *A priori estimates and bifurcation of solutions for an elliptic equation with semidefinite critical growth in the gradient.*

We study the boundary value problem

$$-\Delta u = \lambda c(x) u + \mu(x) |\nabla u|^2 + h(x), \quad 0 \le u \in H_0^1 \cap L^\infty(\Omega),$$

where $\Omega \subset \mathbf{R}^n$ is a smooth bounded domain, $\mu, c \in L^\infty(\Omega)$, $h \in L^r(\Omega)$ for some $r > n/2$, with $\mu, c, h \ge 0$. Our main motivation is to study the "semidefinite" case. Namely, unlike in previous work on the subject, we do not assume μ to be uniformly positive in Ω, nor even positive everywhere.

For $n \le 5$, we establish uniform a priori estimates when $\lambda > 0$ is bounded away from 0. This is proved under the assumption that the supports of μ and c intersect, a condition that we show to be actually necessary, and in some cases we further assume that μ is uniformly positive on the support of c and/or some other conditions.

As a consequence of our a priori estimates, assuming existence for $\lambda = 0$, we deduce the existence of a continuum $\mathcal{C}$ of solutions, such that the projection of $\mathcal{C}$ onto the λ-axis is an interval of the form $[0, a]$ for some $a > 0$ and that $\mathcal{C}$ bifurcates from infinity to the right of the axis $\lambda = 0$. In particular, for each $\lambda > 0$ small enough, the problem has at least two distinct solutions. (Received February 06, 2015)

Session 43 1111-35-370 **Paulo L. Dattori da Silva** and **Jorge Marques*** (jmarques@fe.uc.pt), School of Economics, University of Coimbra, Av. Dias da Silva, 165, 3004 - 512, Coimbra, Portugal, Portugal, and **Evandro R. Da Silva**. *C^k-solvability near the characteristic set for a class of elliptic vector fields with degeneracies.*

The paper studies the solvability near the characteristic set $\Sigma = \{0\} \times S^1$ of operators of the form $L = \partial/\partial t + (x^n a(x) + ixb(x))\partial/\partial x$, $b(0) \neq 0$ and $n \ge 2$, defined on $\Omega_\epsilon = (-\epsilon, \epsilon) \times S^1$, $\epsilon > 0$, where a and b are real-valued smooth functions in $(-\epsilon, \epsilon)$. For fixed $k \ge 1$, it is shown that given f belonging to a subspace of finite codimension (depending on k) of $C^\infty(\Omega_\epsilon)$ there is $u \in C^k$ solution of the equation $Lu = f$ in a neighborhood of Σ. (Received February 06, 2015)

Session 31

1111-35-380 **Guy Bouchitte*** (bouchitte@univ-tln.fr), 83957 Toulon, France, and **Christophe Bourel** and **Luigi Manca**. *Diffraction by random nanorods structures.*

Recently a theory for artificial magnetism in photonic crystals has been developed for large wavelength (homogenization) by designing suitably scaled dielectric inclusions. Here we present a random model in which parallel dielectric rods of infinitesimal thickness are randomly disposed, each of them having, up to a large scaling factor, a random permittivity ϵ_r whose law is represented by a density on a window $\Delta = [a,b]x[0,h]$ of the complex plane. In this work we determine conditions on the probability law of ϵ^r under which the homogenization process can be identified and leads to a deterministic effective permeability. The key point is that, when the photonic crystal is illuminated at a given frequency, it happens that some values in the interval [a,b] are associated with internal resonances of the inclusions. We give precise conditions on the initial probability law under which the homogenization process can be performed leading to a deterministic dispersion law for the effective permeability with possibly negative real part. Subsequently a limit analysis $h \to 0$, accounting a density law of ϵ_r which concentrates on the real axis, reveals singular behavior due to the presence of resonances. (Received February 06, 2015)

Session 43

1111-35-389 **Alexandre Montaru** and **Boyan Sirakov*** (bsirakov@mat.puc-rio.br). *Existence and classification theorems for elliptic systems in non-divergence form.*

We prove several results classifying the positive solutions of elliptic systems of the type

$$\begin{cases} -F_1[u] &= u^r\, v^p\, [a(x)v^q - c(x)u^q] \\ \\ -F_2[u] &= v^r\, u^p\, [b(x)u^q - d(x)v^q] \end{cases}$$

where $p, q, r \geq 0$ and F_1, F_2 are (linear or nonlinear) operators in non-divergence form. (Received February 06, 2015)

Session 43

1111-35-406 **Filomena Pacella*** (pacella@mat.uniroma1.it). *Morse index of solutions of semilinear elliptic equations and related eigenvalue problems.*

The talk focuses on giving estimates on the Morse index of solutions of general semilinear elliptic equations. In particular the case of radial sign changing solutions in the ball or in the annulus will be considered stressing some relations between the symmetry of the problems and the symmetry of the eigenfunctions of the associated linearized equation. Some suitable change of variables will be introduced to relate eigenvalues and eigenfunctions of different problems. (Received February 07, 2015)

Session 31

1111-35-412 **Antoine Gloria*** (antoine.gloria@ulb.ac.be). *Quantitative homogenization via weighted nonlocal concentration inequalities.*

An optimal quantitative theory of stochastic homogenization of linear elliptic equations was developed in the recent years under the assumption of a spectral gap estimate (SG). Spectral gap is a very strong inequality which essentially requires the coefficient field to have finite range of dependence (although this is not strictly needed nor sufficient). Examples of interest in practice do not satisfy this assumption besides random Poisson inclusions. In this talk I will introduce a weighted nonlocal version of (SG). This weaker concentration inequality is enough to obtain quantitative results in stochastic homogenization and holds for a class of alpha-mixing coefficients (which includes the random parking measure). (Received February 07, 2015)

Session 31

1111-35-414 **Stefan Neukamm*** (stefan.neukamm@wias-berlin.de). *Quantitative stochastic homogenization: Bounds on the corrector in the discrete, non-symmetric case.*

We consider the discrete elliptic corrector equation of stochastic homogenization posed on the integer lattice in dimensions d=2 and larger. We assume that the random coefficients are uniformly elliptic, but possibly nonsymmetric. We prove optimal moment bounds on the corrector and its gradient based on a quantification of ergodicity via a Logarithmic-Sobolev-Inequality. (Received February 07, 2015)

Session 10

1111-35-417 **Barbara Niethammer**, **Sebastian Throm*** (throm@iam.uni-bonn.de) and **Juan J.L. Velázquez**. *Self-similar solutions with fat tails for Smoluchowski's coagulation equation with singular kernels.*

We consider Smoluchowski's coagulation equation, a mean-field model for mass aggregation. We will present an existence result of self-similar solutions with algebraic decay, so called fat-tails, for homogeneous kernels satisfying $C_1(x^{-a}y^b + x^b y^{-a}) \leq K(x,y) \leq C_2(x^{-a}y^b + x^b y^{-a})$ with $a > 0$ and $b < 1$. This covers especially the case of Smoluchowski's classical kernel $K(x,y) = \left(x^{1/3} + y^{1/3}\right)\left(x^{-1/3} + y^{-1/3}\right)$.

The result includes also the asymptotic behaviour for large and small cluster sizes up to first order as well as higher regularity for the solution (depending on the regularity of the kernel). (Received February 07, 2015)

Session 49

1111-35-419 **Tomasz Adamowicz*** (tadamowi@impan.pl), Institute of Mathematics, Polish Academy of Sciences, Sniadeckich 8, 00-656 Warsaw, Poland. *Topics in geometric function theory for variable exponent equations.*

The purpose of this talk is to give a brief overview of some of the geometric properties of solutions to variable exponent PDEs. Equations of the $p(\cdot)$-Laplace type will serve as main examples. We will discuss relations between $p(\cdot)$-harmonic functions and quasiregular maps, Harnack type inequalities, boundary Harnack inequalities and boundary regularity results. The presentation is based on joint works with Peter Hästö, Niklas Lundström and Anders and Jana Björn.

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(Received February 07, 2015)

Session 48

1111-35-420 **Cleopatra Christoforou*** (christoforou.cleopatra@ucy.ac.cy), University of Cyprus, 1678 Nicosia, Cyprus. *From Hyperbolic Balance Laws to Differential Geometry.*

The isometric embedding problem is a fundamental problem in Differential Geometry, that has been extensively studied. In this talk, I will present this problem for complete two-dimensional Riemannian manifolds with negative Gauss curvature in three-dimensional Euclidean space in the setting of hyperbolic systems of balance laws. (Received February 07, 2015)

Session 10

1111-35-437 **Ryan W Murray*** (rwmurray@andrew.cmu.edu), Wean Hall 7209, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA 15213, and **Robert Pego**. *Algebraic Convergence Rates for the Becker-Doering Equations.*

We study rates of convergence to equilibria of sub-critical solutions to the Becker-Doering coagulation-fragmentation equations. Specifically, we use non-linear stability estimates along with interpolation inequalities to establish decay rates, without utilizing a priori exponential moment bounds. We obtain algebraic decay in time for initial data with only polynomial moments. (Received February 07, 2015)

Session 31

1111-35-442 **Rita Ferreira*** (rita.ferreira@kaust.edu.sa), King Abdullah University of, Science and Technology, Al-Khawarizmi (bldg.1), Room 4401, Thuwal, Jeddah 23955-6900, Saudi Arabia. *Spectral analysis in thin tubes with axial heterogeneities.*

In this talk, we address a spectral problem in the realm of homogenization and lower dimensional theories, whose physical motivation is the study of waves propagation in nanowires presenting axial heterogeneities. Precisely, we consider an elliptic operator with ε-periodic coefficients and the corresponding Dirichlet spectral problem in a three-dimensional bounded domain of small cross section δ. We characterize the asymptotic behavior of the spectrum as ε and δ tend to zero. This asymptotic behavior depends crucially on the ratio between the two small parameters. We will give special attention to the case where the scale of thickness δ is much smaller than the scale of the heterogeneities ε and the planar coefficient presents a unique global minimum in the periodic cell, which was not addressed in the previous analogous $3D$-$2D$ analysis.

This is a joint work with M. Luísa Mascarenhas and Andrey Piatnitski. (Received February 08, 2015)

Session 48

1111-35-443 **Luigi c Berselli*** (berselli@dma.unipi.it), Dipartimento di Matematica, Via F. Buonarroti 1/c, Pisa, Italy, and **Matteo Cerminara**. *Multiphase flows in volcanology: Modeling, theory and Experiment.* Preliminary report.

We study reduced models for transport of heavy particles in the air as in some problems arising after volcanic eruptions. Models can be applied also to the analysis of transport of particles of pollutant in the ocean. If the suspension is dilute, the particles transported by the fluid can modeled by another continuum phase with certain Eulerian models. Theoretical results and some numerical experiments will be shown. (Received February 08, 2015)

Session 43

1111-35-450 **Gianmaria Verzini*** (gianmaria.verzini@polimi.it), Politecnico di Milano, Italy. *Solutions with prescribed mass for nonlinear Schrödinger equations and systems.*

For a class of nonlinear Schrödinger equations and systems, we investigate the existence and the orbital stability of standing waves having components with prescribed L^2-mass. We provide a variational characterization of such solutions, which gives information on the stability through a condition of Grillakis-Shatah-Strauss type. (Received February 08, 2015)

Session 10

1111-35-466 **Jacek Banasiak*** (banasiak@ukzn.ac.za), School of Mathematics, Statistics and, Computer Science, University of KwaZulu-Natal, Durban, KwaZulu-Na 4000, South Africa. *Analyticity of fragmentation semigroups with applications.*

We consider discrete fragmentation coagulation models and present results on analyticity and compactness of the fragmentation semigroup. These results allow for showing global classical solvability of a class of fragmentation-coagulation equations.

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Session 10

1111-35-500 **Henry van Roessel*** (hvanroes@ualberta.ca), Department of Math & Stat Sciences, University of Alberta, Edmonton, Alberta T6G 2G1, Canada. *Coagulation equations with nonhomogeneous kernels.*

Coagulation processes are to be found everywhere in nature: from the coalescence of aerosols and polymers on the microscopic scale to the coalescence of water to form hail stones on the macroscopic scale to the formation of planets and stars on the cosmic scale.

The earliest equation to model coagulation processes was derived by Smoluchowski in 1916. The Smoluchowski coagulation equation, along with various extensions and generalizations, have been widely studied. While the general coagulation process, namely the coming together of small particle clusters to form larger particle clusters, are common, the physics governing the coalescence of aerosols and the formation of planets is undoubtedly very different. These physical differences are manifested in the particular coagulation kernel that is assumed in the coagulation equation.

In their quest to understand symmetry in coagulation processes, mathematicians and physicists have attempted to find self-similar solutions to Smoluchowski's coagulation equation. When looking for self-similar solutions, it is natural to consider homogeneous coagulation kernels. In this talk I hope to show that some interesting phenomena can be found by considering non-homogeneous coagulation kernels. (Received February 08, 2015)

Session 43

1111-35-513 **Denis Bonheure*** (dbonheur@ulb.ac.be), Université libre de Bruxelles, Département de mathématique, Blvd du Triomphe CP 214, 1050 Bruxelles, Belgium. *Mixed diffusion or mixed dispersion.*

Two models extensively studied by the community in elliptic PDE in the past 25 years are the Allen-Cahn equation ($\alpha = 1$) and the stationary Schrödinger equation ($\alpha = -1$)

$$-\Delta u = \alpha(u - u^3).$$

The aim of my talk will be to address some perspectives on fourth order extensions of these models, namely on mixed diffusion/dispersion equations

$$\gamma\Delta^2 u - \Delta u = \alpha(u - u^3).$$

The parameter γ is positive, $\alpha = 1$ corresponds to the extended Fisher-Kolmogorov equation (EFK) and $\alpha = -1$ to the stationary fourth order nonlinear Schrödinger equation (4NLS) with Kerr nonlinearity. I will first explain the phenomenological interests of these mixed diffusion/dispersion models and then I will review a (certainly non exhaustive) list of classical results for the second order models and their counterparts for the extended models, emphasizing the recent progresses, new difficulties and some central open questions. (Received February 09, 2015)

Session 33

1111-35-515 **Youcef Mammeri*** (youcef.mammeri@u-picardie.fr), Université de Picardie Jules Verne, LAMFA CNRS UMR 7352, 33 rue Saint Leu, 80300 Amiens, France, and **Nabil Bedjaoui** and **Joaquim M.C. Correia**. *On vanishing nonlinear dissipative-dispersive perturbations of conservation laws.*

In presence of nonlinear diffusion and dispersion, we study the well-posedness of the conservation equation

$$u_t + f(u)_x = \delta g(u_{xx})_x + \varepsilon h(u_x)_x.$$

Then, as the right-hand perturbations vanish, we prove convergence of the previous solutions to the entropy weak solution of the hyperbolic conservation law

$$u_t + f(u)_x = 0.$$

When $\delta = 0$ we reduce to the generalized Burgers equation and the approximate solutions $u^{\varepsilon,0}$ converge to the solution of the inviscid Burgers equation. This is the *vanishing viscosity method*. On the other hand, when $\varepsilon = 0$ and considering the flux function $f(u) = u^2$ and the linear dispersion δu_{xxx}, we obtain the Korteweg-de Vries equation for which the approximate solutions $u^{0,\delta}$ do not converge. So, as parameters ε and δ vanish, we are concerned with singular limits and a dominant dissipation regime is needed to ensure convergence. (Received February 09, 2015)

Session 48

1111-35-555 **Raphael Danchin*** (danchin@univ-paris12.fr), LAMA, UMR 8050, Universite Paris-Est Creteil, 94010 Creteil, France. *Mathematical analysis of a model for radiative flows.* Preliminary report.

In this joint work with B. Ducomet (from CEA, France), we consider a simplified model arising in radiation hydrodynamics which is based on the barotropic Navier-Stokes system describing the macroscopic fluid motion, and on the so-called P1-approximation of the transfer radiative equation modeling the propagation of radiative intensity.

We establish the global-in-time existence of strong solutions for the associated Cauchy problem when initial data are close to a stable radiative equilibrium, and local existence for large data with no vacuum. All our results are stated in the so-called critical Besov spaces. In passing we point out a necessary and sufficient condition for linear stability, that implies nonlinear stability. (Received February 09, 2015)

Session 48

1111-35-560 **Donatella Donatelli**, I, and **Konstantina Trivisa*** (trivisa@math.umd.edu), University of Maryland, College Park, MD 20742. *On a nonlinear model for tumor growth with drug application.*

This work deals with the investigation of the dynamics of a nonlinear system modeling tumor growth with drug application. The tumor is viewed as a mixture consisting of proliferating, quiescent and extra-cellular cells as well as a nutrient in the presence of a drug. The system is given by a multi-phase flow model: the densities of the different cells are governed by a set of transport equations, the density of the nutrient and the density of the drug are governed by rather general diffusion equations, while the velocity of the tumor is given by Brinkman's equation. The domain occupied by the tumor in this setting is a growing continuum Ω with boundary $\partial\Omega$ both of which evolve in time. Global-in-time weak solutions are obtained using an approach based on penalization of the boundary behavior, diffusion and viscosity in the weak formulation. Both the solutions and the domain are rather general, no symmetry assumption is required and the result holds for large initial data. This article is part of a research program whose aim is the investigation of the effect of drug application in tumor growth. (Received February 09, 2015)

Session 33

1111-35-570 **Michael Grinfeld*** (m.grinfeld@strath.ac.uk), Department of Mathematics and Statistics, University of Strathclyde, 26 Richmond Street, Glasgow, United Kingdom. *Burgers equation with saturating flux.*

We reconsider the problem of one-dimensional Burgers equation with a quasilinear parabolic operator with monotone saturating flux introduced by Rosenau and coworkers,

$$u_t + 1/2(u^2)_x = \mu(Q(u_x))_x, x \in \mathbb{R},$$

where

$$Q(s) = \frac{s}{\sqrt{1+s^2}}.$$

We present a comprehensive classification of all possible behaviors of solutions to the Riemann problem under changes of initial data and the diffusion coefficient μ. (Received February 09, 2015)

Session 33

1111-35-604 **Philippe G. LeFloch*** (contact@philippelefloch.org), Laboratoire Jacques-Louis Lions, University Pierre et Marie Curie, 92160 PARIS, France. *Hyperbolic balance laws with entropy on a curved spacetime.*

In this talk, I will discuss the class of nonlinear, first-order, hyperbolic balance laws that are posed on a curved spacetime and are endowed with an entropy which need not be uniformly convex. I will present a weak–strong uniqueness and stability theorem for the initial value problem, which compares two solutions with limited regularity, that is, a continuous solution that need not be Lipschitz continuous and a weak solution that satisfies an entropy inequality. The proposed theory applies to the Euler system for compressible fluid flows on a curved spacetime, for which the entropy is strictly convex but fails to be uniformly convex as vacuum is approached. This analysis yields a uniqueness theorem for (both the relativistic and non-relativistic versions of) the Euler system for solutions with vacuum. (Received February 09, 2015)

Session 36

1111-35-646 **Graça Carita*** (gcarita@uevora.pt), **Vladimir Goncharov** and **Gueorgui Smirnov**. *Variational Problem of Plastic Surgery.*

We prove existence of minimizers in variational problems with polyconvex coercive integrands and so called knitting (or suturing) boundary conditions. Such kind of variational problems appears as minimization of the energy of elastic tissues in the Plastic Surgery. This is a joint work with Vladimir Goncharov and Gueorgui Smirnov. (Received February 09, 2015)

Session 33

1111-35-683 **François James***, MAPMO - UMR CNRS 7349, Université d'Orléans, 45067 Orléans, France, and **Hélène Mathis**. *Phase transition and metastability.*

We propose a model for phase transition which describes metastable states as well. In constrast with usual models, it makes use of only one equation of state, of van der Waals type. Thermodynamics is accounted for by a dynamical system whose attractors represent all the possible thermodynamical states, in the spinodal zone as well as thermodynamically or metastable states. This dynamical system is then used as a relaxation term for the isothermal Euler equations, and some examples are proposed (Received February 10, 2015)

Session 33

1111-35-709 **Wladimir Neves***, wladimir@im.ufrj.br. *Some results for nonlocal diffusion equations.*

We present some results concerning nonlocal diffusion equations. Mostly, the nonlocal operator it will be the fractional Laplacian. Besides the mathematical interesting aspects, we address also the physical interpretation behind the nonlocal diffusion process, which is to enlarge the concept of Simple Materials introduced by Walter Noll. (Received February 10, 2015)

Session 43

1111-35-722 **Marie-Françoise Bidaut-Veron*** (veronmf@univ-tours.fr), LMPT, Université F. Rabelais, 37200 Tours, France. *Existence of solutions of an Hamiltonian elliptic system with measure data.*

Here we consider the positive solutions of the Hamiltonian system in $\mathbb{R}^N$

$$(S)\begin{cases} -\Delta u = v^p + \mu \\ -\Delta v = u^q + \eta \end{cases}$$

where $p, q > 0$ and $pq > 1$, and μ, η are bounded Radon measures on $\mathbb{R}^N$. We give sufficient conditions for existence in terms of capacity of fractional order, which appear to be optimal when $p < N/(N-2)$ or $q < N/(N-2)$. For this purpose, we prove suitable Wölf potential estimates on the solutions. Thus the method can be extended to more general quasilinear systems, where for example the Laplacian is replaced by a m-Laplacian, $m > 1$.

We recall that in case $\mu = \eta = 0$, the Serrin's conjecture of nonexistence of positive solutions of system (S) in whole $\mathbb{R}^N$ for (p, q) under the hyperbola $1/(p+1) + 1/(q+1) = (N-2)/N$ has been solved for $N \leqq 4$ by P. Souplet, and the question is still open in higher dimensions. (Received February 10, 2015)

Contr.Session

1111-35-740 **Maria Lewtchuk Espindola*** (mariia@mat.ufpb.br), DM/CCEN/Universidade Federal da Paraiba, Brazil. *Generalized Solution to the p-Laplace PDE:* $u_x^2 u_{xx} + 2u_x u_y u_{xy} + u_y^2 u_{yy} = 0.$

The solutions to the p-Laplace partial differential equation $u_x^2 u_{xx} + 2u_x u_y u_{xy} + u_y^2 u_{yy} = 0$ are enlarged in this article. For this purpose the Monge method for uniform partial differential equations reduces the above equation to a Monge system. This system results in a PDE of first order of the type $f(u_x, u_y) = 0$. A method developed in previous papers by Espindola* to the PDE $f(u_x, u_y) = 0$, furnishes a general solution which is a generalized solution of the p-Laplace as it contains one an arbitrary function.

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Session 24

1111-35-754 **Steve Zelditch*** (zelditch@math.northwestern.edu), 839 Lincoln St., Evanston, IL 60208. *Counting nodal domains on surfaces.*

An open problem in spectral geometry is to show that the number of nodal domains tends to infinity for some sequence of eigenfunctions. It is known the number does not tend to infinity for all sequences of eigenfunctions on some special Riemannian manifolds. The main result to be presented is that if a surface has non-positive curvature and concave boundary, then the number of nodal domains tends to infinity for almost the entire sequence of eigenfunctions (there may exist a sparse subsequence of exceptional eigenfunctions). The same result also holds for negatively curved surfaces without boundary but with an anti-holomorphic isometric involution. This is joint work with Junehyuk Jung. (Received February 10, 2015)

Session 10

1111-35-756 **Ankik Kumar Giri*** (ankik.math@gmail.com), Department of Mathematics, Indian Institute of Technology Roorkee, Roorkee, 247667, India, and **Prasanta Kumar Barik**. *Existence and uniqueness of weak solutions to the general nonlinear fragmentation equation.*

Fragmentation is a continuous process of the breaking up of particles into small sized particles. This process occurs due to external forces, spontaneously or due to collision or interaction between a pair of particles. This process may occur in many physical environment such as breakup of grains, polymer degradation, liquid droplet breakup and breakup of small eddies in a turbulent fluid flow etc. The fragmentation occurs due to external force can be expressed by linear fragmentation equation.

In this work, we are mainly interested in a nonlinear irreversible fragmentation which is induced by interactions/collisions between pairs of particles. This process can be expressed by a nonlinear integro-partial differential equation, which is called the nonlinear fragmentation equation.

Most of mathematical studies on the existence and uniqueness of weak solutions of fragmentation equations are devoted to the linear fragmentation equation. In the present work, we study the existence and uniqueness of weak solutions to the general nonlinear fragmentation equation for large classes of unbounded collision kernel and breakage function. (Received February 10, 2015)

Session 43

1111-35-763 **Eugenio M. Rocha*** (eugenio@ua.pt), Campus de Santiago, 3810-193 Aveiro, Aveiro, Portugal. *Multiplicity results for elliptic problems in adapted Sobolev spaces.*

We discuss the existence and multiplicity of solutions of some classes of variational elliptic problems defined in Sobolev spaces, which are adapted to a monotone operator (with further required properties). Such framework may include local and nonlocal operators, as the p-Laplacian and the fractional Laplacian. Briefly, we also discuss a very general discretisation method for problems of Schrodinger-Poisson system type, by applying the theory of reproducing kernels and the homotopy analysis method. (Received February 10, 2015)

Session 46

1111-35-777 **Matteo Dalla Riva*** (matteo@ua.pt), Departamento de Matemática, Universidade de Aveiro, Campus Universitário de Santiago, 3800-193 Aveiro, Portugal, and **Gennady Mishuris**, Department of Mathematics, Physical Sciences Building, Penglais Campus, Aberystwyth University, Aberystwyth, Ceredigion SY23 3BZ, United Kingdom. *Existence results for a nonlinear transmission problem.*

We consider two open regular domains Ω^o and Ω^i, with the closure of Ω^i contained in Ω^o. Then we consider the problem of finding two functions u^o and u^i, harmonic in $\Omega^o \setminus \Omega^i$ and Ω^i, respectively, which satisfy the contact conditions $u^o(x) = F(x, u^i(x))$ and $\partial_{\nu^i} u^o(x) - \partial_{\nu^i} u^i(x) = G(x, u^i(x))$ on the interface boundary $\partial\Omega^i$, where ν^i denotes the outer unit normal to Ω^i. We aim to study existence and uniqueness properties of u^o and u^i under minimal assumptions on the functions F and G, and show that the existence of solutions is achievable also under conditions that are not sufficient to imply the uniqueness. We observe that nonlinear transmission conditions of this kind arise in continuum mechanics when considering heat flow through a thin adhesive layer between component materials. (Received February 10, 2015)

Session 43

1111-35-787 **Benedetta Pellacci*** (benedetta.pellacci@uniparthenope.it). *Saturable Schrödinger equation and systems: Existence and related topics.*

We will discuss some aspects of Schrödinger equations and systems with the presence of a saturable effect; namely, we will focus on existence of least action solutions and concentration phenomena. (Received February 10, 2015)

Session 36

1111-35-802 **Gurgen Hayrapetyan***, hayrapet@ohio.edu. *Sharp interface evolution in amphiphilic systems.* Preliminary report.

Amphiphilic systems arise as cellular membranes and ion channels in biological systems and drive the self-assembled nanoscale network morphologies, which are essential to the efficiency of energy conversion devices such as fuel cells, Lithium ion batteries, and dye sensitized solar cells. We discuss results in interface evolution within amphiphilic systems, including the nonlinear stability of bi-layer interfaces in the Functionalized Cahn-Hilliard equation. (Received February 10, 2015)

37 ► Dynamical systems and ergodic theory

Session 50

1111-37-61 **Sandro Vaienti*** (sandro.vaienti@gmail.com). *Extreme value theory for perturbed and contracting systems.*

We present new results on extreme value theory for randomly perturbed dynamical systems with applications to piecewise contracting maps. (Received January 16, 2015)

Session 30

1111-37-72 **Arnaud Chéritat*** (arnaud.cheritat@math.univ-toulouse.fr). *Siegel disks of degree 3 polynomials.* Preliminary report.

I will review the state of the art on Siegel disks of degree three polynomials. (Received January 19, 2015)

Session 50

1111-37-83 **Paulo Varandas*** (pcvarand@gmail.com), Instituto de Matemática da UFBA, Av. Ademar de Barros s/n, Salvador, Bahia 40170-110, Brazil. *Specification properties and thermodynamical properties of semigroups.* Preliminary report.

The thermodynamical formalism was brought from statistical mechanics to dynamical systems by the pioneering works of Sinai, Ruelle and Bowen. An extension of the thermodynamical formalism for continuous finitely generated group actions has revealed fundamental difficulties and a unified approach to the thermodynamical formalism of continuous group actions is still unavailable. In fact, few definitions of topological pressure exist, most of them unrelated, and take into account either abelianity, amenability or the group growth rate. In this talk we will extend partially some notions from statistical mechanics and used much successfully by Ruelle for Zd-actions. We introduce the strong and orbital specification notions for continuous actions associated to finitely generated (not necessarily abelian) groups and study its relation with entropy points, exponential growth of periodic points and positive (averaged) topological entropy. This is a joint work with Fagner Bernardini (UFRGS). (Received January 20, 2015)

Session 39

1111-37-93 **Michael J Field*** (mikefield@gmail.com), Department of Mathematics, Imperial College, South Kensington Campus, London, SW7 2AZ, United Kingdom. *Visualizing complex dynamics and structure in dynamical systems.* Preliminary report.

We explain and show some recent work that uses graphic art to discover, describe and analyze complex dynamics in networks of dynamical systems. Notwithstanding the title and abstract, the talk is intended for a general audience and will have a significant visual component. (Received January 21, 2015)

Session 14

1111-37-99 **Nessim Sibony*** (nessim.sibony@math.u-psud.fr). *Analysis on laminations by Riemann Surfaces.*

Let (X,L,E) be be a lamination by Riemann surfaces. Assume, for simplicity,that the singularity set E is a finite set of points Then every hyperbolic leaf, l, is covered by the unit disc D. We consider the associated measure m(a,R) which is obtained by averaging until "hyperbolic time" R along the leaves. using the parametrization by the universal covering map . Let ω_P denote the Poincaré metric on D and also on the leaves of X. We obtain the following Birkhoff type Theorem.

Theorem. (Dinh-Nguyen-Sibony) Let (X,L,E) be a compact lamination with isolated singularities in a complex manifold M and ω_P the Poincaré metric on the leaves. Let T be an extremal positive harmonic current of Poincar{é} mass 1 on (X,L,E) without mass on the union of parabolic leaves. Then for almost every point a in X with respect to the measure $m_P := T \wedge \omega_P$, the measure m{a,R} defined above converges to m_P when $R \to \infty$. If time permits, I will mention a notion of entropy for foliations and discuss some analogies with Nevanlinna's theory. (Received January 22, 2015)

Session 26

1111-37-105 **Michael J Field*** (mikefield@gmail.com), Department of Mathematics, Imperial College, South Kensington Campus, London, SW7 2AZ, United Kingdom. *Realizing a heteroclinic network in a homogeneous or heterogeneous identical cell system.*

We describe results that enable realization of general heteroclinic networks in coupled homogeneous and heterogeneous systems of identical cells. As part of this work, we describe models for network dynamics that allow for realistic input structure and coupling and, in particular, variation in the number of inputs to identical cells: additive input structure. (Received January 22, 2015)

Session 26

1111-37-120 **Roberto Barrio*** (rbarrio@unizar.es), Departamento de Matematica Aplicada, Edificio de Matematicas, Universidad de Zaragoza, 50009 Zaragoza, Spain, and **M. Angeles Martinez**, **Marcos Rodriguez**, **Sergio Serrano** and **Andrey Shilnikov**. *Homoclinic and Heteroclinic phenomena in single neuron models and in small neuron networks.*

In this talk we study the role of the homoclinic and heteroclinic bifurcations in single neuron models and in small neuron networks (CPGs).

In the single neuron case we characterize the systematic changes in the topological structure of chaotic attractors that occur as spike-adding and homoclinic bifurcations are encountered in the slow-fast dynamics of neuron models. This phenomenon is detailed in the Hindmarsh-Rose neuron model and in the heart leech neuron-model, where we show that the unstable periodic orbits appearing after each spike-adding bifurcation are associated with specific symbolic sequences in the canonical symbolic encoding of the dynamics.

The heteroclinic cycles in neuron networks (CPGs) create slow switching oscillations that achieve the level of robustness and stability observed in nature. This fact creates a typical behavior of a robust "jiggling" behaviour in bursting synchronization. To study biologically plausible CPG models (in our case a CPG model of 3 leech heart neurons) it is necessary to use specially adapted techniques to take into account that the equations are grouped by each neuron. The combination of these techniques permits to obtain "continuation-like" results that detail the complete bifurcation process. (Received January 26, 2015)

Session 30

1111-37-121 **Bogusława Karpińska*** (b.karpinska@mini.pw.edu.pl), Faculty of Mathematics and Inf. Science, Warsaw University of Technology, ul.Koszykowa 75, 00-661 Warsaw, Poland. *Absorbing domains for holomorphic maps I.*

We present some results concerning the existence and properties of absorbing domains for holomorphic self-maps f of a hyperbolic domain U in $\mathbb{C}$ such that the iterates of f converge to a boundary point of U. In particular, we discuss the relation between the type of f (in the sense of the Baker-Pommerenke-Cowen classification), its dynamical behavior and simple-connectedness of the absorbing domain. This is a joint work with K. Barański, N. Fagella and X. Jarque. (Received January 26, 2015)

Session 30

1111-37-122 **Krzysztof Barański*** (baranski@mimuw.edu.pl), Institute of Mathematics, University of Warsaw, ul. Banacha 2, 02-097 Warsaw, Poland. *Absorbing domains for holomorphic maps II.*

We consider holomorphic maps $f : U \to U$ for a hyperbolic domain U in the complex plane, such that the iterates of f converge to a boundary point of U. For such maps there exist nice absorbing domains $W \subset U$. We show that W can be chosen to be simply connected, if f has doubly parabolic type in the sense of the Baker–Pommerenke–Cowen classification of its lift by a universal covering. Moreover, we provide counterexamples for other types of the map f. This is a joint work with N. Fagella, X. Jarque and B. Karpińska. (Received January 26, 2015)

Session 26

1111-37-141 **Juergen Knobloch*** (juergen.knobloch@tu-ilmenau.de), TU Ilmenau, PF 100565, 98684 Ilmenau, Germany. *Perturbations of homoclinic snaking scenarios.*

Homoclinic snaking refers to the shape of the continuation curve of homoclinic orbits to an equilibrium E near a heteroclinic cycle connecting this equilibrium and a periodic orbit P. Typically this behaviour has been studied in reversible, conservative systems where the continuation takes place within a one-parameter family. The entire bifurcation/continuation diagram is also referred to as snakes-and-ladder structure.

Here we discuss perturbations of this scenario which are both non-reversible and non-conservative. We treat this problem analytically in the spirit of the work by Beck et al., *SIAM J. Math. Anal.* **41** (2009) 936–972. The continuation of homoclinic orbits now happens with respect to both the original continuation parameter μ and the perturbation parameter λ. The continuation curves are parametrised by the dwelling time L of the homoclinic orbit near P. It turns out that λ tends to zero while the μ vs. L diagram displays isolas or criss-cross snaking curves in a neighbourhood of the original snakes-and-ladder structure.

In the course of our studies we adapt both Fenichel coordinates near P and the analysis of Shilnikov problems near P to the present situation. (Received January 28, 2015)

Session 21

1111-37-155 **Natalia Martins*** (natalia@ua.pt), University of Aveiro, 3810-193 Aveiro, Portugal, and **Agnieszka B. Malinowska**, **Ewa Girejko** and **Luis Machado**. *Krause's model of opinion dynamics on time scales.*

We analyse bounded confidence models on time scales. In such models each agent takes into account only the assessments of the agents whose opinions are not too far away from his own opinion. We prove a convergence into clusters of agents, with all agents in the same cluster having the same opinion. A necessary condition for reaching a consensus is given. Simulations are performed to validate the theoretical results. (Received January 29, 2015)

Session 26

1111-37-157 **Claire M. Postlethwaite** (c.postlethwaite@auckland.ac.nz), Department of Mathematics, Auckland University, Auckland, New Zealand, and **Alastair M. Rucklidge*** (a.m.rucklidge@leeds.ac.uk), School of Mathematics, University of Leeds, Leeds, LS2 9JT, United Kingdom. *Travelling waves in spatial Rock–Paper–Scissors.* Preliminary report.

The simple game of Rock–Paper–Scissors, where rock is wrapped by paper, paper is cut by scissors, and scissors are crushed by rock, is an archetype for cyclic dominance in evolutionary game theory. Without spatial structure, the dynamics results in a heteroclinic cycle between three equilibria; with one spatial dimension, travelling waves are found; whereas in two-dimensional spatially extended systems, spiral patterns of cyclic dominance can be observed. We use heteroclinic cycle methods to compute the wavelength and speed of the waves in the spiral pattern. (Received January 30, 2015)

Session 18

1111-37-187 **C. S. Moreira*** (cmoreira@fc.up.pt). *Special Jordan subspaces and synchrony in coupled cell networks.*

Networks are studied in many different areas of science and examples are numerous and varied. From the dynamical point of view in networks, it is of interest to study when distinct individuals exhibit identical dynamics, at all instants of time, being synchronized. For example, in the 17th century, the physicist Christiaan Huygens, inventor of the pendulum clock, was surprised by the synchronization of the motion of two pendula. In nature, one of the most spectacular examples occurs when thousands of male fireflies gather in trees at night and flash in unison to attract females, providing a silent, hypnotic concert.

Given a regular network, we single out a class of special subspaces of eigenspaces and generalized eigenspaces and we use these subspaces to study the synchrony phenomenon in the theory of coupled cell networks. To be more precise, we prove that the synchrony subspaces of a regular network are precisely the polydiagonals that are direct sums of these special subspaces. We also show that they play an important role in the lattice structure of all synchrony subspaces because every join-irreducible element of the lattice is the smallest synchrony subspace containing at least one of those special subspaces. (Received February 02, 2015)

Session 30

1111-37-209 **Jinsong Zeng*** (mczjs@qq.com). *Criterion for rays landing together.*

Let f be a polynomial with degree ≥ 2 and the Julia set J_f locally connected. We give a partition of complex plane $\mathbb{C}$ and show that, if z, z' in J_f have the same itinerary respect to the partition, then either $z = z'$ or both of them lie in the boundary of a Fatou component U, which is eventually iterated to a siegel disk. As an application, we prove the monotonicity of core entropy for the quadratic polynomial family $\{f_c = z^2 + c :$ f_c has no Siegel disks and J_{f_c} is locally connected $\}$. (Received February 02, 2015)

Session 50

1111-37-249 **J.R. Chazottes***, CPHT, Ecole polytechnique, 91128 Palaiseau, France. *Approximation for the number of visits to balls for a class of non uniformly hyperbolic systems.*

For dynamical systems modeled by Young towers with exponential tails, we present a theorem giving a poisonnian approximation for the number of visits to balls. This is a joint work with Pierre Collet. (Received February 03, 2015)

Session 18

1111-37-256 **Bob Rink*** (b.w.rink@vu.nl), **Jan Sanders** and **Eddie Nijholt**. *Are networks governed by hidden symmetry?*

Networks of coupled nonlinear dynamical systems often display unexpected phenomena. They may for example synchronise. This form of collective behaviour occurs when the agents of the network behave in unison. An example is the simultaneous firing of neurons. The existing elaborate theory for synchrony was recently reformulated by DeVille and Lerman. They show that the patterns of synchrony of network systems are determined by so-called graph fibrations.

In this talk I will show how graph fibrations also impact the global dynamics of networks. They are for example responsible for the unusual character of synchrony-breaking bifurcations in various networks. These bifurcations are forced by self-fibrations of a high dimensional lift of these networks. This observation implies that these networks are nothing but unusual examples of equivariant dynamical systems, and can be understood with the help of semigroup theory, representation theory and techniques from equivariant dynamical systems theory. (Received February 04, 2015)

Session 30

1111-37-283 **Pascale Roesch*** (`pascale.roesch@univ-amu.fr`), Technopôle Château-Gombert, 39, rue Frédéric Joliot-Curie, 13453 Marseille Cedex 13, France. *Newton Methods.*

This is a common work with Magnus Aspenberg. I will explain how to see that cubic Newton methods are matings of two particular cubic polynomials. This result has been conjectured by Tan Lei. (Received February 04, 2015)

Session 50

1111-37-312 **Henk Bruin*** (`henk.bruin@univie.ac.at`), Faculty of Mathematic, University of Vienna, Oskar Morgensternplatz 1, Vienna, Austria. *A renewal scheme for non-uniformly hyperbolic semiflows.*

In this talk I want to report on joint work with Dalia Terhesiu, establishing an abstract framework of hypotheses leading to sharp mixing rates of non-uniformly hyperbolic semiflows (in both the finite and infnite measure preserving setting). In particular I want to explain the use of remetrizing (unbounded length) flowbox so as to give a transfer operator that plays a central role in the renewal theory approach the required spectral properties. (Received February 05, 2015)

Session 30

1111-37-314 **Núria Fagella*** (`fagella@maia.ub.es`), Dep. of Matemàtica Aplicada i Anàlisi, Universitat de Barcelona, Gran Via 585, 08007 Barcelona, Spain. *Connectivity of Julia sets of Newton maps: A unified approach (II).*

This is part II of Xavier Jarque's talk. The common abstract is as follows.

In this series of two talks we give a unified proof of the fact that the Julia set of Newton's method applied to a holomorphic function of the complex plane (a polynomial of degree larger than 1 or an entire transcendental function) is connected. The result was recently completed by the speaker's previous work (joint with K. Barański, X. Jarque and B. Karpińska), as a consequence of a more general theorem whose proof spreads among many papers, which consider separately a number of particular cases for rational and transcendental maps, and use a variety of techniques. In this talk we present a unified, direct and reasonably self-contained proof which works for all situations alike. (Received February 05, 2015)

Session 30

1111-37-319 **Adam Lawrence Epstein*** (`a.l.epstein@warwick.ac.uk`), Mathematics Institute, University of Warwick, Coventry, CV47AL, United Kingdom. *Generalizing Douady's Magic Formula.* Preliminary report.

Douady observed that the dyadic affine transformation $\theta \mapsto \frac{1}{4}\theta + \frac{1}{2}$ sends angles of external rays landing on the main cardioid of the Mandelbrot set to angles of rays landing on the real axis. We show that every hyperbolic component gives rise to such a formula. (Received February 05, 2015)

Session 30

1111-37-321 **Nuria Fagella** (`fagella@maia.ub.es`), Universitat Barcelona, Dep. de Matemàtica Aplicada i Anàlisi, Gran Via 585, 08005 Barcelona, Spain, and **Linda Keen*** (`lkeen@gc.cuny.edu`), Graduate Center CUNY, Mathematics Program, 365 Fifth Ave, New York, NY 10016. *Shell components of transcendental meromorphic maps.* Preliminary report.

In this talk we will be concerned with some one (complex) dimensional slices of parameter spaces transcendental meromorphic maps. Properties of components of these slices are controlled by the singularities of the functions. Components in which the functions have attracting cycles that attract a critical point are often "Mandelbrot-like" whereas those that attract an asymptotic value are quite different and have a shell-like appearance. These appear, for example, in the family of tangent maps. In this talk we will describe these *Shell components.* (Received February 05, 2015)

Session 50

1111-37-323 **Neil B Dobbs*** (`neil.dobbs@unige.ch`). *Quasistatic dynamical systems.*

We investigate slowly-transforming deterministic dynamical systems. Since there are no equilibrium states in such a set-up, we study Birkhoff sums of observables. In the limit, we obtain a description of the statistical properties of the system as a stochastic diffusion process. This is joint work with Mikko Stenlund. (Received February 05, 2015)

Session 14

1111-37-336 **Alexey Glutsyuk*** (aglutsyu@ens-lyon.fr), UMPA, M.R., ENS de Lyon, 46, allée d'Italie, 69364 Lyon, France. *On periodic orbits in complex billiards and tangential correspondence.*

A conjecture of Victor Ivrii (1980) says that in every billiard with smooth boundary the set of periodic orbits has measure zero. This conjecture is closely related to spectral theory. Its particular case for triangular orbits was proved by M. Rychlik (1989), Ya. Vorobets (1994) and other mathematicians. The case of quadrilateral orbits in dimension two was treated in our joint work with Yu. Kudryashov (2012). A new approach to Ivrii's conjecture is to study its complexification. We present a survey of results on the complexified Ivrii's conjecture and open questions. A positive answer for triangular complex orbits and the classification of complex counterexamples with four reflections were earlier obtained by the speaker. We present recent positive results for a billiard on one irreducible complex planar algebraic curve under mild additional conditions on the tangential correspondence. (Received February 06, 2015)

Session 26

1111-37-340 **Ale Jan Homburg*** (a.j.homburg@uva.nl), Korteweg-de Vries Institute for Mathematics, University of Amsterdam, Science Park 107, 1098XG Amsterdam, Netherlands. *Codimension one homoclinic cycles.*

I will discuss homoclinic cycles in differential equations that are equivariant under the action of a finite group. Depending on symmetry and differential equation, such homoclinic cycles may occur robustly or be of some codimension. I will discuss bifurcations of homoclinic cycles that are of codimension one. (Received February 06, 2015)

Session 50

1111-37-341 **Romain Aimino*** (aimino@mat.uniroma2.it), **Matthew Nicol** and **Sandro Vaienti**. *Annealed and quenched central limit theorems for random dynamical systems.*

For random dynamical systems, one can distinguish two kinds of limit theorems: annealed results, which refer to the Birkhoff sums seen as functions of both the phase space variable and the choice of the maps composed, and quenched results, which refer to Birkhoff sums for a fixed, but generic, composition of maps. In this talk, I will describe results about the central limit theorem for random dynamical systems consisting of uniformly expanding maps. In particular, I will show that the annealed central limit theorem is valid for such systems, and I will give a necessary and sufficient condition for its quenched version without random centering to hold. (Received February 06, 2015)

Session 14

1111-37-355 **Helena Reis*** (hreis@fep.up.pt), Univ. Porto, Portugal. *2-dimensional Lie algebras and separatrices for vector fields on $(\mathbb{C}^3, 0)$, I.*

We show that holomorphic vector fields on $(\mathbb{C}^3, 0)$ have separatrices provided that they are embedded in a rank 2 representation of a two-dimensional Lie algebra. In turn, this result enables us to show that the second jet of a holomorphic vector field defined on a compact complex manifold M of dimension 3 cannot vanish at an isolated singular point provided that M carries more than a single holomorphic vector field. (Received February 06, 2015)

Session 14

1111-37-357 **Matthieu Astorg**, **Xavier Buff**, **Romain Dujardin**, **Han Peters** and **Jasmin Raissy*** (jraissy@math.univ-toulouse.fr), Institut de Mathématiques de Toulouse, 118 route de Narbonne, F-31062 Toulouse, France. *Wandering Fatou components in dimension two.*

The Fatou set of a holomorphic endomorphism of a complex manifold is the largest open set where the family of iterates of the map forms a normal family, and a Fatou component is a connected component of the Fatou set. In dimension one, Sullivan's Non Wandering Domain Theorem asserts that every Fatou component of a rational map is eventually periodic. Several classes of counter-examples have been found and studied for entire transcendental function in dimension one, but the question of the existence wandering Fatou components for polynomial endomorphisms in higher dimension remained open. We show, using techniques of parabolic bifurcation, that there exist polynomial endomorphisms of $\mathbb{C}^2$ with a wandering Fatou component. These maps are polynomial skew-products, and can be chosen to extend to holomorphic endomorphisms of the complex projective space. (Received February 06, 2015)

Session 14

1111-37-358 **Julio Rebelo*** (rebelo@math.univ-toulouse.fr), Institut de Mathematiques de Toulouse, France. *2-dimensional Lie algebras and separatrices for vector fields on* $(\mathbb{C}^3, 0)$*, II.*

We show that holomorphic vector fields on $(\mathbb{C}^3, 0)$ have separatrices provided that they are embedded in a rank 2 representation of a two-dimensional Lie algebra. In turn, this result enables us to show that the second jet of a holomorphic vector field defined on a compact complex manifold M of dimension 3 cannot vanish at an isolated singular point provided that M carries more than a single holomorphic vector field. (Received February 06, 2015)

Session 50

1111-37-382 **Joao Lopes Dias*** (jldias@iseg.ulisboa.pt), Departamento de Matemática, ISEG, Universidade de Lisboa, Rua do Quelhas 6, 1200-781 Lisbon, Portugal. *Hyperbolic attractors for contracting polygonal billiards.*

We consider polygonal billiards with a reflection law that contracts the angle. In this setting we show that if the polygon does not have parallel sides facing each other, then there are SRB measures that correspond to hyperbolic attractors. (Received February 06, 2015)

Session 26

1111-37-390 **Olga Podvigina*** (olgap@mitp.ru), IEPT RAS, 84/32 Profsoyuznaya St, Moscow, 117997, Russia, and **Pascal Chossat**. *Simple and pseudo-simple heteroclinic cycles in* R^4.

A heteroclinic cycle is a collection of equilibria (or more complicated bounded invariant sets) together with a set of connecting trajectories. In generic dynamical systems heteroclinic cycles are invariant sets of codimension at least one, but they can be structurally stable in systems which are equivariant under the action of a symmetry group, due to the existence of flow-invariant subspaces. A subgroup G of O(n) admits (pseudo-)simple heteroclinic cycles (structurally stable heteroclinic cycles satisfying certain additional constraints) if there exists an open subset of smooth G-equivariant vector fields in R^n, possessing such heteroclinic cycles. Using the quaternionic presentation of finite subgroups of SO(4), we obtain a list of subgroups of SO(4) that admit simple and/or pseudo-simple heteroclinic cycles. We discuss asymptotic stability of pseudo-simple cycles in R^4 and give an example of a periodic orbit bifurcating from such a cycle. (Received February 06, 2015)

Session 50

1111-37-398 **Ian Melbourne*** (i.melbourne@warwick.ac.uk), Department of Mathematics, University of Warwick, Coventry, CV4 7AL, United Kingdom, and **Paulo Varandas**. *Statistical properties for nonuniformly hyperbolic systems with slow contraction and expansion.*

We provide a systematic approach for deducing statistical limit laws via martingale-coboundary decomposition, for nonuniformly hyperbolic systems with slowly contracting and expanding directions. In particular, if the associated return time function is square-integrable, then we obtain the central limit theorem, the weak invariance principle, and an iterated version of the weak invariance principle. (The latter is a crucial ingredient in recent applications of rough path theory to homogenization of deterministic systems with multiple timescales.) (Received February 06, 2015)

Session 14

1111-37-402 **Scott Kaschner**, **Rodrigo Perez** and **Roland Roeder*** (rroeder@math.iupui.edu). *Rational maps of the projective plane with equal dynamical degrees and no invariant foliation.*

We present simple examples of rational maps of the complex projective plane with equal first and second dynamical degrees and no invariant foliation. We then discuss the search to understand their ergodic properties. (Received February 06, 2015)

Session 50

1111-37-403 **Vaughn Climenhaga*** (climenha@math.uh.edu). *Specification, statistical properties, and towers.*

Given a dynamical system with some hyperbolicity, the equilibrium states associated to sufficiently regular potentials often display stochastic behaviour. Two important tools for studying these equilibrium states are specification properties and tower constructions. I will describe how both uniform and non-uniform specification properties can be used to deduce existence of a tower with exponential tails, and hence to establish various statistical properties. (Received February 06, 2015)

Session 50

1111-37-458 **Thomas M Jordan***, School of Mathematics, University of Bristol, Bristol, BS8 1TW. *Phase transitions and multifractal analysis.*

Multifractal analysis typically involves studying how the Hausdorff dimension of certain level sets varies. In the case of standard Markov maps on the interval with finiteley many branches it is often the case that the Hausdorff dimension varies analytically. This is the case for level sets defined by the local dimension of Gibbs measure and quotients of Birkhoff sums for Hoelder continuous functions. However this is not always the case for maps with countably many branches such as the Gauss map.

The talk will look at possible phase transitions which occur when looking at multifractal spectra for countable Markov systems. In particular we will look at the result for Quotients of Birkhoff sums for Hoelder continuous functions. We will show that even in the countable case phase transitions are possible both in the case when the system satisfies the 'big image property' and when it is not satisfied. This talk contains joint work with Godofredo Iommi and with Godofredo Iommi and Mike Todd. (Received February 08, 2015)

Session 30

1111-37-459 **Carsten Lunde Petersen*** (lunde@ruc.dk), NSM, Build. 27.2, Roskilde University, Universitetsvej 1, DK-4000 Roskilde, Denmark, and **Luna Lomonaco** (lunalomonaco@gmail.com), Universidade de Sao Paulo., Rua do Matao, Butanta, Sao Paulo,, Sao Paulo 05508090, Brazil. *On quasi-conformal (in-) compatibility of satellite copies of the Mandelbrot set.*

In the paper "On the dynamics of polynomial-like mappings" Douady and Hubbard introduced the notion of polynomial-like maps. They used it to identify copies M′ of the Mandelbrot set inside the Mandelbrot set M. They conjectured that the primitive copies, which are characterized by having a cusp and a root for which the parabolic multiplier is equal to 1, are quasi-conformally homeomorphic to M. This is now a Theorem due to Lyubich. The satellite copies M′, which are characterized by having a smooth round main component and a root for which the parabolic multiplier is a q-th root of unity for some $q > 1$, are clearly not q-c homeomorphic to M. But are they mutually q-c homeomorphic? Or even q-c homeomorphic to half of the logistic Mandelbrot set? In this talk I will present a proof that two satellite copies M′ and M′′ are not q-c homeomorphic, if the root multipliers are q- and q'- roots of unity with $q \neq q'$. (Received February 08, 2015)

Session 19

1111-37-479 **Carlos Correia Ramos*** (ccr@uevora.pt), Dep de Matemática, Universidade de Évora, Rua Romão Ramalho, 59, 7000-671 Évora, Evora, Portugal. *Nonlinearity, control and decision.*

We analyse how nonlinearity is related with the concepts of control and decision making in certain key examples arising from well known simple models from biomathematics and computation. We develop further the relation between the three concepts in the context of iterated maps of the interval. (Received February 08, 2015)

Session 50

1111-37-505 **Mark Pollicott*** (masdbl@warwick.ac.uk), Department of Mathematics, Warwick University, Coventry, Warks CV4 7AL, United Kingdom, and **Anders Oberg** and **Anders Johansson**. *Ergodic properties of the Kusuoka measure.* Preliminary report.

We consider the Kusuoka measure on the Sierpinski triangle, and other related pro-finite fractals. We establish various dynamical and analytical properties of the measure by using transfer operator properties on a suitable Banach space. (Received February 09, 2015)

Session 14

1111-37-511 **Dominique Cerveau*** (dominique.cerveau@univ-rennes1.fr), IRMAR, Bat 22-23, Campus de Beaulieu, 35042 Rennes cedex, France. *Holomorphic foliations with hamiltonian initial part.*

We describe germs of codimension one holomorphic foliations with hamiltonian initial part. Such foliations are defined by holomorphic integrable 1-forms with generic initial part having a holomorphic first integral.

Joint work with M. Ravarra Vago and W. Costa e Silva. (Received February 09, 2015)

Session 44

1111-37-516 **Luis Gonzaga Albuquerque*** (lgalbu@uab.pt). *Smooth models of discontinuous systems.* Preliminary report.

In this talk we present smooth models of discontinuos systems and make a comparative study of their dynamics using Nonstandard Analysis, once the difference bettween continuity and S continuity allows the existence of smooth models of quick changing situations, where usually a discontinuos approach is used. (Received February 09, 2015)

Session 35

1111-37-526 **Nuno Franco*** (nmf@uevora.pt), Rua Romão Ramalho 59, 7000 Évora, Portugal, **Paulo Gomes** (pgomes@adm.isel.pt), Rua Conselheiro Emídio Navarro, 1, Lisboa, Portugal, and **Luís Silva** (lfs@adm.isel.pt), Rua Conselheiro Emídio Navarro, 1, Lisboa, Portugal. *Syllable Permutations and Hyperbolic Lorenz Knots.*

Lorenz knots are the knots corresponding to periodic orbits in the flow associated to the Lorenz system. This flow induces an iterated one-dimensional first-return map whose orbits can be represented, using symbolic dynamics, by finite words. As a result of Thurston's geometrization theorem, all knots can be classified as either torus, satellite or hyperbolic knots. Birman and Williams proved that all torus knots are Lorenz knots which can be represented by a class of words with a precise form. We consider about 20000 words corresponding to all non-trivial permutations of a sample of words associated to torus knots and, using the Topology and Geometry software *SnapPy*, we compute their hyperbolic volume, concluding that it is significantly different from zero, meaning that all these knots are hyperbolic. This leads us to conjecture that all knots in this family are hyperbolic. (Received February 09, 2015)

Session 30

1111-37-536 **Antonio Garijo*** (antonio.garijo@urv.cat), Avinguda dels Països Catalans, 26, Tarragona, Tarragona 43007. *On McMullen-like mappings.*

We introduce a generalization of particular dynamical behavior for rational maps. In 1988, C. McMullen showed that the Julia set of $f_\lambda(z) = z^n + \lambda/z^d$ for $|\lambda| \neq 0$ small enough is a Cantor set of circles if and only if $1/n + 1/d < 1$ holds. Several other specific singular perturbations of polynomials have been studied in recent years, all have parameter values where a Cantor set of circles is present in the associated Julia set. We unify these examples by defining a McMullen-like mapping as a rational map f associated to a hyperbolic postcritically finite polynomial P and a pole data $\mathcal{D}$ where we encode the location of every pole of f and the local degree at each pole. As for the McMullen family f_λ, we characterize a McMullen-like mapping using an arithmetic condition depending only on $(P, \mathcal{D})$. We show how to check the definition in practice providing new explicit examples of McMullen-like mappings for which a complete topological description of their Julia sets is made. (Received February 09, 2015)

Session 18

1111-37-561 **A S Dias*** (apdias@fc.up.pt), , Portugal. *An Overview of Synchrony in Coupled Cell Networks.*

One of the key aspects in the theory of coupled cell networks concerns the existence of flow-invariant subspaces defined in terms of equalities between cell coordinates for all coupled cell systems that respect a given coupled cell network structure - the synchrony subspaces. We review some recent concepts and results concerning synchrony subspaces on coupled cell networks. (Received February 09, 2015)

Session 18

1111-37-569 **Nikita Agarwal*** (nagarwal@iiserb.ac.in). *Networks with dynamic topology.* Preliminary report.

With the growing population, a large number of inter-connected networks are emerging. These networks can be viewed as a graph with nodes representing the members in the network and edges representing the flow of resources within the members of the network. In most cases, these edges are weighted. Also, in networks such as power grids and computer systems, the underlying graph structure or topology varies with time. Such a network is often termed as a switched network. In this talk, we will view a coupled cell network with a time-varying graph structure as a time-dependent switched network, give examples, and discuss results. (Received February 09, 2015)

Session 50

1111-37-577 **Nicolai Haydn** and **Matthew Nicol*** (nicol@math.uh.edu), Cullen Boulevard, Houston, TX 77204-3008, and **Andrew Torok** and **Sandro Vaienti**. *Almost sure invariance principle for sequential and non-stationary dynamical systems.* Preliminary report.

We establish almost sure invariance principles, a strong form of approximation by Brownian motion, for non-stationary time-series arising as observations on dynamical systems. Our examples include observations on sequential expanding maps, perturbed dynamical systems, non-stationary sequences of functions on hyperbolic systems as well as applications to the shrinking target problem in expanding systems. (Received February 09, 2015)

Session 50

1111-37-581 **Vaughn Climenhaga**, **Todd Fisher** and **Daniel J Thompson*** (thompson@math.osu.edu). *Unique equilibrium states for the robustly transitive diffeomorphisms of Mañé and Bonatti-Viana.*

We establish results on uniqueness of equilibrium states for the well-known Mañé and Bonatti-Viana examples of robustly transitive diffeomorphisms. This is an application of machinery developed by Vaughn Climenhaga and myself, which applies when systems satisfy suitably weakened versions of expansivity and the specification property. The Mañé examples are partially hyperbolic, whereas the Bonatti-Viana examples are not partially hyperbolic but admit a dominated splitting. I'll explain why these maps satisfy our hypotheses. This is joint work with Vaughn Climenhaga (Houston) and Todd Fisher (Brigham Young). (Received February 09, 2015)

Session 50

1111-37-582 **M P Holland*** (m.p.holland@exeter.ac.uk). *On Extremes, recurrence and record events in dynamical systems.* Preliminary report.

For dynamical systems we discuss the statistics of extremes, namely the statistical limit laws that govern the process $M_n = \max\{X_1, X_2, \ldots, X_n\}$, where X_i correspond to a stationary time series of observations generated by the dynamical system. We discuss extreme statistics for a range of examples of interest to those working in ergodic theory and chaotic dynamical systems. In a recent work, we discuss almost sure growth rates of M_n, and the statistics of records: namely the distribution of times n such that $X_n = M_n$. (Received February 09, 2015)

Session 30 1111-37-603 **Vasiliki Evdoridou*** (vasiliki.evdoridou@open.ac.uk). *Uniform rates of escape of transcendental entire functions.*

Let f be a transcendental entire function. A lot of progress has been made recently on the escaping set of f, I(f), and also the fast escaping set of f, A(f), which consists of the points that eventually escape to infinity faster than the iterates of the maximum modulus function. We consider other sets of points that escape uniformly to infinity under iteration of f, and we study the properties of these sets and their relationship to I(f) and A(f). (Received February 09, 2015)

Session 37 1111-37-660 **Maira Aguiar*** (mafsantos@fc.ul.pt), CMAF-CIO, University of Lisbon, Avenida Professor Gama Pinto, 2, 1649-003 Lisbon, Portugal. *Modelling dengue fever epidemiology: complex dynamics and its implication for data analysis.*

Dengue fever models including multi-strain interactions via antibody dependent enhancement show deterministic chaos when strong infectivity on secondary infection is assumed. The addition of temporary cross immunity in such models shows a new chaotic attractor in an unexpected parameter region of reduced infectivity (Aguiar et al. (2011) The role of seasonality and import in a minimalistic multi-strain dengue model capturing differences between primary and secondary infections, J. Theor. Biol., 289, 181-196). The introduction of stochasticity explains the fluctuations observed in some of the available data sets, revealing a scenario where noise and complex deterministic skeleton strongly interact. Often parsimony in such models is needed to be predictive from data analysis (Aguiar, Kooi, Rocha, Ghaffari & Stollenwerk (2013) How much complexity is needed to describe the fluctuations observed in dengue hemorrhagic fever incidence data? Ecol. Comp. 16, 31-40). We present a set of models which are parametrized on official dengue data from the Ministry of Public Health in Thailand (Aguiar, Paul, Sakuntabhai & Stollenwerk (2014) Are we modeling the correct data set? Minimizing false predictions for dengue fever in Thailand. Epidem. & Inf., 142, 2447-59). (Received February 09, 2015)

Session 16 1111-37-661 **Leonardo Macarini*** (leomacarini@gmail.com). *Reeb flows with positive topological entropy and contact surgery.*

Some contact manifolds have the property that the Reeb flow of every contact form supporting the corresponding contact structure has positive topological entropy. Examples of such manifolds are given by the unit sphere bundle of rationally hyperbolic manifolds and manifolds whose fundamental group has exponential growth. In this talk I will discuss the construction of new examples using contact surgery. This is joint work with Marcelo Alves. (Received February 09, 2015)

Session 30 1111-37-681 **Bastien Rossetti*** (bastien.rossetti@math.univ-toulouse.fr). *Characterization of postcritically finite ramified coverings by finite planar graphs.*

We describe a finite planar graph, called admissible graph, which, if it exists, characterizes a postcritically finite ramified covering, in the following sense : if two postcritically finite ramified coverings f and g have equivalent admissible graphs then they are Thurston equivalent. In most cases if f and g are rational maps then it leads to a Möbius conjugacy between f and g. We will use this characterization to identify formal matings of polynomials. (Received February 10, 2015)

Session 30 1111-37-687 **David Martí Pete*** (david.martipete@open.ac.uk). *Escaping Fatou components of transcendental self-maps of the punctured plane.*

We study the escaping set of transcendental self-maps of the punctured plane. The orbits of these points accumulate to zero and/or infinity following what we call essential itineraries. It can be shown that for every essential itinerary, there are points in the Julia set that escape following that itinerary. Therefore, it is a natural question to ask whether there are examples of Fatou components that escape in each possible way as well. Using approximation theory we are able to construct functions with wandering domains and Baker domains that do this. We also study a fairly simple concrete family of functions with hyperbolic Baker domains. (Received February 10, 2015)

Session 19 1111-37-703 **João P. Almeida*** (jpa@ipb.pt), Escola Superior de Tecnologia e Gestão, Campus de Santa Apolónia, Ap. 1145, 5301-875 Bragança, Portugal, and **Alberto A. Pinto** (aapinto@fc.up.pt), Department of Mathematics, Faculty of Sciences, Rua Campo Alegre 687, 4169-007 Porto, Portugal. *Anosov diffeomorphisms and tilings.*

We consider a toral Anosov automorphism $G_\gamma : T \to T$ given by $G_\gamma(x, y) = (ax + y, x)$, where $a > 1$ is a fixed integer, and introduce the notion of γ-tiling to prove the existence of a one-to-one correspondence between (i) smooth conjugacy classes of Anosov diffeomorphisms with invariant measure absolutely continuous with respect to the Lebesgue measure and topologically conjugate to G_γ, (ii) affine classes of γ-tilings and (iii) solenoid functions. Solenoid functions provide a parametrization of the infinite dimensional space of the mathematical objects described in these equivalences. (Received February 10, 2015)

Session 18

1111-37-728 **Marc Timme*** (timme@nld.ds.mpg.de), Network Dynamics, MPI for Dynamics and Self-Organization, Am Fassberg 17, 37077 Goettingen, Germany. *From Hamilton via Kuramoto to Power Grids – Nonlinearly Coupled Oscillators.*

How does Sir Hamilton link to Modern Power Grids?

Consider three facts: 1) Hamilton systems are *conservative* dynamical systems with a multitude of realizations in physics. 2) The Kuramoto model constitutes the paradigmatic class of *dissipative* systems characterizing the collective dynamics of coupled oscillators. 3) The reliable function of electric power grids is determined by phase-locking and fundamentally underlies our daily life every minute.

In this talk, I closely link these three facts: I present how exact Kuramoto dynamics happens on invariant manifolds in a class of Hamiltonian systems. I then show how stability of phase-locked states in the Kuramoto model is linked to stability of oscillatory power grid models. I highlight interesting consequences of these links for the systems' collective dynamics, starting from conservation of state space volume and ending with power outages.

This is work with Dirk Witthaut, Martin Rohden, Andreas Sorge, Debsankha Manik and others.

References:

[1] D. Manik, et al., Eur. J. Sp. Top. 02274-y-1:1–21 (2014)

[2] D. Witthaut and M. Timme, Phys. Rev. E 90(3):032917 (2014) http://dx.doi.org/10.1103/PhysRevE.90.032917

(Received February 10, 2015)

Session 18

1111-37-735 **Michael Field*** (mikefield@gmail.com), Deptartment of Mathematics, Imperial College, South Kensington Campus, London, SW7 2AZ, United Kingdom. *The factorization of dynamics theorem for asynchronous networks.* Preliminary report.

We describe a factorization of dynamics theorem for functional asynchronous networks built from simpler classes of what we call primitive networks. Our results allow for varying connection structure, stopping and restarting of nodes, dynamical deadlocks and the quantitative analysis of a large class of complex modular networks related to production, scheduling, biology and engineering. (Joint work with Christian Bick, Exeter and Rice.) (Received February 10, 2015)

Session 18

1111-37-738 **C Bick*** (c.bick@exeter.ac.uk), CEMPS - University of Exeter, Harrison Building, North Park Road, Exeter, Devon EX4 4QF, United Kingdom. *Dynamics of Phase Oscillators with Generalized Coupling.*

We study the dynamics of networks of interacting oscillators whose state is given by a single phase-like variable. In contrast to the classical Kuramoto equations, where the interaction is determined by the sine of the phase differences, we are interested in networks where the interaction can take more general forms. We outline some recent results on small networks and investigate ways how generalized coupling can be exploited in nonlocally coupled rings of oscillators. On the one hand, coupling through the mean field can be used to control the position of spatially localized states such as chimera states. On the other hand, implementing aspects of asynchronous networks in coupled phase oscillates can significantly enhance computational speed. This is joint work with Peter Ashwin, Mike Field, Erik A. Martens, and Marc Timme. (Received February 10, 2015)

Session 30

1111-37-746 **Masashi Kisaka*** (kisaka@math.h.kyoto-u.ac.jp), Yoshida Nihonmatsu-cho, Sakyo-ku, Kyoto, 606-8501, Japan. *Baby Mandelbrot sets are born in Julia sets.* Preliminary report.

In this talk, I will explain some phenomena on how baby Mandelbrot sets appear in the Mandelbrot set and their mechanism. (Received February 10, 2015)

Session 30

1111-37-751 **Saeed Zakeri***, Department of Mathematics, Queens College of CUNY, 65-30 Kissena Blvd., Flushing, NY 11367. *Conformal fitness and uniformization of holomorphically moving disks.*

Let $\{U_t\}_{t\in\mathbb{D}}$ be a family of topological disks on the Riemann sphere containing 0 whose boundaries move holomorphically over the unit disk $\mathbb{D}$. We investigate when there exists a family of Riemann maps $g_t : (\mathbb{D}, 0) \to (U_t, 0)$ which depends holomorphically on the parameter t. Using analytic, dynamical and measure-theoretic approaches, we give five conditions that are equivalent to the existence of the family $\{g_t\}$, and explore the consequences. Somewhat curiously, one of these equivalent conditions is harmonicity of the map $t \mapsto \log r_t$, where r_t is the conformal radius of the pointed disk $(U_t, 0)$. (Received February 10, 2015)

Session 26

1111-37-752 **Jonathan Dawes*** (j.h.p.dawes@bath.ac.uk), Department of Mathematical Sciences, University of Bath, Claverton Down, Bath, BA2 7AY, United Kingdom, and **Tsung-Lung Tsai**. *Frequency locking near heteroclinic cycles.*

I will discuss aspects of frequency locking behaviour that arise near robust heteroclinic cycles (RHCs). Such behaviour can be induced either by internal or external time-periodicity in the dynamics, in particular by couplings between similar but non-identical copies of low-dimensional systems of ODEs exhibiting RHCs. (Received February 10, 2015)

Session 44

1111-37-759 **Fernando J Moreira*** (fjm@fc.up.pt), Rua Campo Alegre 687, 4169-007 Porto, Portugal. *Ergodic properties for non invariant measuress.* Preliminary report.

Let (X, μ) be a measure space and $T : X \to X$ an endomorphism. In ergodic theory of discrete dynamical systems we study the asymptotic properties of T under the assumption that μ is invariant by T, i.e. $mu(T^{-1}(A)) = \mu(A)$. for any measurable set A.

In this talk we will show how the non-standard framework allow us to obtain asymptotic properties of T removing the hypothesis on the invariance of μ by T. (Received February 10, 2015)

Session 30

1111-37-804 **Mitsuhiro Shishikura*** (mitsu@math.kyoto-u.ac.jp), Department of Mathematics, Kyoto University, Kitashirakawa-oiwakecho, Sakyo-ku, Kyoto, Kyoto 606-8502, Japan, and **Masashi Kisaka**. *Smoothness of hairs for some entire functions.*

For complex exponential functions, Devaney and Krych have shown that there are "hairs" which consist of escaping points. Viana showed that each hair is smooth (C^∞). Rempe constructed a topological model ("straight brush" which a subset of the product of symbol sapace and a half line) for the escaping set. The goal od this talk is to extend these results to a larger class of entire functions, including structurally finite maps. We construct a model map on a straight brush, then construct a conjugacy between this model and the escaping set of our map. Finally we prove that the conjugacy is smooth and the derivatives depend continuously on the itineraries. (Received February 10, 2015)

Session 19

1111-37-817 **Bruno M. P. M. Oliveira*** (bmpmo@fcna.up.pt), FCNAUP, R. Dr. Roberto Frias, 4200-465 Porto, Portugal, and **Isabel P. Figueiredo**, **Nigel J. Burroughs** and **Alberto A. Pinto**. *Equilibria in a model of immune responses by T cells.*

We analyse a model of immune response by T cells (CD4), where regulatory T cells (Tregs) act by inhibiting IL-2 secretion. We study an asymmetry reflecting that the difference between the growth and death rates can be higher for the active T cells and the active Tregs than for the inactive T cells and inactive Tregs. We present explicit formulas that give the concentration of T cells as a function of the concentration of Tregs and explicit formulas that relate the antigenic stimulation of T cells, the concentration of T cells and the concentration of Tregs. The relation between the antigenic stimulation of T cells and the concentration of T cells is an hysteresis that is unfolded when some of the parameters are changed. We also consider a linear tuning between the antigenic stimulation of T cells and the antigenic stimulation of Tregs. In this case, we also have obtained explicit formulas, both approximate and exact, relating the antigenic stimulation of T cells, the concentration of T cells and the concentration of Tregs. With these, we can explain the appearance of an isola and a transcritical bifurcation. (Received February 10, 2015)

Session 30

1111-37-822 **Christian Henriksen*** (chrh@dtu.dk). *Fine structure of Herman rings.*

Building on the work of McMullen, we will show that the fine structure of the boundary components of certain Herman rings will be equivalent to that of a corresponding Siegel disk. In particular, the fine structure does not depend on modulus and twist. (Received February 11, 2015)

Session 26

1111-37-826 **Andrey L Shilnikov*** (ashilnikov@gsu.edu), 100 Piedmont street, Atlanta, GA 30303, and **Roberto Barrio** and **Tingli Xing**. *Quest into Homoclinic Chaos.*

We explore the multifractal, self-similar organization of heteroclinic and homoclinic bifurcations of saddle singularities in the parameter space of the models with the Lorenz attractor. We show that complex transformations that underlie the transitions from the Lorenz attractor to wildly chaotic dynamics are intensified by Shilnikov saddle-foci. These transformations are due to the emergence of Shilnikov flames originating from inclination-switch homoclinic bifurcations of codimension-two. We demonstrate how the original computational technique, based on the symbolic description and kneading invariants, can disclose the complexity and universality of parametric structures and their link with nonlocal bifurcations in this representative model. (Received February 11, 2015)

39 ► Difference and functional equations

Session 21

1111-39-25 **Christopher S. Goodrich*** (cgood@prep.creighton.edu), 7400 Western Ave., Omaha, NE 68114. *Monotonicity and Convexity for Discrete Fractional Difference Operators.*

We will discuss some recent discoveries regarding the fractional difference operator and its relationship to the monotonicity or convexity of functions. In particular, it will be shown how these properties are affected by the nonlocal character of the discrete fractional difference. Some applications of these results to boundary and initial value problems will be explained. (Received January 02, 2015)

Session 21

1111-39-28 **Moulay Rchid Sidi Ammi*** (rachidsidiammi@yahoo.fr), B. P 509, Boutalamine, 52000 Errachidia, Morocco. *Finite Difference/spectral approximations for the Time-Fractional Thermistor Problem.*

The use of fractional partial differential equations (FPDEs) in mathematical models has become increasingly popular in recent years. Different models using FPDEs have been proposed, and there has been significant interest in developing numerical schemes for their solution. In this paper we propose a finite difference scheme for temporal discretization of the time-fractional thermistor problem, which is obtained from the so-called thermistor problem by replacing the first-order time derivative with a fractional derivative of order $\alpha(0 \leq \alpha \leq 1)$. An existence result is established for the semi-discrete problem. The main purpose of this work is to construct and analyze stable and high order scheme to efficiently solve the time-fractional thermistor problem. The proposed method is based on a finite difference scheme in time and Legendre spectral method in space. Stability and error analysis are then provided, showing that the temporal accuracy is of $2-\alpha$ order. We prove that the full discretization is unconditionally stable. (Received January 05, 2015)

Session 44

1111-39-367 **Augustin Fruchard*** (augustin.fruchard@uha.fr), LMIA, FST, UHA, 6, rue des Frères Lumière, F-68350 Mulhouse, France. *Composite Asymptotic Expansions for Differential and Difference Equations (Joint work with Reinhard Schäfke).*

The theory of Composite Asymptotic Expansions (CAsEs for short) had been established in order to describe the behavior of solutions of Singularly Perturbed Ordinary Differential Equations (SPODEs) near turning points. SPODEs are differential equations containing a small parameter ε multiplying the highest derivative. Turning points are points where classical approximations are no longer valid. They have been subject to intensive studies for more than a century. CAsEs are asymptotic expansions that involve simultaneously functions of the so-called slow variable x and the fast variable $X = x/\eta$, where $\eta = \varepsilon^{1/p}$ and $p-1$ is the order of the turning point.

I will present the main theorems of this theory, especially a theorem "à la Ramis-Sibuya" useful in order to prove the existence of CAsEs. Then I will apply this theory to a certain difference equation with small step-size, thus illustrating that CAsEs are useful beyond the framework of SPODEs. It is interesting that here the reduced outer and the inner equations are of different type: the reduced outer equation is a differential equation whereas the reduced inner equation is a difference equation. (Received February 06, 2015)

Session 47

1111-39-445 **Walter Van Assche*** (walter@wis.kuleuven.be), Department of Mathematics, KU Leuven, Celestijnenlaan 200B box 2400, 3001 Leuven, Belgium. *Uniqueness of certain solutions of discrete Painlevé II.*

The recurrence coefficients of generalized Charlier polynomials and the Verblunsky coefficients of orthogonal polynomials on the unit circle with weight $\exp(\lambda \cos\theta)$ satisfy a nonlinear recurrence relation which can be identified as discrete Painlevé II (d-PII). The required solution of this d-PII has to satisfy the constraint $0 < c_n < 1$. We show that there is a unique solution of d-PII which satisfies $c_0 = 1$ and $0 < c_n < 1$ for all $n > 0$. This solution can be expressed in terms of determinants containing modified Bessel functions. (Received February 08, 2015)

Session 47

1111-39-481 **T. Augusta Mesquita*** (teresam@portugalmail.pt). *Appell two-orthogonal polynomial sequences with respect to a third order differential operator.*

We address the problem of finding two-orthogonal polynomial sequences which behave as Appell sequences with regard to differential operators of the form $\Lambda = a_0 D + a_1 DxD + a_2 (Dx)^2 D$, where D denotes the usual derivative and a_0, a_1, and a_2 are constants. A few results concerning those kind of operators, widely defined for different orders, are reviewed, and now re-analysed with the help of the non-lowering operators of the form $\Xi = a_0 + a_1 Dx + a_2 (Dx)^2$.

We present functional identities fulfilled by the forms of the dual sequence of such two-orthogonal polynomial sequences, and for a specific third order operator, it is proved that the resultant polynomial sequence is classical in the Hahn's sense.

As an example, it is given the vectorial relation fulfilled by the fundamental tuple of functionals (u_0, u_1) of a two-orthogonal polynomial sequence analogous to the classical Laguerre polynomials, treated in a work of Y. Ben Cheikh and K. Douak.

This is joint work with P. Maroni. (Received February 08, 2015)

40 ► Sequences, series, summability

Session 25

1111-40-379 **Ricardo Couso-Santamaria*** (santamaria@math.tecnico.ulisboa.pt). *The theory of resurgence in matrix models and topological strings.*

The theory of resurgence has built a new bridge between mathematics and physics that is becoming more and more frequented by practicioners from both sides. For the physics camp resurgence is a natural language in which to describe nonperturbative effects. For the mathematical front it is a powerful formalism to describe general classes of functions, for example as solutions of differential equations. It started as a formal mathematical theory of functions in the 80's by the hand of J. Écalle. It soon found applications on the computation of physical observables whose perturbative expansion is asymptotic. Recently, it has been used in topological string theory, matrix models and certain quantum field theories. An ultimate goal is to understand nonperturbative features of the latter theories in the language of resurgence. I describe the main ideas of resurgence and how they can be applied to particular problems in physics. I focus on the related subjects of matrix models and topological string theories, where we can discuss resummations, large-order growths, Stokes phenomena and analytic continuations explicitly. (Received February 06, 2015)

41 ► Approximations and expansions

Session 49

1111-41-15 **David E Edmunds*** (davideedmunds@aol.com), , United Kingdom. *Approximation numbers of a Sobolev embedding.*

Sharp two-sided estimates are obtained of the approximation numbers of an embedding involving a first-order Sobolev space based on a space with variable integrability. (Received December 22, 2014)

Session 21

1111-41-56 **Ricardo Almeida** (ricardo.almeida@ua.pt) and **Nuno R. O. Bastos*** (nbastos@estv.ipv.pt). *A numerical method to solve higher-order fractional differential equations.*

In this talk, we present a new numerical method to solve fractional differential equations. Given a fractional derivative of arbitrary real order, we present an approximation formula for the fractional operator that involves integer-order derivatives only. With this, we can rewrite FDEs in terms of a classical one and then apply any known technique. With some examples, we show the accuracy of the method. (Received January 14, 2015)

Session 47

1111-41-225 **Henrik L. Pedersen*** (henrikp@math.ku.dk). *Asymptotic Expansions and Generalized Stieltjes Functions.*

A result due to Hamburger and Nevanlinna pertaining to the classical moment problem characterizes those Nevanlinna–Pick functions that have an asymptotic series expansion in sectors of the complex plane avoiding the real axis. These are exactly the Cauchy transforms of positive measures having moments of all orders.

In this talk we give a version of this result for generalized Stieltjes transforms of positive order of measures on the half line having moments of all orders. Our characterization is given in terms of properties of the remainders in asymptotic expansions of the generalized Stieltjes functions, and these properties are related to completely monotonic functions of positive order.

The talk is based on joint work with Stamatis Koumandos, University of Cyprus. (Received February 03, 2015)

Session 47

1111-41-699 **Franck Wielonsky*** (franck.wielonsky@univ-amu.fr), Laboratoire I2M, Aix-Marseille University, 13013 Marseille, France. *Lax pairs and Riemann-Hilbert problems for conjugate conductivity equations.*

We use the unified transform method to derive explicit integral expressions for the solutions of the conductivity equations

$$\Delta u + \frac{p}{x}\partial_x u = 0, \qquad p \in \mathbb{Z},$$

in a bounded domain of the right half-plane. These equations are the topic of the so-called axially symmetric potential theory, which was initiated by A. Weinstein in the 50's.

The present method is based on the use of Lax pairs and the study of a specific Riemann-Hilbert problem, depending on the parity of p. The existence of a Lax pair can be expressed as the closeness of a differential form. We show how this global relation allows for an explicit correspondance between Dirichlet and Neumann boundary values. This also involves a result by Karlin and Szegö on wronskians of orthogonal polynomials.

This is a joint work with Slah Chaabi and Stéphane Rigat. (Received February 10, 2015)

42 ► Fourier analysis

Session 49

1111-42-177 **Vakhtang Kokilashvili*** (kokil@rmi.ge), 6. Tamarashvili Str., Tbilisi, GA 0177. *Approximation problems in the framework of new nonstandard Banach function spaces.* Preliminary report.

The goal of our talk is to present our recent results regarding the approximate properties of functions in new function spaces or their certain subspaces. Under new function spaces we mean variable exponent Lebesgue spaces, Iwaniec-Sbordone grand Lebesgue and grand variable exponent Lebesgue spaces. An extension of Nikolsky type inequality for trigonometric polynomials and of finite order entire functions to the weighted setting will be given. We focus also our attention on the extensions of Ul'yanov embedding theorems in weighted function spaces. (Received February 01, 2015)

Session 49

1111-42-181 **Alexander Meskhi*** (meskhi@rmi.ge), A. Razmadze Mathematical Institute, I. Javakhishvili Tbilisi State University, 6. Tamarashvili Str., Tbilisi, GA. *One-sided operators in grand variable exponent Lebesgue spaces.*

The boundedness of one-sided integral operators (one-sided maximal functions Calderón-Zygmund singular integrals and fractional integrals) is established under the condition on exponents of spaces which is weaker than the well-known log-Hölder condition. Similar problems for integral operators defined, generally speaking, on quasimetric measure spaces were studied recently by the speaker jointly with V. Kokilashvili assuming that the exponents of spaces satisfying the log-Hölder condition. (Received February 02, 2015)

Session 49

1111-42-218 **Alexei Yu. Karlovich*** (oyk@fct.unl.pt), Departamento de Matemática, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Quinta da Torre, 2815-526 Caparica, Portugal. *Maximally modulated Hilbert transform and its applications to pseudodifferential operators on variable Lebesgue spaces.*

We prove the boundedness of the maximally modulated Hilbert transform on variable Lebesgue spaces $L^{p(\cdot)}(\mathbb{R})$ under natural assumptions on the variable exponent $p : \mathbb{R} \to (1, \infty)$. Applications of the above result to the boundedness and compactness of pseudodifferential operators with $L^\infty(\mathbb{R}, V(\mathbb{R}))$-symbols on variable Lebesgue spaces $L^{p(\cdot)}(\mathbb{R})$ are considered. Here the Banach algebra $L^\infty(\mathbb{R}, V(\mathbb{R}))$ consists of all bounded measurable $V(\mathbb{R})$-valued functions on $\mathbb{R}$ where $V(\mathbb{R})$ is the Banach algebra of all functions of bounded total variation. (Received February 03, 2015)

Session 9

1111-42-237 **Denis Constales**, **Hendrik De Bie** and **Pan Lian*** (pan.lian@ugent.be). *A new construction of the Clifford-Fourier kernel.*

A new method based on the Laplace transform to give the closed kernels of Clifford-Fourier transform is presented. We use this new method to re-obtain the already known results and give the generating function of even dimensional kernels. Then this method is used to compute the kernels of generalized Fourier transform introduced in [De Bie H, Oste R, Van der Jeugt J. Generalized Fourier transforms and unique characterization of the Fourier transform. arXiv preprint arXiv:1411.6856, 2014]. We also develop this method further to compute the kernel of radially deformed Fourier transform. (Received February 03, 2015)

Session 23

1111-42-242 **Kevin Hughes*** (kevin.hughes@ed.ac.uk). *Lacunary averages for discrete hypersurfaces.*
Lacunary maximal functions over hypersurfaces have been considered in Euclidean space where it is known that under mild conditions, the lacunary maximal function is bounded on $L^p(R^d)$ for $1 < p \leq \infty$. In particular, these conditions do not depend on the choice of lacunary averages and have 'little' dependence on the hypersurface.

The corresponding problem for averages over discrete hypersurfaces, by which mean the integer points on the hypersurfaces, is subtler. We will focus on the case of spheres. Boundedness of the lacunary averages over discrete spheres is connected to the fluctuations in the distribution of integer points on these spheres. In particular, other than Euclidean effects, there are more p-adic effects to consider than for the full maximal function. I will discuss a positive result due to the author and negative results due to J. Zienkiewicz. If there is time, I will discuss generalizations. (Received February 03, 2015)

Session 49

1111-42-270 **Yoshihiro Sawano*** (yoshihiro-sawano@celery.ocn.ne.jp), 1-1 Minami-Ohsawa, Hachioji, Tokyo 192-0397, Japan. *Hardy spaces with variable exponents and generalized Campanato spaces.*
In this talk, we define Hardy spaces with variable exponents on $\mathbb{R}^n$ by the grand maximal function, and then investigate their several properties. We will connect harmonic analysis with function spaces with variable exponents. We obtain the atomic decomposition and the molecular decomposition based on the results of the speaker. With these decomposition proved, we investigate the Littlewood-Paley characterization. Also, we specify the dual spaces of Hardy spaces with variable exponents. They will turn out to be Campanato spaces with variable growth conditions. The speaker covers local Hardy spaces with variable exponents. (Received February 04, 2015)

Session 23

1111-42-316 **Antonio Córdoba*** (antonio.cordoba@uam.es), Departamento de Matemáticas, Universidad Autónoma de Madrid, 28049 Madrid, Madrid, Spain. *Pointwise estimates for fractional laplacians.*
Abstract: The fractional laplacian is an operator appearing in several evolution models where diffusion coming from a Lévy process is present, but also in the analysis of fluid interphases. An extensión of a remarkable pointwise inequality that plays a rôle in their study will be presented in two different scenarios, namely, for fractional Laplace-Beltrami operators on compact Riemannian manifolds and for de Dirichlet-Neumann operator on domain of the euclidean space. (Received February 05, 2015)

Session 23

1111-42-394 **Camil Muscalu***, Department of Mathematics, Cornell University, Ithaca, NY 14850. *Higher Singular Integrals.* Preliminary report.
The goal of the lecture is to describe the most recent observations that we made, and results that we have obtained, in the theory of (what we like to call) "higher singular integrals". (Received February 06, 2015)

Session 23

1111-42-498 **Sagun Chanillo**, **Jean van Schaftingen** and **Po-Lam Yung*** (plyung@math.cuhk.edu.hk). *A critical Sobolev embedding for the hyperbolic spaces.*
It is known that a $W^{1,n}$ function on a Riemannian manifold of dimension n is not necessarily in L^∞. Building upon earlier works of Bourgain, Brezis and van Schaftingen, we provide a remedy for this when the underlying manifold is a real/complex hyperbolic space. One new ingredient in our approach is the Iwasawa decomposition of the isometry group of the underlying hyperbolic space. We hope this more geometric point of view would help us gain a better understanding of the nature of this kind of estimates. (Received February 08, 2015)

Session 23

1111-42-590 **Eyvindur Ari Palsson*** (eap2@williams.edu). *Finite point configurations.*
Finding and understanding patterns in data sets is of significant importance in many applications. One example of a simple pattern is the distance between data points, which can be thought of as a 2-point configuration. Two classic questions, the Erdős distinct distance problem, which asks about the least number of distinct distances determined by N points in the plane, and its continuous analog, the Falconer distance problem, explore that simple pattern. Questions similar to the Erdős distinct distance problem and the Falconer distance problem can also be posed for more complicated patterns such as triangles, which can be viewed as 3-point configurations. In this talk I will present recent progress on Erdős and Falconer type problems for simplices. The main techniques used come from analysis and geometric measure theory. (Received February 09, 2015)

Session 23

1111-42-609 **Francesco Di Plinio***, Brown University Mathematics Department, 151 Thayer St, Providence, RI 02916, and **Christoph Thiele**. *A Calderon-Zygmund decompositions for multiple frequencies and applications.*
We prove that the bilinear Hilbert transform maps into weak $L^{2/3}$, up to a doubly logarithmic factor. The main technical advancement we employ in the proof is a strengthening of the multi-frequency Calderon-Zygmund

decomposition of Nazarov, Oberlin and Thiele where, loosely speaking, the interaction of the bad part, i.e. having mean-zero with respect to N frequencies,with functions localized near one of these frequencies is exponentially small in terms of the good, i.e. L^2, part.

Via the same techniques, we also investigate the sharp behavior of weak type L^p bounds near $p = 1$ for the Carleson operator and its lacunary version, which is intimately and directly connected to Konyagin's conjectures on pointwise convergence of Fourier series in endpoint Lorentz-Orlicz spaces near L^1.

A further application we explore, in joint work with Andrei Lerner, is to sharp weighted bounds for Carleson-type operators in terms of the A_p constant of the weight. (Received February 09, 2015)

Session 23

1111-42-626 **Mariusz Mirek*** (mirek@math.uni-bonn.de), University of Bonn, Endenicher Allee 60, 53115 Bonn, Germany. *$\ell^p(\mathbf{Z}^d)$ boundedness for discrete operators of Radon types: maximal and variational estimates.* Preliminary report.

In recent times - particularly the last two decades - discrete analogues in harmonic analysis have gone through a period of considerable changes and developments. This is due in part to Bourgain's pointwise ergodic theorem for the squares on $L^p(X, \mu)$ for any $p > 1$. The main aim of this talk is to discuss recent developments in discrete harmonic analysis. We will be mainly concerned with $\ell^p(\mathbf{Z}^d)$ estimates ($p > 1$) of r-variations ($r > 2$) for discrete averaging operators and singular integral operators along polynomial mappings. All the results are subjects of the ongoing projects with Elias M. Stein and Bartosz Trojan. (Received February 09, 2015)

Session 23

1111-42-662 **Taryn C Flock*** (t.c.flock@bham.ac.uk). *On extremizers of certain inequalities for the k-plane transform.*

The Radon transform is an integral transform with applications in mathematics, tomography, and medicine. The k-plane transform is an integral transform that maps a function to its integrals over all k-dimensional planes. When $k = n - 1$, the k-plane transform and the Radon transform coincide.

The k-plane transform is a bounded operator from L^p of Euclidean space to L^q of the Grassman manifold of all affine k-planes for certain values of q and p. Extremizers have been determined in a few cases, but most remain open. We identify all extremizers in the endpoint case $q = n + 1$. (Received February 09, 2015)

Session 23

1111-42-665 **Emanuel Carneiro*** (carneiro@impa.br), Estrada Dona Castorina, 110, Jardim Botanico, Rio de janeiro, RJ 22230060, Brazil. *Gaussian subordination and the weighted Beurling-Selberg extremal problem.*

In the late 1930's, Arne Beurling solved the problem of majorizing the signum function by an entire function of prescribed exponential type, minimizing the $L^1(\mathbb{R})$-error. Later in the 1950's, Selberg considered the analogous problem for characteristic functions of intervals, and these optimal bandlimited approximations have been important in many applications in analysis and number theory. Over the last 80 years, the knowledge on this type of problem has been extended in different ways with a wide range of applications.

In this talk I will present a very robust framework to treat this problem, generalizing the original Beurling-Selberg construction to a multivariable setting and weighted $L^1(\mathbb{R}^d)$-measures. This is a joint work with Friedrich Littmann. (Received February 09, 2015)

Session 23

1111-42-672 **J. A. Barceló** and **A. Carbery*** (a.carbery@ed.ac.uk), School of Mathematics, Maxwell Institute for Mathematical Sciences, University of Edinburgh, Edinburgh, EH9 3FD, United Kingdom. *The magnitude of balls in Euclidean spaces – an application of analysis to the theory of enriched categories.* Preliminary report.

The notion of the **magnitude** of a compact metric space has been introduced by Leinster, Meckes and Willerton, motivated by more general consideration of the Euler charcteristic of an enriched category. However, explicit expressions for the magnitudes of common spaces are lacking. We calculate explicitly the magnitudes of balls in certain Euclidean spaces. The analysis involves consideration of certain higher-order elliptic PDEs in exterior domains. (Received February 10, 2015)

Session 23

1111-42-732 **Jacek Dziubanski*** (jdziuban@math.uni.wroc.pl), Instytut Matematyczny, Uniwersytet Wroclawski, pl. Grunwaldzki 2/4, 50-384 Wroclaw, Poland. *On certain characterizations of Hardy spaces associated with some Schrödinger operators.*

On $\mathbb{R}^d$, $d \geq 3$, we consider the semigroup $\{K_t\}_{t>0}$ of linear operators generated by $-L = \Delta - V(x)$, $V(x) \geq 0$, $V \in L^1_{\mathrm{loc}}(\mathbb{R}^d)$. The Hardy space H^1_L is defined as

$$H^1_L = \{f \in L^1(\mathbb{R}^d) : \|f\|_{H^1_L} = \|M_L f\|_{L^1} < \infty\},$$

where $M_L f(x) = \sup_{t>0} |K_t f(x)|$.

We shall prove that the following conditions are equivalent:

(1) there is a function w, $0 < \delta \leq w(x) \leq C$, such that

$$H^1_L \ni f \mapsto wf \in H^1(\mathbb{R}^d)$$

is an isomorphism of H^1_L and the classical Hardy space $H^1(\mathbb{R}^d)$;

(2) the global Kato norm

$$\|V\|_{\mathcal{K}} = \sup_{x \in \mathbb{R}^d} \int_{\mathbb{R}^d} |x-y|^{2-d} V(y)\, dy$$

is finite.

Our second result states that in this case the operator $(-\Delta)^{1/2} L^{-1/2}$, which is bounded on $L^1(\mathbb{R}^d)$, is an another isomorphism of H^1_L and $H^1(\mathbb{R}^d)$.

As corollaries we obtain that the space H^1_L admits:

(3) atomic decomposition with atoms satisfying the usual support and size conditions and the cancellation condition $\int a(x)w(x)dx = 0$

(4) characterization by the Riesz transforms $R_j = \partial_{x_j} L^{-1/2}$.

The results are joint works with Jacek Zienkiewicz. (Received February 10, 2015)

Session 23

1111-42-739 **Vjekoslav Kovac*** (vjekovac@math.hr), Department of Mathematics, University of Zagreb, Bijenicka cesta 30, 10000 Zagreb, Croatia. *On some multilinear operators with general dilation invariances.*

The structure of a multilinear singular integral form can sometimes be complicated enough that many classical objects can be encoded in it. Consequently, its L^p boundedness can be related to certain problems in Fourier analysis or ergodic theory. Here we discuss some recent examples of such forms generalized to the “more geometric” setting of general dilation groups on the Euclidean space. Our techniques are primarily probabilistic, as the martingale counterparts are easier to handle. (Received February 10, 2015)

Session 23

1111-42-783 **Maria Carmen Reguera*** (m.reguera@bham.ac.uk). *Weighted theory for the Bergman projection.*

The Bergman space $A^2(\mathbb{D})$ is the closed subspace of $L^2(\mathbb{D})$ consisting of analytic functions, where $\mathbb{D}$ denotes the unit disk. One considers the projection from $L^2(\mathbb{D})$ into $A^2(\mathbb{D})$, such a projection can be written as a convolution operator with a singular kernel. In this talk, we will present the recent advances on the one weight and two weight theory for the Bergman projection that resulted from combining techniques from complex analysis and the theory of singular integrals in harmonic analysis. This is joint work with A. Aleman and S. Pott. (Received February 10, 2015)

43 ► Abstract harmonic analysis

Session 9

1111-43-615 **Milton Ferreira*** (mferreira@ua.pt), ESTG-IPL, Campus 2 Morro do Lena - Alto do Vieiro, Apartado 4163 2411 - 901 Leiria - PORTUGAL, 2411 - 901 Leiria, Portugal. *Aspects of harmonic analysis over some gyrogroups.* Preliminary report.

Möbius, Einstein, and proper velocity gyrogroups appear from the projective hyperbolic model in Clifford analysis considering the projection of Lorentz transformations in the Minkowski space onto some canonical manifolds inside the future cone. Recently, we studied harmonic analysis on these gyrogroups considering a generalised Laplace Beltrami operator depending on an arbitrary complex parameter. The spectral analysis of these operators gives rise to analysis and synthesis operators, which are related to a generalised Poisson transform over S^{n-1} and a generalised Fourier Helgason transform. We proved Plancherel's Theorem and obtained Paley Wiener Theorems for these operators. In this talk we will discuss also possible factorisations of these generalised Laplace Beltrami operators into Dirac operators. (Received February 09, 2015)

44 ► Integral transforms, operational calculus

Session 47

1111-44-35 **Semyon Yakubovich*** (syakubov@fc.up.pt), University of Porto, Faculty of Sciences, Department of Mathematics, 4169-007 Porto, Portugal. *The affirmative solution to Salem's problem revisited.*

In this paper we, finally, answer affirmatively on Salem's question (posed in *Trans. Amer. Math. Soc.* **53** (3) (1943), p. 439) whether Fourier-Stieltjes coefficients of the Minkowski question mark function vanish at infinity. Moreover, we generalize the Salem problem, proving that the Fourier-Stieltjes coefficients of any power $m \in \mathbb{N}$ of the Minkowski question mark function vanish at infinity as well. (Received January 08, 2015)

Contr.Session

1111-44-441 **Ranjan Kumar Jana*** (rkjana2003@yahoo.com), Dept. of Applied Mathematics & Humanities, S.V. National Institute of Technology, Surat, Gujarat 395007, India. *Recent Developments in the study of Generalized Mittag-Leffler function.* Preliminary report.

In the present talk, an attempt is made to present the developments Mittag-Leffler function defined by Swedish mathematician Gösta Mittag-Leffler in 1903. Generalized Mittag-Leffler function operator has been defined. Investigation of Laplace and Mellin transform of this operator have been made. The obtained results are useful, where Mittag-Leffler function occurs naturally. (Received February 08, 2015)

Session 9

1111-44-616 **Paula Cerejeiras** (pceres@ua.pt), CIDMA, Universidade de Aveiro, 3810-193 Aveiro, Portugal, and **Uwe Kaehler*** (ukaehler@ua.prt), CIDMA, Universidade de Aveiro, 3810-193 Aveiro, Portugal. *Discrete Function theory and Hardy spaces.*

In recent years one can observe an increasing interest in obtaining discrete counterparts for various continuous structures, especially a discrete equivalent to continuous function theory. While such ideas are very much developed in the complex case the higher-dimensional case is yet underdeveloped. This is mainly due to the fact that while discrete complex analysis is under (more or less) continuous development since the 1940's higher-dimensional discrete analysis started effectively only in the eighties and nineties with the construction of discrete Dirac operators either for numerical methods for partial differential equations or for problems in physics. Although since this time discrete equivalent operators to various integral operators were introduced by many authors a discrete version of Hardy spaces and a discussion of conditions for boundary values of discrete monogenic functions are missing. In this talk we will not only close this gap, but also show the applicability of this theory to the question of discrete Riemann-Hilbert problems as well as the link to practical applications. (Received February 09, 2015)

Session 23

1111-44-632 **Jonathan Bennett*** (j.bennett@bham.ac.uk), School of Mathematics, University of Birmingham, Edgbaston, Birmingham, B15 2TT, United Kingdom. *Regularity and the Brascamp–Lieb constant.*

The Brascamp–Lieb inequality simultaneously generalises several important inequalities in analysis, such as the multilinear Hölder, sharp Young convolution and Loomis–Whitney inequalities. Motivated by certain conjectural nonlinear and combinatorial generalisations of this inequality, we discuss the regularity of the best constant (the so-called Brascamp–Lieb constant) as a function of the underlying parameters. This is joint work with Taryn Flock. (Received February 09, 2015)

45 ► Integral equations

Session 17

1111-45-169 **Vladimir Rabinovich*** (vladimir.rabinovich@gmail.com). *Boundary Integral Equations of Diffraction Problems on Non-compact Obstacles.* Preliminary report.

We consider the Dirchlet, Neumann and Roben problems in domains with unbounded boundary described by the Helmholtz operators with coefficients bounded with all derivatives. We construct single and double layers potentials for reduction of the mentioned problems to the integral operators on the boundary. Applying the limit operators machinery we obtain the necessary and sufficient conditions for the boundary operators to be Fredholm in the Sobolev spaces. If the coefficients of the Helmholtz operators and the boundary are slowly oscillating at infinity we prove that the boundary integral operators of the Dirichlet and Neumann problems are invertible in Sobolev spaces. (Received January 31, 2015)

Session 34

1111-45-194 **Roland Duduchava*** (roldud@gmail.com), Andrea Razmadze Mathematical Institute, Tbilisi, 0177, and **Victor Didenko** (diviol@gmail.com), Universiti Brunei Darussalam, Bandar Seri Begawan, BE1410. *Mellin Convolution Equations In Bessel Potential Spaces.*

A class of Mellin convolution equations with meromorphic kernels is introduced and proved that the corresponding operators are bounded in the Bessel potential spaces. We encounter such equations in boundary value problems for elliptic equations in planar 2D domains with angular points on the boundary as a model problem after localization. The study is based upon two results. The first one concerns the commutants of Mellin convolution and Bessel potential operators. It is shown how Bessel potentials change after commutation with a Mellin convolution operator with meromorphic symbol, in contrast to a Fourier convolutions, when BPOs dose not change. The result is applied to the lifting of Mellin convolution equations from a Bessel potential space setting to a Lebesgue space setting. The resulting operator belong to a Banach algebra generated by Mellin and Fourier convolutions. Fredholm properties and the index formulae for such operators have been studied by R. Duduchava in his earlier papers.

The obtained results have important applications to the study of boundary value problems for elliptic partial differential equations in planar Lipschitz domains. (Received February 02, 2015)

Session 17

1111-45-485 **Tony Hill**, Department of Mathematics, King's College London, Strand, London, WC2R 2LS, United Kingdom, and **Eugene Shargorodsky*** (eugene.shargorodsky@kcl.ac.uk), Department of Mathematics, King's College London, Strand, London, WC2R 2LS, United Kingdom. *On a Wiener-Hopf plus Mellin operator arising in the theory of Levy processes.* Preliminary report.

Markov processes are especially well understood in the case when they take place in the whole Euclidean space. The situation becomes much more complicated if a Markov process is restricted to a domain with a boundary, and a satisfactory theory exists only for processes with continuous trajectories. The aim of the talk is to present results of an ongoing research project concerned with a model Wiener-Hopf plus Mellin operator, which is related to the generator of a symmetric stable Levy process on a half-line. (Received February 08, 2015)

46 ► Functional analysis

Session 49

1111-46-96 **Yongqiang Fu*** (fuyongqiang@hit.edu.cn). *Several Kinds of Variable Exponent Spaces.*

In this talk, we discuss several kinds of variable exponent spaces, for examples, variable exponent spaces of differential forms in the setting of Euclidean spaces and Riemannian manifolds, Clifford valued variable exponent spaces and stochastic exponent function spaces. Some properties of these spaces as well as some simple applications are also given. (Received January 21, 2015)

Session 9

1111-46-130 **Daniel Aron Alpay*** (dany@math.bgu.ac.il), Department of mathematics, Ben-Gurion university of the Negev, Beer-Sheva, Israel, and **Guy Salomon** (salomonguy@hotmail.com), Department of mathematics, Technion, Haifa, Israel. *On algebras which are inductive limits of Banach spaces.*

We define algebras which are inductive limits of Banach spaces and carry inequalities which are counterparts of the inequality for the norm in a Banach algebra. We then define an associated Wiener algebra, and present the corresponding version of the Wiener theorem. Applications to stochastic processes and non commutative stochastic processes will be given. (Received January 27, 2015)

Contr.Session

1111-46-195 **Elvio Accinelli*** (elvioaccinelli@hotmail.com), Facultad de Economia de la UASLP, Mexico. *The equilibrium set of infinite dimensional Walrasian economies and the natural projection.*

The natural projection plays a fundamental role to understand the behavior of the Walrasian economies. In this paper we extend this method to analyze the behavior of infinite dimensional economies. We introduce the definition of the social equilibrium set, and we show that there exists a bijection between this set and the Walrasian equilibria set of an infinite dimensional economy. In order to describe the main topological characteristics of both sets, we analyze the main differential characteristics of the excess utility function and then, we extend the method of the natural projection as suggested by Y. Balasko. (Received February 02, 2015)

Session 49

1111-46-290 **Peter Hästö*** (peter.hasto@oulu.fi). *Maximal operator in generalized Orlicz spaces.*

In this talk I present a sufficient condition for the boundedness of the maximal operator on Musielak–Orlicz spaces. The result includes as special cases the optimal condition for Orlicz spaces as well as the essentially optimal the log-Hölder condition for variable exponent Lebesgue spaces (Received February 05, 2015)

Session 46

1111-46-303 **Stefan Samko*** (ssamko@ualg.pt). *Exact formulas for p -> q norms of one- and many-dimensional Hardy operators.*

In this talk based on a joint paper with L.E. Persson, we give precise expressions for the norms of Hardy operators acting between Lebesgue spaces with p<q. Such formulas were earlier known in the general case only when p=q. (Received February 05, 2015)

Session 46

1111-46-307 **Lars-Erik Persson*** (larserik@ltu.se). *Some new sharp refinements of Bennett's inequalities.*

In this talk based on a joint paper with S. Barza and N. Samko, we present some new refinements of Bennett's inequalities. Each of these refined inequalities contain two constants and both constants are in fact sharp. The technique in the proofs is new and based on some convexity arguments of independent interest. There is also pointed out that these inequalities may be regarded as limit cases of some Hardy type inequalities. (Received February 05, 2015)

Session 49 1111-46-315 **Osvaldo D. Mendez*** (osmendez@utep.edu), 124 Bell Hall, 500W University Ave., El Paso, TX 79968. *The eigenvalue problem for the modular $p(\cdot)$-Laplacian. Convergence analysis.*

We investigate the family of variable-exponent-type eigenvalue problems $-\Delta_{p_j(\cdot)}u = \lambda_j|u|^{p_j(\cdot)-2}u$ and prove the convergence of the eigenfunctions under suitable conditions on the sequence (p_j). (Received February 05, 2015)

Session 49 1111-46-447 **Petteri Harjulehto*** (petteri.harjulehto@utu.fi), Department of Mathematics and statistics, 20014 University of Turku, Finland. *The Riesz potential in generalized Orlicz spaces.*

In this talk I discuss about Hedberg's method in generalized Orlicz spaces (also knows as Musielak–Orlicz spaces) and show Sobolev embedding for the Riesz potential. The idea is to choose a regular representative for the Φ-function. The proof requires fewer assumptions than the previously known one. The talk is based on my joint work with Peter Hästö. (Received February 08, 2015)

Session 34 1111-46-456 **Jan H Fourie*** (jan.fourie@nwu.ac.za), North-West University, Potchefstroom, South Africa. *ℓ_p-Extensions of operator ideals and α-integral operators.*

Let $(\mathcal{A}, \alpha)$ be a Banach operator ideal. For $1 \leq p < \infty$, let $\mathcal{A}_p(X,Y) := \{T \in B(X,Y) : ST \in \mathcal{A}(X, \ell_p), \forall S \in B(Y, \ell_p\}$. Then $(\mathcal{A}_p, \alpha_p)$, where $\alpha_p(T) := \sup\{\alpha(ST) : S \in B(Y, \ell_p), \|S\| \leq 1\}$, is a Banach operator ideal. The focus will be the ideal $\mathcal{A}_p$ obtained when $\mathcal{A}$ is the ideal of p-summing operators. Then $\mathcal{A}_p$ is the ideal of sequentially p-limited operators, introduced in the paper (2). This part of the talk relates to the manuscript (1). We also consider "associated ℓ_p-tensor norms" that result in "ℓ_p-extensions" of α-integral operators. For instance, is it possible to characterize the sequentially p-limited operators as α-integral operators with respect to some tensor norm α? We report on our findings.

1. Fourie, J.H. and Zeekoei, E.D. (2015) Classes of sequentially limited operators. Glasgow Math. J. (to appear).
2. Karn, A.K. and Sinha, D.P. 2014. An operator summability of sequences in Banach spaces.*Glasgow Math. J.* **56(2)** : 427 – 437.

(Received February 08, 2015)

Session 49 1111-46-465 **Alberto Fiorenza*** (fiorenza@unina.it), Dipartimento di Architettura, Università di Napoli "Federico II", via Monteoliveto, 3, 80134 Napoli, Italy. *On "essentially variable" variable Lebesgue space problems.*

Many results in the theory of variable exponent Lebesgue spaces generalize those that are true for the classical Lebesgue spaces, and one of the most attractive features of the theory is the problem of characterizing the class of exponents for which certain statements remain true. However, some questions are of interest because they arise directly from the framework of variable exponents: for instance, those results where the loss of rearrangement-invariance of the space or the unboundedness of the exponent are the main feature.

In this talk we will discuss some problems of this type from Function Space Theory, Harmonic Analysis, and Differential Equations. (Received February 08, 2015)

Contr.Session 1111-46-473 **António M. Caetano*** (acaetano@ua.pt), Dep. Matemática, Univ. Aveiro, 3810-193 Aveiro, Portugal. *Compactness in quasi-Banach function spaces.*

The well-known criterion for the precompactness of sets in a Banach function space states that a subset K of the absolutely continuous part X_a of a Banach function space X is precompact in X if and only if K is locally precompact in measure and K has uniformly absolutely continuous norm.

There is a natural question whether this criterion characterizing precompact subsets in Banach function spaces can be extended to the setting of quasi-Banach function spaces when the elements of these spaces are not necessarily locally integrable (as for example is the case with the space $L_p(\mathbb{R}^n)$ with $0 < p < 1$). We give a positive answer to this question.

We also establish an extension of the well-known criterion characterizing precompact sets in the Lebesgue space $L_p(\mathbb{R}^n)$, $1 \leq p < \infty$, to the case when the space $L_p(\mathbb{R}^n)$ is replaced by a so-called power quasi-Banach function space over $\mathbb{R}^n$.

This is joint work with Amiran Gogatishvili and Bohumír Opic. (Received February 08, 2015)

Session 49

1111-46-578 **Alexandre Almeida*** (jaralmeida@ua.pt), University of Aveiro, Department Mathematics, 3810-193 Aveiro, Portugal, 3810-193 Aveiro, Portugal. *Atomic decompositions in variable 2-microlocal spaces and applications.* Preliminary report.

In this talk we consider \$2\$-microlocal function spaces with variable integrability of Besov and Triebel-Lizorkin type. This is a wide class of spaces that includes, for example, variable/generalized smoothness and weighted spaces as special cases. We shall give precise atomic and molecular decompositions and show that in some cases the convergence holds in the space itself. This fact can be used to derive additional properties of the space. This is joint work with António Caetano. (Received February 09, 2015)

Session 17

1111-46-649 **Pedro A Santos***, IST - Taguspark, Av. Prof. Doutor Cavaco Silva, Gabinete 2N4.18, 2744-016 Porto Salvo, Portugal, and **Torsten Ehrhardt**. *Some notes on the Singular Integral Operator acting on Super Lebesgue spaces.* Preliminary report.

Given a (bounded or unbounded) interval $\mathbb{I} \subseteq \mathbb{R}$, $L^p(\mathbb{I})$ refers to the standard Lebesgue space on $\mathbb{I}$ with norm $\|.\|_p$. Let now $1 \leq p < q < \infty$, and define the super-Lebesgue space $L_{pq}(X)$ by

$$L_{pq}(\mathbb{I}) := L_p(\mathbb{I}) + L_q(\mathbb{I}), \tag{1}$$

that is, the elements of $L_{pq}(\mathbb{I})$ are those functions[1] u that can be written as a sum $u = u_p + u_q$, with $u_p \in L_p(\mathbb{I})$ and $u_q \in L_q(\mathbb{I})$.

We will present some preliminary results on the properties of Singular Integral Operator

$$\frac{1}{\pi \mathbf{i}} \int_{\mathbb{I}} \frac{u(s)}{s-t}\, ds, \qquad t \in \mathbb{I}, \tag{2}$$

when acting in these spaces. (Received February 09, 2015)

Session 17

1111-46-654 **Helena M. Mascarenhas*** (hmasc@math.ist.utl.pt), **Pedro A. Santos** and **Markus Seidel**. *Quasi-banded operators and approximations of convolutions with almost periodic or quasi-continuous symbol.*

The class of quasi-banded operators is significantly larger than that of band-dominated operators. We derive criteria for the stability and Fredholm property of the finite sections of quasi-banded operators acting on Lp spaces over the real line. The splitting property of the approximation numbers, as well as an index formula, are stablished. In particular, this class covers convolution type operators with semi-almost periodic and quasi-continuous symbols, and operators of multiplication by slowly oscillating, almost periodic and more general coefficients. This talk is based on joint work with Pedro Santos and Markus Seidel [1].

[1] H. Mascarenhas, P.A. Santos, M. Seidel, "Quasi-banded operators, convolutions with almost periodic or quasi-continuous data, and their approximations", J. Math. Anal. Appl. and Applications, 418 (2014) 938-963.
(Received February 09, 2015)

Session 46

1111-46-737 **Talat Nazir*** (talat.nazir@mdh.se), Department of Mathematics, Malardalen Unversity Vasteras, 72123 Vasteras, Sweden. *Existence the Solutions of Operator Equations and its Applications.*

In this talk, we describe some results for sufficient conditions on existence of the solutions of operator equations by employing the operator their in. Some examples are given to validate the concepts and results presented herein. We also provide certain applications of our results. The established results unify and improve many recent results of the existing literature. (Received February 10, 2015)

Session 46

1111-46-770 **Eugenio M. Rocha*** (eugenio@ua.pt), Campus de Santiago, University of Aveiro, Aveiro, Portugal. *A nonlinear extension and applications of the ADMM method.*

By using homotopy analysis techniques, we discuss an extension of a general discretization method, the so-called 'Aveiro Discretization Method in Mathematics' (ADMM), introduced by L. P. Castro et al. [1], which is based on the theory of reproducing kernels and the Tikhonov regularization procedure. Applications of the extension to PDEs involving nonlocal operators will be discussed, e.g. to Schrodinger-Poisson systems, beside others.

[1] Castro, L.P.; Fujiwara, H.; Rodrigues, M.M.; Saitoh, S.; Tuan, V.K., Aveiro Discretization Method in Mathematics: A New Discretization Principle, in Mathematics Without Boundaries (eds. Rassias, Themistocles M. and Pardalos, Panos M.), 37-92, (2014). (Received February 10, 2015)

[1] as is normal, functions which differ only on a set of measure 0 are identified

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Session 46 1111-47-62 **Alexander Sakhnovich*** (oleksandr.sakhnovych@univie.ac.at). *Weyl theory for Dirac operators and applications to initial-boundary value problems for integrable wave equations.*
We present Weyl theory for Dirac operators (selfadjoint and skew-selfadjoint cases). Direct and inverse problems are discussed. Applications to initial-boundary value problems for integrable wave equations are given. In particular, interesting interrelations between initial and boundary conditions are studied. This talk is based on various results from [1] and their further developments. The talk and research are supported by the Austrian Science Fund (FWF) under Grant No. P24301.

[1] A.L. Sakhnovich, L.A. Sakhnovich, and I.Ya. Roitberg, *Inverse problems and nonlinear evolution equations. Solutions, Darboux matrices and Weyl-Titchmarsh functions.* De Gruyter Studies in Mathematics **47**. De Gruyter, Berlin, 2013.
(Received January 16, 2015)

Session 34 1111-47-101 **Rongwei Yang*** (ryang@albany.edu), 1400 Washington Ave., Albany, NY 12222. *Invariant subspaces in the Hardy space over the Bidisk.*
The unilateral shift operator S is a fundamental example of non-normal operators. Its study has seen profound and far-reaching impacts on Operaotr Theory and Operator Algebras. A representation of S is multiplication by the coordinate function z on the classical Hardy space $H^2(\mathbb{D})$. This representation led Beurling to give a complete characterization of the invariant subspaces of S by inner functions in 1949. While going to the two variable Hardy space $H^2(\mathbb{D}^2)$, one naturally wonders if a similar characterization is possible. This problem turned out to be very difficult, as indicated by Rudin's "pathological examples". Nonetheless, much progress have been made in the past two decades. This talk is a brief survey of the research in this front.
(Received January 22, 2015)

Session 34 1111-47-102 **Natalia Bebiano*** (bebiano@mat.uc.pt), Department of Mathematics, University of Coimbra, 3000434 Coimbra, Portugal, and **Joao da Providencia**. *Products of Laurent operators and fields of values.*
In this talk we address an important topic in the theory of operators, which has deserved the attention of many researchers. We explicitly describe the field of values of Laurent operators. The field of values of products of Laurent operators is shown to be interestingly related with the product of their fields of values. Fields of values of powers of Laurent operators are investigated, and known results in the literature are extended. As a consequence of our investigation, some inequalities are deduced. The spectral radius and Crawford number for this class of operators are studied. (Received January 22, 2015)

Session 46 1111-47-115 **fadi awawdeh*** (fawawadeh@du.edu.om), Department of Mathematics -Dhofar University, Salalah-Oman, 00968 Salalah, Oman. *Degenerate Identification Problems with Smoothing Overdetermination.*
We are concerned with degenerate first-order identification problems with smoothing overdetermination in abstract spaces. A projection method and suitable hypotheses on the operators involved are used in order to reduce the given problem to a non-degenerate problem. Then perturbation theory for linear operators is used to solve the regular problem. The introduced identification method permits one to solve the problems under the minimum restrictions on the input data. Applications to degenerate differential equations of the Sobolev type are indicated extending well-known results in the regular case. The abstract theory is then applied to obtain identifiability results for degenerate systems arising in mathematical physics. (Received January 26, 2015)

Session 34 1111-47-163 **Jan Stochel***, ul. Lojasiewicza 6, 30-348 Krakow, Poland. *Exotic examples related to subnormality of composition operators over directed graphs with one circuit.*
A question of subnormality of composition operators in L^2-spaces over possibly simplest (excluding the case of classical weighted shifts) discrete measure spaces is discussed. We restrict ourselves to the case of composition operators built over connected directed graphs whose vertices, all but one, have valency one. This includes the class of weighted shifts on directed trees with one branching vertex and with infinite trunk, as well as the class of composition operators over the directed graph with one branching vertex, a circuit of length $\kappa + 1$ and eta branches. The former class has been intensively studied since 2012. The latter class is new. It has unexpected properties. In particular, we will show that there exists a nonhyponormal composition operator in the L^2-space built over a directed graph with one loop ($\kappa = 0$) and two branches ($\eta = 2$), which generates Stieltjes moment sequences.

Coauthors: Piotr Budzyński, Zenon Jan Jabłoński, Il Bong Jung (Received January 31, 2015)

Session 34 1111-47-200 **Eva A. Gallardo-Gutiérrez** (eva.gallardo@mat.ucm.es), Departamento de Análisis Matemático, Facultad de Ciencias Matemáticas, Plaza de Ciencias, 3, Madrid, 28040, **Jonathan R. Partington** (j.r.partington@leeds.ac.uk), School of Mathematics, University of Leeds, Leeds, LS2 9JT, and **Daniel J. Rodríguez*** (drluis@unizar.es), Departamento de Matemáticas, Facultad de Ciencias, Plaza San Francisco s/n, Zaragoza, 50009. *A continuous model for quasinilpotent operators.*

A classical result due to Foias and Pearcy establishes a discrete model for every quasinilpotent operator acting on a separable, infinite dimensional complex Hilbert space $\mathcal{H}$. More precisely, given a quasinilpotent operator T on $\mathcal{H}$, there exists a compact quasinilpotent operator K in $\mathcal{H}$ such that T is similar to *a part* of $K \oplus K \oplus \cdots \oplus K \oplus \ldots$ acting on the direct sum of countably many copies of $\mathcal{H}$.

We show that a continuous model for any quasinilpotent operator can be provided. The consequences of such model will be discussed in the context of C_0-semigroups of quasinilpotent operators.

This is joint work with Eva A. Gallardo-Gutíerrez (Madrid, Spain) and Jonathan R. Partington (Leeds, UK). (Received February 02, 2015)

Session 34 1111-47-205 **M. T. Malheiro***, Department of Mathematics and Applications, University of Minho, Campus de Azurém, Guimarães, Braga, Portugal. *Maximal and minimal functions in model spaces.*

We study model spaces as Toeplitz kernels in a Hardy space H_p of the upper half-pane, focusing in particular on their relation with the notion of a minimal T-kernel. This talk is based on joint work with Cristina Câmara and Jonathan Partington. (Received February 02, 2015)

Session 46 1111-47-217 **Alexei Yu. Karlovich*** (oyk@fct.unl.pt), Departamento de Matemática, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Quinta da Torre, 2815-526 Caparica, Portugal. *Banach algebra of the Fourier multipliers on weighted Banach function spaces.* Preliminary report.

Let $\mathcal{M}_{X,w}(\mathbb{R})$ denote the algebra of the Fourier multipliers on a separable weighted Banach function space $X(\mathbb{R}, w)$. We prove that if the Cauchy singular integral operator S is bounded on $X(\mathbb{R}, w)$, then $\mathcal{M}_{X,w}(\mathbb{R})$ is continuously embedded into $L^\infty(\mathbb{R})$. An important consequence of the continuous embedding $\mathcal{M}_{X,w}(\mathbb{R}) \subset L^\infty(\mathbb{R})$ is that $\mathcal{M}_{X,w}(\mathbb{R})$ is a Banach algebra. This result is applied to the case of weighted variable Lebesgue spaces $L^{p(\cdot)}(\mathbb{R}, w)$. (Received February 03, 2015)

Session 17 1111-47-235 **Luis Castro*** (castro@ua.pt), CIDMA, Department of Mathematics, University of Aveiro, Campus Universitario, 3810-193 Aveiro, Portugal, and **David Kapanadze**. *The use of weighted Mellin pseudo-differential operators in BVPs for the Helmholtz equation.*

We will exhibit the use of certain weighted Mellin pseudo-differential operators in boundary value problems for the Helmholtz equation, associated with wave diffraction problems. Potential representation formulas determined by those operators, in appropriate Sobolev spaces, will be generated, and a consequent Fredholm analysis will be derived. (Received February 03, 2015)

Session 34 1111-47-241 **Piotr Budzyński*** (piotr.budzynski@ur.krakow.pl). *Weighted shifts on directed trees and subnormality.*

Weighted shifts on directed trees, introduced recently in [3], form an interesting class of operators. The class is a natural and substantial generalization of classical weighted shifts on ℓ^2 spaces. They have proven to have very interesting features - the underlying relatively simple graph structure gives a rise to a subtle and complex structure of the operators, which turn out to have properties not known before in other classes of operators (see e.g., [2, 1]). We will outline recent results concerning these operators with main emphasis put on subnormality.

The talk is based on a joint work with P. Dymek, Z. J. Jabłoński, I. B. Jung and J. Stochel.

[1] P. Budzyński, P. Dymek, Z. J. Jabłoński, J. Stochel, Subnormal weighted shifts on directed trees and composition operators in L^2-spaces with non-densely defined powers, Abstract Appl. Anal. 2014 (2014), Article ID 791817, 6 pages.

[2] P. Budzyński, Z. J. Jabłoński, I. B. Jung, J. Stochel, Unbounded subnormal weighted shifts on directed trees, J. Math. Anal. Appl. 394 (2012), 819-834.

[3] Z. J. Jabłoński, I. B. Jung and J. Stochel, Weighted shifts on directed trees, Mem. Amer. Math. Soc. 216 (2012), no. 1017.

(Received February 03, 2015)

Session 46

1111-47-247 **M. Cristina Câmara*** (ccamara@math.tecnico.ulisboa.pt), Departamento de Matemática, Instituto Superior Técnico, Av. Rovisco Pais, 1049-001 Lisboa, Portugal. *Asymmetric truncated Toeplitz operators in the Hardy spaces of the half-plane.*

Truncated Toeplitz operators and their asymmetric versions are studied in the context of the Hardy spaces Hp of the half-plane. It is shown that they are equivalent after extension to Toeplitz operators with 2x2 matrix symbols, which allows one to deduce information about their spectral properties. This talk is based on joint work with Jonathan Partington. (Received February 03, 2015)

Session 17

1111-47-266 **Bernd Silbermann*** (silbermn@mathematik.tu-chemnitz.de), TU Chemnitz,Fakultaet fuer Mathematik, 09107 Chemnitz,Deutschland, Chemnitz, Germany. *Banach algbras of matrix sequences:Approximation numbers.*

About 20 years ago Steffen Roch and the author observed that the singular values of the finite sections of Fredholm Toeplitz operators own a specific behavior which is now called the splitting property.It turns out hat this proprty is closely related to some kind of Fredholmness of the sequense under consideration.The aim of the talk is to present a general framework how to handle such problems,including also related questions for the approximation numbers.A few exampls will be considered. (Received February 04, 2015)

Session 17

1111-47-271 **Frank-Olme Speck*** (fspeck@tecnico.pt), Departamento de Matematica, Tecnico, Universidade de Lisboa, Avenida Rovisco Pais, 1049-001 Lisboa, Portugal. *Convolution type operators with symmetry.* Preliminary report.

We study operators of the form $W = P_2 A_{|P_1 X}$ where A is a convolution operator on the real line acting in the Lebesgue space L^2 or, more generally, in Bessel potential spaces $A : X = H^r \to Y = H^s$ with given real numbers r, s, and where $P_1 \in \mathcal{L}(X)$, $P_2 \in \mathcal{L}(Y)$ are projectors onto or along subspaces with symmetry properties such as those of even or odd functionals, or others recognized in applications. Our interest focuses on the (generalized) invertibility of W, inversion by new operator factorization techniques, based upon convenient forms of symmetry. It continues work with L.P. Castro, R. Duduchava and F.S. Teixeira started in 2003 and yields a more direct method for the solution of certain wedge diffraction problems. Some related questions are discussed such as: Equivalence between different kinds of related operators, extension problems, and constructive methods for the factorization of matrix operators.

L. Castro, F.-O. Speck and F.S. Teixeira. A direct approach to convolution type operators with symmetry. Math. Nachrichten 269-270 (2004), 73-85.

L. Castro, F.-O. Speck and F.S. Teixeira. Mixed boundary value problems for the Helmholtz equation in a quadrant. Integr. Equ. Oper. Theory 56 (2006), 1-44. (Received February 04, 2015)

Session 34

1111-47-282 **Zenon J. Jablonski***, Instytut Matematyki, ul Lojasiewicza 6, 30-348 Krakow, Poland. *Quasinormality of unbounded operators.*

In 1953 A. Brown introduced the class of bounded quasinormal operators. In the case of unbounded operators, two different definitions of unbounded quasinormal operators appeared independently. The first one was given in 1983 by Kaufman, and a few years later, the second one by Stochel and Szafraniec. It turns out that both of these definitions coincide.

The lecture will be a survey of results concerning bounded and unbounded quasinormal operators. The talk is based on a joint work with P. Budzyński, I. B. Jung and J. Stochel. (Received February 04, 2015)

Session 17

1111-47-288 **Victor D. Didenko*** (diviol@gmail.com), Universiti Brunei Darussalam, Faculty of Science, Bandar Seri Begawan, BE 1410, Brunei. *An efficient method for solving non-homogeneous Toeplitz plus Hankel equations.*

Considered are the equations

$$(T(a) + H(b))\phi = f, \tag{1}$$

where $T(a)$ and $H(b)$, $a, b \in L^\infty(\mathbb{T})$ are, respectively, Toeplitz and Hankel operators acting on the classical Hardy spaces $H^p(\mathbb{T})$, $1 < p < \infty$. If the generating functions a and b satisfy the so-called matching condition [1,2],

$$a(t)a(1/t) = b(t)b(1/t),\ t \in \mathbb{T},$$

an efficient method for solving equation (1) is proposed. The method employs the Wiener–Hopf factorization of the scalar functions $c(t) = a(t)b^{-1}(t)$ and $d(t) = a(t)b^{-1}(1/t)$ and allows one to find all solutions of the equations mentioned.

This talk is based on joint work with Bernd Silbermann.

References:

[1] V.D. Didenko, B. Silbermann: Structure of kernels and cokernels of Toeplitz plus Hankel operators, *Integral Equations and Operator Theory*, 80 (2014), 1–31.

[2] V.D. Didenko, B. Silbermann: Some results on the invertibility of Toeplitz plus Hankel operators, *Annalas Academie Scientarium Fennicae, Mathematica*, 39 (2014), 439–446.

(Received February 05, 2015)

Session 46

1111-47-289 **M C Câmara** (ccamara@math.ist.utl.pt), Center for Mathematical Analysis, Geometry, and Dynamical Systems, Instituto Superior Técnico, Lisboa, Portugal, **C Diogo** (cristina.diogo@iscte.pt), Departamento de Matemática, Instituto Universitário de Lisboa, Portugal, and **I M Spitkovsky*** (imspitkovsky@gmail.com), New York University Abu Dhabi, UAE, and the College of William and Mary, Williamsburg, VA. *Toeplitz operators of finite interval type and the table method.*

We solve a Riemann-Hilbert problem with almost periodic coefficient G, associated to a Toeplitz operator T_G in a class which is closely connected to finite interval convolution equations, based on a generalization of the so-called table method. The explicit determination of solutions to that problem allows one to establish necessary and sufficient conditions for the invertibility of the corresponding Toeplitz operator, and to determine an appropriate factorization of G, providing explicit formulas for the inverse of T_G. Some unexpected properties of the Fourier spectrum of the solutions are revealed which are not apparent through other approaches to the same problem.
(Received February 05, 2015)

Session 34

1111-47-309 **M. Laura Arias*** (lauraarias@conicet.gov.ar), Saavedra 15, Piso 3, 1083 Buenos Aires, Argentina, and **Gustavo Corach** and **Alejandra Maestripieri**. *On some properties of the additivity of operators ranges.*

Given two bounded linear operators on a Hilbert space $\mathcal{H}$, we say that they satisfy the *range additivity property* if $R(A+B) = R(A) + R(B)$, where $R(T)$ denotes the range of T. In this talk we shall present some results concerning this property and its relationship with the notion of compatiblity and shorted operator. Given a positive operator $A \in L(\mathcal{H})^+$ and a closed subspace $\mathcal{S} \subseteq \mathcal{H}$ we say that they are *compatible* if $\mathcal{S} + (A\mathcal{S})^\perp = \mathcal{H}$. This is equivalent to the existence of an idempotent operator with range $\mathcal{S}$ and selfadjoint with respect to the semi-inner product induced by A. On the other hand, the *shorted operator*, defined as $[\mathcal{S}]A := \max\{X \in L(\mathcal{H})^+ : X \leq A \text{ and } R(X) \subseteq \mathcal{S}\}$, was introduced by M. G. Krein to explore the selfadjoint extensions of operators. Later, W. N. Anderson and G. E. Trapp redefined it and used it in the study of electrical networks. The relationship between these two last notions was studied by G. Corach, A. Maestripieri and D. Stojanoff. Here, we explore how these concepts are also related with the range additivity property and we show some applications to certain operator factorizations. (Received February 05, 2015)

Session 46

1111-47-310 **Natasha Samko*** (natasha.samko@ltu.se), Lulea. *Calderón-Zygmund type singular operators in weighted generalized Morrey spaces.*

In this talk based on a joint paper with L.E. Persson and P. Wall, we present new results concerning weighted boundedness of a general class of multidimensional singular integral operators in generalized Morrey spaces, with radial type weights. These conditions are given in terms of inclusion into generalized Morrey spaces of a certain integral constructions defined by parameters of the space and weight. (Received February 05, 2015)

Session 34

1111-47-348 **Sergio Mendes*** (sergio.mendes@iscte.pt). *K-theory of $C_r^*SL_2(K)$ and a geometric conjecture, K a local function field with characteristic 2.*

A geometric conjecture on the smooth dual of a reductive group over a nonarchimedean local field has been proposed recently by Aubert-Baum-Plymen-Solleveld. We give a proof of this conjecture at the level of the K-theory for the reduced C^* algebra $C_r^*SL(2,K)$ where K is a local function field with characteristic 2. Joint work with Roger Plymen. (Received February 06, 2015)

Session 34

1111-47-366 **Dariusz Cichon*** (dariusz.cichon@im.uj.edu.pl), Instytut Matematyki UJ, ul. prof. Stanislawa Lojasiewicza 6, 30-348 Krakow, Poland. *A class of Hamburger moment sequences.*

The talk will be devoted to a class of Hamburger moment sequences (i.e. those admitting representation as integrals of monic monomials over the real line) induced by a test function. The main feature of the class is the possibility of explicit description of its (uncountable families of) representing measures which share unexpectable properties, such as having supports in the arithmetic progression (among others). The intimate connection between representing measures and extensions of symmetric operators leads in this context to deeper analysis concerning N-extremality of the measures and related results.

This is an account of a paper written together with J. Stochel and F.H. Szafraniec. (Received February 06, 2015)

Session 46

1111-47-384 **M.Amelia Bastos*** (abastos@math.ist.utl.pt). *Representations for classes of nonlocal C*-algebras.*

Representations on Hilbert spaces for nonlocal C*-algebras of singular integral operators with piecewise slowly oscillating coefficients extended by groups of unitary shift operators are constructed. The groups of unitary shift operators are associated with discrete amenable groups that admit distinct fixed points for different shifts. Fredholm symbols for particular classes of nonlocal C*-algebras are obtained. The talk is based on joint works with Yuri Karlovich and Claudio Fernandes. (Received February 06, 2015)

Session 34

1111-47-395 **G. Corach**, **G. Fongi** and **A. Maestripieri*** (amaestri@fi.uba.ar). *Optimal inverses and abstract splines.*

In this talk we discuss the A-optimal inverse of a bounded linear operator operator acting on a Hilbert space H, for a positive bounded linear operator A on H, and its relationship with the solutions of a given abstract spline smoothing problem. In order to do this, we apply two algebraic-geometric tools: the compatibility property between positive operators and closed subspaces and the range additivity between two operators.

It was S. K. Mitra who defined the optimal inverses for matrices. His goal was the search of the best approximate solutions of inconsistent linear systems under seminorms defined by positive semidefinite matrices. We extend Mitra's concept to Hilbert space operators to apply the results to abstract interpolation theory. Abstract spline theory has been developed by M. Atteia in an attempt to unify several classes of spline-type functions. (Received February 06, 2015)

Session 34

1111-47-423 **Raul E Curto*** (raul-curto@uiowa.edu), Department of Mathematics, The University of Iowa, Iowa City, IA 52242. *Abrahamse's Theorem for Matrix-valued Symbols and Subnormal Toeplitz Completions.*

In 1976, M.B. Abrahamse obtained a remarkable result in single operator theory, addressing one of P.R. Halmos's famous Ten Problems in Hilbert Space. Abrahamse proved the following theorem:

Let $\varphi \in L^\infty$ be such that φ or its complex conjugate is of bounded type. If T_φ is subnormal, then T_φ is either normal or analytic.

In this talk we will present a complete generalization of this theorem to the matrix-valued case. We will then apply this result to solve a matricial Toeplitz completion problem with Blaschke factors as data. (Joint work with I.S. Hwang and W.Y. Lee.) (Received February 07, 2015)

Session 17

1111-47-425 **Markus Seidel*** (markus.seidel@fh-zwickau.de). *Essential pseudospectra and essential norms of band-dominated operators.*

The study of Convolution Type Operators is closely connected with Fredholm operators A. Roughly speaking, the Fredholm property of A is the invertibility of its coset $A + \mathcal{K}$ modulo compact operators, and there are well known characterizations which typically read as follows:

An operator A is Fredholm iff all elements of a certain related family of (hopefully simpler) operators are invertible. (1)

Here the philosophy is basically: In order to understand A just take snapshots of A from sufficiently many directions and study their properties. In practice this often means applying homomorphisms or passing to limits.

By that, one particularly gets the essential spectrum of A as the union of the spectra of its snapshots, which is useful as long as the snapshots are simple and their spectra are available. If not, one may try to work with pseudospectra instead, but then it is necessary to improve (1) and to relate not only invertibility, but also the essential norm $\|A + \mathcal{K}\|$ of A with the norms of its snapshots. This talk is about such improved relations, in particular for band-dominated operators. It is based on joint work with R. Hagger and M. Lindner. (Received February 07, 2015)

Session 34

1111-47-455 **Elizabeth Strouse*** (strouse@math.u-bordeaux1.fr), IMB , 351 cours de la liberation, Universite Bordeaux, Talence, France. *Mixed commutators and little product bmo.*

The Nehari theorem in 1957 established the relationship between the boundedness of a Hankel operator (or, equivalently, of commutators of a multiplication operator and the Hilbert transform) and the distance of the symbol from the bounded analytic functions on the unit disc. Later in the century these results were shown to be associated with weak factorization and functions of bounded mean oscillation. The multivariable case characterized boundedness of commutators of Riesz transforms and more general classes of kernel operators in terms of bmo norms. Our recent work explains the relationship between 'mixed bmo' (functions which are uniformly in product bmo with respect to some of their variables), 'mixed' Hankel operators, and iterated commutators of certain classes of tensor products of Riesz transforms.

[1] Yumeng Ou, Stefanie Petermichl and Elizabeth Strouse, Mixed commutators and little product BMO, preprint; HAL-01109050, 2015 (Received February 08, 2015)

Session 46

1111-47-493 **Yuri I. Karlovich*** (`karlovich@uaem.mx`), Centro de Investigación en Ciencias, Universidad Autónoma del Estado de Morelos, Av. Universidad 1001, Col. Chamilpa, 62209 Cuernavaca, Morelos, Mexico. *C^*-algebras of Bergman type operators on polygonal domains.*

Given $\alpha \in (0, 2]$, the C^*-algebra $\mathfrak{A}_{\mathbb{K}_\alpha}$ generated by the operators of multiplication by piecewise constant functions with discontinuities on a system $\mathfrak{L}$ of rays starting from the origin and by the Bergman and anti-Bergman projections acting on the Lebesgue space $L^2(\mathbb{K}_\alpha)$ over the open sector

$$\mathbb{K}_\alpha = \{z = re^{i\theta} : r > 0,\ \theta \in (0, \pi\alpha)\}$$

is studied. Then, for any bounded polygonal domain U, the C^*-algebra $\mathfrak{B}_U$ generated by the operators of multiplication by piecewise continuous functions on the closure $\overline{U}$ of U and by the Bergman and anti-Bergman projections acting on the Lebesgue space $L^2(U)$ is investigated. Symbol calculi for the C^*-algebras $\mathfrak{A}_{\mathbb{K}_\alpha}$ and $\mathfrak{B}_U$ are constructed and an invertibility criterion for operators $A \in \mathfrak{A}_{\mathbb{K}_\alpha}$ and a Fredholm criterion for the operators $B \in \mathfrak{B}_U$ in terms of their symbols are established. (Received February 08, 2015)

Session 17

1111-47-496 **Yuri I. Karlovich*** (`karlovich@uaem.mx`), Centro de Investigación en Ciencias, Universidad Autónoma del Estado de Morelos, Av. Universidad 1001, Col Chamilpa, 62209 Cuernavaca, Morelos, Mexico, and **Iván Loreto-Hernández**. *A C^*-algebra of nonlocal convolution type operators.*

The C^*-subalgebra $\mathfrak{B}$ of bounded linear operators on the space $L^2(\mathbb{R})$, which is generated by all multiplication operators by piecewise slowly oscillating functions, by all convolution operators with piecewise slowly oscillating symbols and by the unitary shift operators associated with the group G of all orientation-preserving affine mappings of $\mathbb{R}$ onto itself, is studied. A faithful representation of the quotient C^*-algebra $\mathfrak{B}^\pi = \mathfrak{B}/\mathcal{K}$ in a Hilbert space, where $\mathcal{K}$ is the ideal of compact operators on $L^2(\mathbb{R})$, is constructed by applying a local-trajectory method, appropriate spectral measures and a lifting theorem. This gives a Fredholm symbol calculus for the C^*-algebra $\mathfrak{B}$ and a Fredholm criterion for the operators $B \in \mathfrak{B}$. (Received February 08, 2015)

Session 10

1111-47-506 **Wilson Lamb*** (`w.lamb@strath.ac.uk`). *Semigroups of Operators and the Discrete Coagulation-Fragmentation Equation.*

The usual starting point when developing a mathematical model of coagulation-fragmentation processes is to regard the system under consideration as one consisting of a large number of clusters that can coagulate to form larger clusters or fragment into a number of smaller clusters. The assumption that each cluster of size n consists of n identical fundamental units (monomers) leads to a discrete model of coagulation-fragmentation that takes the form of an infinite system of ordinary differential equations.

In this talk, the associated initial-value problem for the infinite-dimensional system will be expressed as a semi-linear abstract Cauchy problem, posed in a physically relevant Banach space. Standard perturbation results from the theory of semigroups of operators will be used to establish the existence and uniqueness of globally-defined, strongly differentiable, non-negative solutions for uniformly bounded coagulation rates but with minimal restrictions placed on the fragmentation rates. Some recent results, obtained via the theory of sectorial operators and analytic semigroups of operators, that enable the uniform boundedness of the coagulation rates to be relaxed will also be mentioned briefly. (Received February 09, 2015)

Session 34

1111-47-539 **Rui Marreiros*** (`rmarrei@ualg.pt`), Departamento de Matemática, Faculdade de Ciências, Universidade do Algarve, 8005-139 Faro, Portugal. *An estimate for the dimension of the kernel of a singular integral operator with non-Carleman shift and conjugation.*

On the Hilbert space $\widetilde{L}_2(\mathbb{T})$ the singular integral operator with non-Carleman shift and conjugation $K = P_+ + (aI + AC)P_-$ is considered, where $P_\pm$ are the Cauchy projectors, $A = \sum_{j=0}^{m} a_j U^j$, a, a_j, $j = \overline{1, m}$, are continuous functions on the unit circle $\mathbb{T}$, U is the shift operator and C is the operator of complex conjugation. An estimate for the dimension of the kernel of the operator K is obtained.

This talk is based on a joint work with Ana Conceição. (Received February 09, 2015)

Session 34

1111-47-543 **Franciszek Hugon Szafraniec*** (umszafra@cyf-kr.edu.pl), Uniwersytet Jagielloński, Instytut Matematyki, ul. Łojasiewicza 6, 30 348 Kraków, Poland. *Coherent states without measure.*

The Horzela-Szafraniec approach to coherent states proposed in [1] and [2] is presented here. It is a down-to-earth construction leaving apart the (common in Mathematical Physics) requirement it to be assisted with some measure space. This is made possible if one drops out in studying the reproducing kernel property integrability of its Hilbert space, which at the introductory stage turns out to be a ballast. Further, recent developments are added to this topic.

[1] A. Horzela, F.H. Szafraniec, A measure free approach to coherent states, *J. Phys. A: Math. Theor.* **45** (2012) 244018.

[2] A. Horzela, F.H. Szafraniec, A measure free approach to coherent states refined, in Proceedings of the XXIX International Colloquium on Group-Theoretical Methods in Physics 2012, Tianjin, China, Nankai Series in Pure, Applied Mathematics and Theoretical Physics 11, 277. (Received February 09, 2015)

Session 34

1111-47-544 **Pawel Pietrzycki*** (pawel.pietrzycki@im.uj.edu.pl), Instytut Matematyki, Uniwersytet Jagiellonski, ul. Lojasiewicza 6, 30348 Krakow, Poland. *A note on the equation $|C^n| = |C|^n$ and composition operators.*

It is proved that a closed densely defined operator C is quasinormali if and only if the equality $C^{*n}C^n = (C^*C)^n$ holds for $n = 2, 3$. Let W be bounded injective weighted shift which satisfies the equality $W^{*n}W^n = (W^*W)^n$. We prove that operator W is then quasinormal. We will construct examples of bounded, non-quasinormal operator C which satisfies equality $C^{*n}C^n = (C^*C)^n$. An example of such a operator is given in the class of weighted shifts on directed trees. What is important, the directed tree used in the construction is rootless and therefore the operator in example is unitarily equivalent to a composition operator in L^2-space. (Received February 09, 2015)

Session 46

1111-47-602 **Catarina C Carvalho*** (catarina.carvalho@math.tecnico.ulisboa.pt), Dep. Matemática, Instituto Superior Técnico, 1049-001 Lisbon, Portugal. *Index formulas for pseudodifferential operators on compactified domains.*

We consider here domains in $\mathbb{R}^n$ with a given a compactification to a domain with boundary, and a class of pseudodifferential operators suitably generated by vector fields tangent to the boundary. Examples are, e.g., domains with cylindrical ends, or asymptotically Euclidean. We present an index formula in case the generating vector fields vanish at the boundary, that is, at infinity. There exists a commutative full symbol, defining an invertible function on a $2n-1$-sphere and the index depends only on a "generalized winding number" associated to this function.

We first establish an extension of the known index formula on compact spaces to operators on $\mathbb{R}^n$ that are asymptotically of the form $Q + M_\phi$, where Q has a compactly supported kernel and M_ϕ is a multiplication operator. We then use homotopy arguments and invariance of the index.

As an application, we study the index of Dirac operators coupled with an unbounded potential on an even dimensional domain. We reduce to the computation of the index of a perturbed Dirac operator on a commutative domain, now with a bounded potential, and we obtain a Callias-type index formula in these two cases.

The talk is based on joint work with V. Nistor, Pennsylvania State University. (Received February 09, 2015)

Session 17

1111-47-647 **Cláudio António Fernandes*** (caf@fct.unl.pt). *Wiener-Hopf Factorization in Decomposing Complete Metric Algebras.* Preliminary report.

Following ideas of Georg Heinig and Bernd Silbermann, we develop a factorization theory for a decomposing complete metric algebra A. Namely we prove that for each integer N, the algebra A has the N-factorization property if and only if A has the N-Fredholm property.

This is a joint work with M. Amélia Bastos and Alexey Yu. Karlovich. (Received February 09, 2015)

Session 17

1111-47-666 **J. A. Virtanen*** (virtanen@cims.nyu.edu). *Spectral theory of Toeplitz operators on Hardy spaces and Riemann-Hilbert problems.*

I discuss the existence of eigenvalues in the essential spectra of Toeplitz operators acting on Hardy spaces. While a geometrical description of the essential spectrum $\sigma_{\text{ess}}(T_a)$ is well known for a large class of bounded symbols a, very little is known about the (non)existence of eigenvalues embedded in $\sigma_{\text{ess}}(T_a)$. Most known results are restricted to continuous symbols under additional conditions when the symbol takes its values on a finite number of rays or in two sectors with vertices at the origin.

The aim of this talk is to deal with the case when there are more than two sectors using Riemann-Hilbert methods, state some further open problems related to other symbol classes, such as piecewise continuous symbols, and also consider matrix-valued symbols. (Received February 09, 2015)

Session 34

1111-47-668 **J. A. Virtanen*** (virtanen@cims.nyu.edu). *Fredholm theory of Toeplitz operators on Fock spaces.*

I discuss the theory of bounded and compact Toeplitz and Hankel operators on (generalized) Fock spaces with emphasis on the Fredholm properties of Toeplitz operators on these spaces. Compared with Hardy or Bergman spaces of bounded curved domains, such as the unit disk, much less is known about Fredholmness in Fock spaces. In general, characterizing Fredholm operators in Fock spaces seems more complicated. One reason is the flatness of the unbounded domain, but there are many other reasons why dealing with symbol classes familiar from the Hardy/Bergman space setting is much more difficult in Fock spaces.

The aim of this talk is to review the known results on Fredholm theory of Toeplitz operators on Fock spaces, drawing a comparison between the three function spaces, state some recent generalizations, and also consider the case of matrix-valued symbols. (Received February 09, 2015)

Session 17

1111-47-708 **A B Lebre*** (alebre@math.ist.utl.pt), Instituto Superior Técnico, Departamento de Matemática, Av. Rovisco Pais, 1049-001 Lisboa, Portugal. *Factorization of matrix functions related to singular integral operators with a Carleman shift on the unit circle.* Preliminary report.

Let $L^p(\mathbb{T})$, $p \in (1, \infty)$, be the usual Lebesgue spaces of functions on the unit circle, let α be a linear fractional shift reversing the orientation of the unit circle and U_α the corresponding shift operator, which anti-commutes with the basic singular integral operator with Cauchy kernel S. In a previous work together with V. G. Kravchenko and J. S. Rodríguez we have shown that, if a certain matrix function associated with the singular integral operator on the unit circle $\mathbb{T}$:

$$T_{A,B} = AP_+ + BP_-,$$

where $P_\pm = \frac{1}{2}(I \pm S)$ are the complementary projection operators on $L^p(\mathbb{T})$ associated with S and A, B are functional operators of the form

$$A = aI + bU_\alpha, \quad B = cI + dU_\alpha$$

with $a, b, c, d \in L^\infty(\mathbb{T})$, admits a generalized factorization on $L^p(\mathbb{T})$, then the operator $T_{A,B}$ is Fredholm on that space and its defect numbers can be calculated in terms of the so-called partial indices of the given matrix function and of some parameters resulting from that factorization.

Making some hypotheses on the coefficients of the operators A and B we exhibit a class of matrix functions for which the factorization problem in $L^p(\mathbb{T})$ can be treated. (Received February 10, 2015)

Session 34

1111-47-734 **Issam Louhichi*** (ilouhichi@aus.edu), Department of Mathematics & Statistics, College of Arts and Sciences, American University of Sharjah, Sharjah, 26666, United Arab Emirates. *Commutants of Toeplitz operators.*

One of the major questions in the theory of Toeplitz operators defined on the analytic Bergman space of the unit disk $\mathbb{D}$ in the complex plane $\mathbb{C}$ is a complete description of the commutant of a given Toeplitz operator, that is the set of all Toeplitz operators that commute with it. The main aim of this talk is to survey some recent developments related to this question, with special attention to quasihomogeneous Toeplitz operators. A symbol f is said to be quasihomogeneous of degree p an integer if it is of the form $f(re^{i\theta}) = e^{ip\theta}\phi(r)$, where ϕ is a radial function and (r, θ) are the polar coordinates in $\mathbb{C}$. In this case the associated Toeplitz operator T_f is also called quasihomogeneous Toeplitz operator of degree p. This operator can be seen as a particular case of the so-called Holomorphic Weighted Shifts. (Received February 10, 2015)

Session 34

1111-47-776 **Matthew M Jones*** (matthew1@mdx.ac.uk), Mathematics Department, Middlesex University, Hendon, London, NW4 4BT, United Kingdom. *Composition operators induced by universal covering maps.*

In this talk I will discuss composition operators, C_ϕ, acting on the Hardy spaces that have symbol, ϕ, a universal covering map of the disk onto a finitely connected domain of the form $D_0 \backslash \{p_1, \cdots, p_n\}$, where D_0 is simply connected and p_i, $i = 1, \ldots, n$, are distinct points in the interior of D_0. I will speak in particular about conditions that determine compactness of these operators and demonstrate a link with the Poincare series of the uniformizing Fuchsian group and the Nevanlinna counting function. These results provide a method for extending previous results on the simply connected case to multiply connected domains. (Received February 10, 2015)

Session 17

1111-47-785 **Estelle L Basor*** (`ebasor@aimath.org`), American Institute of Mathematics, San Jose, CA 95112. *Determinant computations in the block Toeplitz case.* Preliminary report.

The infinite determinant of $T(\phi)T(\phi^{-1})$ arises as the constant in the block case of the Szego-Widom Limit Theorem for Toeplitz matrices. While the constant has a very nice form, often a more explicit form, analogous to the one found in the scalar case, is needed in applications. This talk will give examples where the constant can be described very explicitly, in particular when the symbol of the Toeplitz operator is loop in $SU(2)$. This is joint work with Doug Pickrell. (Received February 10, 2015)

Session 34

1111-47-803 **Michael A. Dritschel*** (`michael.dritschel@ncl.ac.uk`). *Realizations via preorderings with application to the Schur Class.*

We extend Agler's notion of a function space defined in terms of test functions to include products, in analogy with practices in real algebraic geometry. We prove a realization theorem for functions in the unit ball of such an algebra, otherwise known as the Schur-Agler class. Restricting to the context of so-called ample and nearly ample preorderings, the realization theorem can be further strengthened, enough so as to allow applications to, among other things, Pick type interpolation problems. This is achieved through the construction of matrix valued auxiliary test functions. (Received February 10, 2015)

49 ► *Calculus of variations and optimal control; optimization*

Session 21

1111-49-18 **Ricardo Almeida***, University of Aveiro, Portugal, **Agnieszka Malinowska**, , Poland, and **Tatiana Odzijewicz**, , Portugal. *The Caputo–Katugampola fractional derivative: properties and optimization problems.*

We study a Caputo-Katugampola fractional derivative, which is a generalization of the Caputo and the Caputo–Hadamard fractional derivatives, with dependence on a real parameter ρ. After presenting some important results about the fractional operator, we study variational problems with dependence on this operator. We present sufficient and necessary conditions of first and second order to determine the extremizers of a functional. The cases of integral and holomonic constraints are also considered. An existence and uniqueness theorem for a fractional Caputo type problem, with dependence on the Caputo–Katugampola derivative, is proven. A decomposition formula for the Caputo–Katugampola derivative is obtained. This formula allows us to provide a simple numerical procedure to solve the fractional differential equation. (Received December 23, 2014)

Session 31

1111-49-60 **Elisa Davoli*** (`edavoli@andrew.cmu.edu`), Department of Mathematical Sciences, Wean Hall 6113, Carnegie Mellon University, Pittsburgh, PA 15213, and **Irene Fonseca** (`fonseca@cmu.edu`), Department of Mathematical Sciences, Wean Hall 6113, Carnegie Mellon University, Pittsburgh, PA 15213. *Homogenization of integral energies under periodically oscillating differential constraint.*

A homogenization result for a family of integral energies

$$u_\epsilon \mapsto \int_\Omega f(u_\epsilon(x))\,dx, \quad \epsilon \to 0^+,$$

is presented, where the fields u_ϵ are subjected to periodic first order oscillating differential constraints in divergence form. The work is based on the theory of A-quasiconvexity with variable coefficients and on two-scale convergence tecniques. (Received January 15, 2015)

Session 36

1111-49-64 **Laura Bufford** (`lbufford@andrew.cmu.edu`), Department of Mathematical Sciences, Wean Hall 6113, Carnegie Mellon University, Pittsburgh, PA 15213, **Elisa Davoli*** (`edavoli@andrew.cmu.edu`), Department of Mathematical Sciences, Wean Hall 6113, Carnegie Mellon University, Pittsburgh, PA 15213, and **Irene Fonseca** (`fonseca@cmu.edu`), Department of Mathematical Sciences, Wean Hall 6113, Carnegie Mellon University, Pittsburgh, PA 15213. *Multiscale homogenization in Kirchhoff's nonlinear plate theory.*

The interplay between multiscale homogenization and dimension reduction for nonlinear elastic thin plates is analyzed in the case in which the scaling of the energy corresponds to Kirchhoff's nonlinear bending theory for plates. Different limit models are deduced depending on the relative ratio between the thickness parameter h and the two homogenization scales ϵ and ϵ^2. (Received January 16, 2015)

Session 36

1111-49-69 **Irene Fonseca*** (`fonseca@andrew.cmu.edu`), Department of Mathematical Sciences, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213. *Second Order Gamma-Convergence for the Modica Mortola Functional.*

The asymptotic behavior of an anisotropic Cahn-Hilliard functional with prescribed mass and Dirichlet boundary condition is studied when a small parameter that determines the width of the transition layers tends to zero. The first order term in the asymptotic development by Gamma-convergence is well-known, and is related to a suitable anisotropic perimeter of the interface. Here it is shown that, under usual assumptions, the second order term is zero, which gives an estimate on the rate of convergence of the minimum value. This is work in collaboration with Gianni Dal Maso and Giovanni Leoni. (Received January 18, 2015)

Session 21

1111-49-80 **Loïc Bourdin*** (`loic.bourdin@unilim.fr`), Université de Limoges, Département Mathématiques et Informatique, Limoges, France, and **Emmanuel Trélat**, Université Pierre et Marie Curie (Paris 6), Laboratoire Jacques-Louis Lions, Paris, France. *Optimal sampled-data controls, and generalizations on time scales.*

We derive a version of the Pontryagin maximum principle for general finite-dimensional nonlinear optimal sampled-data control problems. Our framework is actually much more general, and we treat optimal control problems for which the state variable evolves on a given time scale, and the control variable evolves on a smaller time scale. Sampled-data systems are then a particular case. Our proof is based on the construction of appropriate needle-like variations and on the Ekeland variational principle. (Received January 20, 2015)

Session 21

1111-49-160 **Simão P. S. Santos*** (`spsantos@ua.pt`), Departamento de Matemática, Universidade de Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal, and **Natália Martins** and **Delfim F. M. Torres**. *Noether's theorem for higher-order variational problems of Herglotz type.*

We approach higher-order variational problems of Herglotz type from an optimal control point of view. Using optimal control theory, we derive a generalized Euler–Lagrange equation, transversality conditions, DuBois–Reymond necessary optimality condition and Noether's theorem for Herglotz's type higher-order variational problems, valid for piecewise smooth functions. (Received January 30, 2015)

Session 31

1111-49-294 **Elvira Zappale*** (`ezappale@unisa.it`), DIIN, 84084 FISCIANO, (SA), Italy. *Homogenization for unbounded and supremal functionals.*

Several results dealing with homogenization and dimensional reduction for constrained integral functionals and related properties for supremal functionals will be presented. (Received February 05, 2015)

Session 31

1111-49-332 **Carolin Kreisbeck*** (`carolin.kreisbeck@mathematik.uni-regensburg.de`), Fakultät für Mathematik, Universität Regensburg, 93040 Regensburg, Germany, and **Stefan Krömer**. *Heterogeneous thin films: Homogenization and dimension reduction of functionals with differential constraints.*

Working with variational principles subject to linear PDE constraints conveyed by a constant-rank operator $\mathcal{A}$ allows us to treat a number of problems in continuum mechanics and electromagnetism in a unified way. The topic of this talk is the rigorous derivation of lower dimensional, effective limit models for thin films with periodic heterogeneities in this general framework. We analyze the asymptotic behavior of a multiscale problem given by a sequence of integral functionals with two characteristic length scales, namely the film thickness and the period of the oscillating microstructures, by means of Γ-convergence. On a technical level, this requires a subtile merging of homogenization tools, such as multiscale convergence methods, with dimension reduction techniques for functionals on $\mathcal{A}$-free vector fields. One observes that the results depend critically on the relative magnitude between the two scales. Interestingly, this even regards the fundamental question of locality of the limit model. (Received February 06, 2015)

Session 21

1111-49-454 **Agnieszka B. Malinowska*** (a.malinowska@pb.edu.pl), Faculty of Computer Science, Bialystok University of Technology, 15-351 Bialystok, Poland. *Variational problems with the fractional-order backward-difference.*

The fractional calculus for discrete-variable functions is getting more and more popular due to its technical applications, e.g., *T. Kaczorek, Selected Problems of Fractional Systems Theory, Springer, 2011.* We study one and multidimensional discrete-time fractional problems of the calculus of variations. Necessary optimality conditions are established and the Noether theorems are proved. (Received February 08, 2015)

Session 36

1111-49-507 **Valeriy Slastikov*** (valeriy.slastikov@bristol.ac.uk), Department of Mathematics, University of Bristol, Bristol, BS8 1TW, United Kingdom. *2D point defects in nematic liquid crystals.*

We investigate prototypical profiles of point defects in two dimensional liquid crystals within the framework of Landau-de Gennes theory. We find that radially symmetric critical points of the Landau-de Gennes energy are characterized by a system of ordinary differential equations. We investigate stability of these critical points in various regimes of material parameters. (Received February 09, 2015)

Session 43

1111-49-548 **Susanna Terracini***, Dipartimento di Matematica "Giuseppe Peano", Via Carlo Alberto 10, 10123 Torino, Italy. *Existence and regularity of solutions to optimal partition problems involving Laplacian eigenvalues.*

Let $\Omega \subset \mathbb{R}^N$ be an open bounded domain and $m \in \mathbb{N}$. Given $k_1, \ldots, k_m \in \mathbb{N}$, we consider a wide class of optimal partition problems involving Dirichlet eigenvalues of elliptic operators, including the following

$$\inf \left\{ \Phi(\omega_1, \ldots, \omega_m) := \sum_{i=1}^{m} \lambda_{k_i}(\omega_i) : \ (\omega_1, \ldots, \omega_m) \in \mathcal{P}_m(\Omega) \right\},$$

where $\lambda_{k_i}(\omega_i)$ denotes the k_i–th eigenvalue of $(-\Delta, H_0^1(\omega_i))$ counting multiplicities, and $\mathcal{P}_m(\Omega)$ is the set of all open partitions of Ω, namely

$$\mathcal{P}_m(\Omega) = \{(\omega_1, \ldots, \omega_m) : \ \omega_i \subset \Omega \text{ open}, \ \omega_i \cap \omega_j = \emptyset \ \forall i \neq j\}.$$

We prove the existence of an open optimal partition $(\omega_1, \ldots, \omega_m)$, proving as well its regularity in the sense that the free boundary $\cup_{i=1}^m \partial\omega_i \cap \Omega$ is, up to a residual set, locally a $C^{1,\alpha}$ hypersurface.

This is a joint paper with Miguel Ramos and Hugo Tavares

In order to prove this result, we first treat some general optimal partition problems involving all eigenvalues up to a certain order. (Received February 09, 2015)

Session 37

1111-49-583 **Filipa Nunes Nogueira** (filipan@fe.up.pt), DEEC, FEUP, Rua Dr. Roberto Frias s/n, 4200-465 Porto, Portugal, and **MdR de Pinho*** (mrpinho@fe.up.pt), DEEC, FEUP, Rua Dr. Roberto Frias s/n, 4200-465 Porto, Portugal. *Optimal Control for Epidemiology using SEIR models: the role of state and mixed constraints.*

We investigate the introduction of mixed and state constraints on optimal control problems formulated for the control of infectious diseases via vaccination. Such constraints depict some realistic requirements and situations yielding vaccination policies that differ from those obtained by more standard approaches.

Central to all the work is a SEIR model for a generic infection. Also of relevance is the introduction of L1 costs.

These problems are solved numerically by direct methods using known optimization solvers. Validation of the numerical solutions is performed by optimality conditions. The sensitive of the solutions and control policies to perturbations of the parameters is analised. (Received February 09, 2015)

Session 36

1111-49-596 **Marco Barchiesi*** (barchies@gmail.com), Università di Napoli "Federico II", Via Cintia, 80126 Naples, Italy. *Local invertibility in Sobolev spaces and applications.*

I will discuss the local invertibility of Sobolev maps that are regular, in the sense that they undergo no cavitation. I will show that the invertibility is stable under the weak convergence, and I will use this property to provide the well-posedness of a nonlinear model for nematic elastomers. (Received February 09, 2015)

Session 31

1111-49-725 **Graça Carita** and **Ana Margarida Ribeiro*** (amfr@fct.unl.pt), Dep. de Matemática and CMA, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 2829-516 Caparica, Portugal, and **Elvira Zappale**. *An Homogenization Result in $W^{1,p} \times L^q$.*

An integral representation result is provided for the Γ-limit of integral functionals arising in the study of homogenization problems for the study of coherent thermochemical equilibria in multiphase solids. (Received February 10, 2015)

Session 21

1111-49-769 **Hegagi Mohamed Ali*** (hegagi_math@yahoo.com), Rua Campo Alegre, s/n, 4169-007 Porto, Portugal, **Fernando Manuel Ferreira Lobo Pereira** (flp@fe.up.pt), Rua Dr. Roberto Frias, s/n, 4200-465 Porto, Portugal, and **Silvio M.A. Gama** (smgama@fc.up.pt), Rua Campo Alegre, s/n, 4169-007 Porto, Portugal. *A new technique to find Pontryagin maximum principle and necessary optimality conditions of fractional nonlinear optimal control problems.*

In this talk, we introduce a new general formulation of fractional optimal control problems which considers the performance index (objective function) in the fractional integral form and contains state and control variables. The dynamic constraints are described by a set of fractional differential equations in the Caputo sense. We use a new technique to find necessary optimality conditions and Pontryagin maximum principle for fractional nonlinear optimal control problems.The resulting differential equations were solved using an analytical technique based on a generalization of the Mittag-Leffler function. A simple example is provided to illustrate the effectiveness of the results. (Received February 10, 2015)

Session 21

1111-49-806 **Nagwa Mohamed Arafa*** (nagwaarafa@yahoo.com), Dept. Matematics, FCUP, Rua do Campo Alegre, s/n, 4169-007 Porto, Portugal, **Silvio M.A. Gama** (smgama@fc.up.pt), Dept. Mathematics, FCUP, Rua do Campo Alegre, s/n, 4169-007 Porto, Portugal, and **Fernando Lobo Pereira** (flp@fe.up.pt), Dept. Electrical and Computer Engineering, FEUP, Rua Dr. Roberto Frias, s/n, 4200-465 Porto, Portugal. *Controlling the power laws in shell models of turbulence.*

A shell models of turbulence is a system of ordinary differential equations structurally similar to the Navier-Stokes equations written in Fourier space. Farazmand et. al. [J. Fluid Mech. (668), 202-222, 2011] use and develop an optimal control theory approach to find a forcing that produces the dual scaling ranges predicted by Kraichnan-Leith-Batchelor theory in the context of incompressible two-dimensional turbulence. Following the same strategy, we will show how some two- and three-dimensional shell models of turbulence can also be controlled through tuning of force so that a given power law is, statistically, achieved in a relatively small prescribed time. (Received February 10, 2015)

51 ► Geometry

Session 39

1111-51-33 **Ugo Comollo** (ugo.comollo@gmail.com), Dipartimento di Disegno Architettura e Design, Politecnico di Torino, C.so Mattioli 39, 10125 Torino, Italy, **Caterina Cumino** (caterina.cumino@polito.it), Dipartimento di Scienze Matematiche, Politecnico di torino, C.so Duca degli Abruzzi 24, Torino, 10129, **Matteo Semplice** (matteo.semplice@unito.it), Dipartimento di Matematica, Università di Torino, Via C. Alberto 10, Torino, 10123, **Maria Luisa Spreafico*** (maria.spreafico@polito.it), Dipartimento di Scienze Matematiche, Politecnico di Torino, C.so Duca degli Abruzzi 24, Torino, 10129, and **Ursula Zich** (ursula.zich@polito.it), Dipartimento di Disegno Architettura e Design, Politecnico di Torino, C.so Mattioli 39, 10125 Torino, Italy. *Modelling vaults: from laser scanning techniques to origami.*

We aim to construct 3D models of vaults from a single sheet of paper, using origami techniques. We approach this problem with different methods based on the interaction between mathematical and architectural languages.

First we analyze mathematically the pure form of vaults generated by the intersection of cylinders with any cross-section provided that their intersection is a piecewise planar curve with suitable hypotheses of symmetry. In this case our goal is to find, on a sheet of paper, a set of folding lines and a folding process that allow us to fold the desired vault. To achieve it, we describe the development on the plane of the intersection curves and their positioning and we suitable translate them.

Secondly we aim to find model of a real vault. With this purpose we choose a cloister type vault in the royal residence of Venaria Reale (Turin), and we describe an approximation method that recovers the ruled surfaces that best fit data of the real vault obtained via laser scanning techniques.

We are investigating applications of our work in: architectural drawing courses, preliminary studies before preservation work, creation of vaulted-roofed temporary architecture and design for cultural merchandising. (Received January 07, 2015)

Session 39

1111-51-36 **Rinus Roelofs*** (rinus@rinusroelofs.nl), Rinus Roelofs, 7553AL Hengelo, Netherlands. *Leonardo's Elevated Polyhedra – Extended to flat patterns - Models.* Preliminary report.

Stellation is a well known operation which you can apply to a polyhedron. About a century before this operation was defined by Kepler, Luca Pacioli and Leonardo da Vinci had published the book "La Divina Proportione" in which another operation, called Elevation, was described. Both operations have much in common, but there are also many differences. The Elevation operation as described by Luca Pacioli and Leonardo da Vinci turns out to be a big field of inspiration, which leads to many interesting constructions, esthetic as well as constructive. Comparing Elevation and Stellation inspired me to define a new operation, which I called Edge Elevation. Besides on spherical patterns, the Elevation operation can also be applied on cylindrical patterns and flat patterns. This all leads to interesting artistic constructions. Also because the resulting structures are double layered. The woven flat structures, which are in fact Elevations of 2D tiling patterns, can be made using simple elements. And with these elements also double woven patterns can be realized. (Received January 08, 2015)

Session 39

1111-51-79 **Francesco De Comité*** (`francesco.de-comite@univ-lille1.fr`), Bat M3 Info, Université des Sciences de Lille, Cité Scientifique, 59655 Villeneuve d'Ascq, France. *Yvon-Villarceau Circles Equivalents on Dupin Cyclides.*

Dupin cyclides are algebraic surfaces obtained as images under inversion of cylinders, cones of revolution or tori. Since inversion preserves circles, Dupin cyclides obtained from tori (ring and parabolic ring cyclides) carry four families of circles: meridians, parallels and the images under inversion of the two sets of Yvon-Villarceau circles. Craftworks and artworks based on Yvon-Villarceau circles can be very attractive. Trying to transfer this aesthetic appeal from tori to cyclides was the origin of this work. Using Lionel Garnier's equations for images of Yvon-Villarceau circles, I wrote several programs to visualize them. it then became possible to explore this family of cyclides, either as two-dimensional pictures, or as 3D-printed objects. The regularity and the hidden complexity of those representations make them very attractive. Moreover, reviving the old tradition of mathematical models making, I printed several models, which can be of great help for understanding their geometry. Other artworks, images of constructions on a torus, are proven to be feasible. The tools developed in this work are generalized to explore families of images of ruled surfaces under inversion.This exploration is just beginning, but has already produced interesting new objects. (Received January 21, 2015)

Session 20

1111-51-131 **Erwan Brugallé*** (`erwan.brugalle@math.cnrs.fr`), École polytechnique, Centre Mathématiques Laurent Schwatrz, 91 128 Palaiseau, France. *Enumeration of complex, real and tropical curves in surfaces.*

The main question I plan to address is: given an algebraic surface (or 4-symplectic manifold) X, how many (J-)holomorphic curves of a given genus and homology class pass through a given configuration of points x? (the cardinality of x is chosen such that the number of curves is finite.)

A possible approach to solve such an enumerative problem is to construct configurations x, called effective, for which one can exhibit all curves under enumeration. The main advantage of effective configurations is to provide simultaneous enumeration of both complex and real curves, furthermore without assuming any invariance with respect to x. This is particularly useful in real enumerative geometry where invariants are lacking.

The goal of this course is to explain how one can construct effective configurations thanks to Tropical geometry, or by degenerating the target space X and using either Li's degeneration formula or symplectic sum formulas.

As an application, I plan to discuss how to reduce sometimes the geometric enumeration of curves to a combinatorial enumeration of the so-called floor diagrams. (Received January 27, 2015)

Session 27

1111-51-251 **Laura Schaposnik*** (`schapos@illinois.edu`), 1409 West Green Street, Urbana, IL 61801. *Higgs bundles, spectral data, and applications.*

The moduli space of complex Higgs bundles carries a natural Hyperkahler structure, through which we can study Lagrangian subspaces (A-branes) or holomorphic subspaces (B-branes) with respect to each choice of complex and symplectic structure. In this talk we shall look at a natural construction of families of real slices of the moduli space which give different types of branes. Then, by means of spectral data, we shall relate these branes to the study of surface group representations into real Lie groups, 3-manifolds, knot and graph complements, and (curve and brane) quantization. We shall conclude with some conjectures related to Langlands duality. (Received February 03, 2015)

Session 39

1111-51-277 **Craig S. Kaplan*** (`csk@uwaterloo.ca`), 200 University Avenue West, Waterloo, Ontario N2L 3G1, Canada. *Islamic star patterns from X-tiles.* Preliminary report.

I discuss the use of X-tiles, rhombs with inscribed crossing lines, as a means of replicating traditional Islamic star patterns and of generating novel patterns. X-tiles represent an unusual decomposition of star patterns in which line crossings, rather than other complete motifs, are considered as the primary geometric primitive. I begin with a set of fivefold X-tiles first suggested by Castera, and explore the extent to which these tiles can be used to generate both periodic and nonperiodic star patterns. I then present some attempts to generalize the fivefold set to other orders of symmetry, and the challenges involved in creating periodic and non-periodic tilings by these rhombs that respect the matching conditions implied by their inscribed crossings. (Received February 04, 2015)

Session 16

1111-51-483 **Yun Hyung Cho*** (yhcho@kias.re.kr), Avenida Rovisco Pais 1, 1049-001 Lisbon, Portugal, and **Min Kyu Kim** (mkkim@kias.re.kr), San 59-12, Gyesan-dong, Gyeyang-gu., Incheon, 407-753, South Korea. *Unimodality of the Betti numbers for Hamiltonian circle action with isolated fixed points.*

A sequence of real numbers $a_1, a_2, \cdots, a_n$ is called *unimodal* if there exists a positive integer k (called a *mode*) such that $a_i \leq a_{i+1}$ for $i < k$ and $a_i \geq a_{i+1}$ for $i \geq k$. A unimodal sequence appears in many counting problems such as a counting sequence of certain combinatorial objects (binomial coefficients, Stirling numbers of the first kind, and so on).

A unimodal sequence also appears in symplectic topology. It is well-known that for any compact Kähler manifold (M, ω, J), the sequences $\{b_0(M), b_2(M), \cdots\}$ and $\{b_1(M), b_3(M), \cdots\}$ are unimodal by the *hard Lefschetz theorem*. In particular, if there is a holomorphic Hamiltonian $\mathbb{C}^*$-action on (M, ω, J) with only isolated fixed points, then each $b_{2i}(M)$ counts the number of fixed points of Morse index $2i$ with respect to the corresponding moment map.

In this talk, we will discuss the generalization of the unimodality of the Betti numbers for Hamiltonian S^1-manifold(possibly non-Kähler) with isolated fixed points. In particular, I will describe the localization technique to approach this problem, and stetch the proof in eight-dimensional cases. (Received February 08, 2015)

Session 39

1111-51-492 **Douglas Dunham*** (ddunham@d.umn.edu), Department of Computer Science 320HH, University of Minnesota, Duluth, 1114, Duluth, MN 55812-3036. *Repeating Patterns on Triply Periodic Polyhedra.* Preliminary report.

Many artists have decorated convex polyhedra with different kinds of patterns. We extend this artistry by applying patterns to *triply periodic polyhedra*, infinite polyhedra in 3-dimensional Euclidean space that repeat in three independent directions. The faces of the polyhedra we consider will be copies of a regular polygon; and we further require that they be *uniform*: there is an isometry of the polyhedron that takes any vertex to any other vertex. These polyhedra are often called hyperbolic since the sum of the angles about each vertex is greater than 2π. Up to color symmetry, we decorate each polygon face with the same pattern of motifs. Most of the triply periodic polyhedra that are known contain embedded Euclidean lines. These embedded lines can be used for artistic purposes. For example if the motif is an animal with bilateral symmetry, that mirror line can be placed on one of the embedded lines. Although the polyhedra we discuss do not seem to have been classified, in 1926 H.S.M. Coxeter and John Petrie proved that there were three such polyhedra whose symmetry groups are flag-transitive, the natural analogs of the Platonic solids. We show patterns on those and other triply periodic polyhedra. (Received February 08, 2015)

Session 27

1111-51-607 **Oscar Garcia-Prada*** (oscar.garcia-prada@icmat.es), Instituto de Ciencias Matematicas, CSIC, Calle Nicolas Cabrera, 13, 28049 Madrid, Madrid, Spain. *Parabolic Higgs bundles and representations of the fundamental group of a punctured surface.*

Parabolic G-Higgs bundles on a punctured Riemann surface, and their relation with representations of the fundamental group of the punctured surface, have been much studied when G is a complex reductive Lie group, starting with the seminal work of Mehta-Seshadri on parabolic bundles. In this talk I will discuss a similar theory when the group G is a real form of a complex reductive Lie group (joint work with Olivier Biquard and Ignasi Mundet i Riera). (Received February 09, 2015)

Session 39

1111-51-814 **Konrad Polthier***, Arnimallee 6, 14195 Berlin, Germany. *Lifted domain coloring.*

The technique of domain coloring has been widely used to visualize complicated functions, typically real- or complex-valued functions living on the plane. Here we will lift the technique to functions on surfaces resp. on branched coverings of surfaces. In this talk we will discuss how a atlas of good Charts (to-be-constructed) and improvements of the domain coloring technique lead to novel illustrations such as the visualization of complex maps on Riemann surfaces and of parametric nets on geometric surfaces. (Received February 10, 2015)

53 ► Differential geometry

Session 9

1111-53-20 **Roger Nakad*** (rnakad@ndu.edu.lb), Department of Mathematics and statistics, Faculty of Natural and applied sceinces, Zouk Mosbeh, Lebanon. *Complex differential forms and the Spin^c Dirac spectrum.*

In a joint work with Mikaela Pilca (University of Regensburg-Germany), we establish a lower bound for the eigenvalues of the square of the Dirac operator defined on a compact Kähler-Einstein manifold of positive scalar curvature and endowed with a Spin^c structure whose auxiliary line bundle is a tensoriel power $\mathcal{L}^q$ ($q \in \mathbb{Z}$) of the Maslov *p-th* root $\mathcal{L}$ of the canonical bundle. This lower bound involves the tensoriel power q, the scalar curvature of the manifold and its Maslov index p. The limiting case is characterized by the existence of Kählerian Killing Spin^c spinors. As an application, we prove that on a compact Kähler-Einstein manifold carrying a complex contact structure, the only parallel forms of type (t, t) with $t > 0$ are the constant multiples of exterior powers of the Kähler form. This last result can be seen as a generalization of Moroianu's result on complex differential forms. (Received December 29, 2014)

Session 38

1111-53-47 **Miguel Sanchez*** (sanchezm@ugr.es), Departamento de Geometria y Topologia, Facultad de Ciencias, U. Granada, Campus de Fuentenueva, E18003 Granada, Spain. *Wind Finsler structures: from Zermelo's navigation to the causality of spacetimes.*

The notion of wind Finsler structure is developed. This a generalization of Finsler metrics where the indicatrices at the tangent spaces may not contain the zero vector. In the particular case that these indicatrices are ellipsoids (called here wind Riemannian structures), they admit a double interpretation which provides: (a) a model for Zermelo's navigation problem even when the trajectories of the ships are influenced by strong winds or streams, and (b) a natural description of the causal structure of relativistic spacetimes endowed with a non-vanishing Killing vector field K (SSTK spacetimes), in terms of Finslerian elements.

These elements can be regarded as conformally invariant Killing initial data on a partial Cauchy hypersurface. The links between both interpretations as well as the possibility to improve the results on each interpretation by using the other viewpoint, are stressed.

(Based on joint work with E. Caponio and MA. Javaloyes, arxiv: 1407.5494.) (Received January 12, 2015)

Session 16

1111-53-113 **Eva Miranda*** (eva.miranda@upc.es), Departament de Matematica I EPSEB Edifici P, Universitat Politècnica de Catalunya, Avinguda del Doctor Marañon 44-50, 08028 Barcelona, Spain. *The geometry and topology of b-symplectic manifolds.*

A b-symplectic manifold is a Poisson manifold which is symplectic everywhere except for a hypersurface defined by a transversality condition. In this talk, I will present the current state of the art in the study of the geometry and topology of b-symplectic manifolds. (Received January 25, 2015)

Session 14

1111-53-124 **Sorin Mihail Dumitrescu*** (dumitres@unice.fr). *Holomorphic Geometric Structures on Parallelizable Manifolds.*

This talk deals with rigid holomorphic geometric structures on compact complex manifolds. One can think at the following interesting examples: holomorphic affine connections or holomorphic Riemannian metrics.

We will discuss the classification of compact complex manifolds bearing a holomorphic Riemannian metric or, more general a holomorphic affine connection. We will also present a recent joint work with Benjamin McKay about the classification of locally homogeneous holomorphic geometric structures on complex tori and on parallelizable manifolds. (Received January 26, 2015)

Session 16

1111-53-125 **Hansjörg Geiges*** (geiges@math.uni-koeln.de). *Cobordisms between symplectic fibrations.*

I shall discuss the existence and non-existence of cobordisms between symplectic surface bundles over the circle. The methods used are holomorphic curves, fibre connected sums, and gauge theory. This is joint work with Kai Zehmisch. (Received January 27, 2015)

Session 27

1111-53-228 **Hartmut Weiss*** (weiss@math.uni-kiel.de), Mathematisches Seminar, der Christian-Albrechts-Universität zu Kiel, Ludewig-Meyn-Str. 4, 24098 Kiel, Germany. *Ends of moduli spaces of Higgs bundles.*

I will report on joint work with Rafe Mazzeo, Jan Swoboda and Frederik Witt concerning the degeneration behavior of solutions to Hitchin's equation in the rank 2 fixed determinant case. More precisely, I will describe a class of singular solutions (so-called limiting configurations) which may be desingularized via gluing methods to exact solutions with large Higgs fields. Further, I will discuss first consequences for the asymptotics of hyperkähler metric on the Higgs bundle moduli space. (Received February 03, 2015)

Session 27

1111-53-253 **David Baraglia*** (david.baraglia@adelaide.edu.au), School of Mathematical Sciences, University of Adelaide, North Terrace, Adelaide, 5005, Australia. *Automorphism and isometry groups of Higgs bundle moduli spaces.*

In this talk I will discuss recent work giving the classification of several symmetry groups associated to the moduli space of Higgs bundles (of fixed determinant and trace-free Higgs field). In particular, I will give the classification of the group of complex analytic automorphisms and the isometry group of the hyper-Kahler metric. (Received February 04, 2015)

Session 22

1111-53-295 **Ana Cannas*** (ana.cannas@math.ethz.ch), Dep. Mathematik, ETH Zurich, 8092 Zurich, Switzerland. *Lagrangian correspondences - a toric case study.*

I will discuss a concrete lagrangian in the complex projective plane CP^2 which exhibits a friendly behaviour under reduction by one of the toric circle actions. This is joint work with Radivoje Bankovic motivated by a question going back to Katrin Wehrheim and Chris Woodward. (Received February 05, 2015)

1111-53-330 **Goncalo Oliveira*** (oliveira@math.duke.edu), Mathematics Department, Duke University, Box 90320, Durham, NC 27708-0320. *Monopoles in 3 dimensions.*

Monopoles are solutions to the Bogomolnyi equation, which is a PDE for a connection and an Higgs field (a section of an certain bundle) on a 3 dimensional Riemannian manifold. In this talk I plan to introduce these equations. Then I want to tell you some properties of its solutions on $\mathbb{R}^3$. Finally, I shall explain how to construct monopoles on a more general class of noncompact manifolds known as asymptotically conical. The construction gives coordinates on an open set of the moduli space of monopoles, and I will explain the geometric meaning of each such coordinate. (Received February 05, 2015)

Session 22

1111-53-350 **Benjamin G Sharp*** (ben.g.sharp@gmail.com), 180 Queen's Gate, Imperial College London, London, SW7 2AZ, United Kingdom. *Compactness theorems for minimal hypersurfaces with bounded index.*

We prove a compactness result for embedded minimal hypersurfaces $M^n \hookrightarrow N^{n+1}$ with bounded index and volume, which can be thought of as an extension of the compactness theorem of Choi-Schoen (Invent. Math 1985) to higher dimensions. Our theorems are proved under the restriction $2 \leq n \leq 6$.

These results rely heavily on the local regularity theory for stable minimal hypersurfaces due to Schoen-Simon (Comm. Pure Appl. Math 1981), coupled with a notion of almost stability due to Pitts.

Roughly speaking our main theorem says that given a sequence of smooth embedded minimal hypersurfaces with bounded volume and index, in some closed Riemannian manifold, they converge smoothly and graphically to some smooth limit away from a finite number of points. Moreover if the number of sheets in the convergence is greater than one, then the limit must be stable. An easy corollary of this result is that if the ambient manifold has strictly positive Ricci curvature, then the space of finite volume and index minimal hypersurfaces is strongly compact in the smooth topology. (Received February 06, 2015)

Session 27

1111-53-373 **Brian Collier*** (collier3@illinois.edu), Department of Mathematics, 1409 W. Green Street, Urbana, IL 61801. *A mapping class group invariant parameterization of maximal $Sp(4,\mathbb{R})$ representations.*

Let S be a closed surface of genus $g \geq 2$, and consider the moduli space of representations $\rho : \pi_1(S) \to Sp(4,\mathbb{R})$. There is an invariant $\tau \in \mathbb{Z}$, called the Toledo invariant, which satisfies a Milnor-Wood inequality $|\tau| \leq 2g-2$, and helps to distinguish connected components. Representations with maximal Toledo invariant have many geometrically interesting properties, for instance, they are all discrete and faithful. In this talk, we will give a mapping class group invariant parameterization of the $2g-3$ special connected components of the maximal $Sp(4,\mathbb{R})$ representations. Our main tool is Higgs bundles. However, to utilize Higgs bundle techniques, one has to fix a conformal structure of the surface S, hence breaking the mapping class group symmetry. To restore the symmetry, we associate a unique 'preferred' conformal structure to each such representation. This is done by exploiting the relationship between the associated Higgs bundles and minimal surfaces. (Received February 06, 2015)

Contr.Session

1111-53-400 **Beniamino Cappelletti-Montano**, **Antonio De Nicola*** (antondenicola@gmail.com) and **Ivan Yudin**. *Hard Lefschetz Theorem for Sasakian manifolds.*

It is well known that in any compact Kähler manifold the exterior multiplication by suitable powers of the symplectic form induces isomorphisms between the de Rham cohomology spaces of complementary degrees. This is the content of the celebrated Hard Lefschetz Theorem. In my talk I will present our recent result [arXiv:1306.2896] showing the existence of similar isomorphisms for compact Sasakian manifolds. We prove that such isomorphisms are independent of the choice of a compatible Sasakian metric on a given contact manifold.

As a consequence, we find an obstruction for a contact manifold to admit compatible Sasakian structures. (Received February 06, 2015)

Session 16

1111-53-411 **Milena Pabiniak*** (milenapabiniak@gmail.com), Department of Mathematics, Instituto Superior Tecnico, Av Rovisco Pais, 1049-001 Lisbon, Portugal. *On displaceability of pre-Lagrangians in toric contact manifolds.*

In symplectic geometry one can observe a rigidity of intersections: certain (Lagrangian) submanifolds are forced to intersect each other in more points than an argument from algebraic or differential topology would predict. For example, every compact symplectic toric manifold contains a non-displaceable (i.e. one that cannot be made disjoint from itself by the means of a Hamiltonian isotopy) Lagrangian toric fiber. In contact geometry, pre-Lagrangians play a related role. We define this notion and explore the question of displaceability of pre-Lagrangian toric fibers in toric contact manifolds. We obtain some results complementary to the symplectic rigidity case. In particular, we show that every generic orbit in the toric contact sphere S^{2d-1}, $d > 1$, is displaceable while every generic orbit in $T^d \times S^{d-1}$, $d > 1$, is non-displaceable. The first result is related to the non-orderability of the sphere, while the second one seems to be related to the existence of a free toric action. We discuss possible generalizations of these examples. The talk is based on a joint work with Aleksandra Marinkovic. (Received February 07, 2015)

Session 16

1111-53-429 **Viktor L. Ginzburg***, Department of Mathematics, UCSC, Santa Cruz, CA 95064. *Periodic Orbits of Hamiltonian Systems: Conjectures and Recent Results.*

In this talk we will discuss some recent results and conjectures concerning the existence of infinitely many periodic orbits for certain classes of Hamiltonian systems, e.g., various variants of the Conley conjecture. Among the systems we will consider are some Reeb flows and twisted geodesic flows and, of course, many classes of Hamiltonian diffeomorphisms. We will also touch upon the existence of non-contractible periodic orbits. (Received February 07, 2015)

Session 16

1111-53-433 **Marta Batoreo***, mbatoreo@impa.br. *Periodic points of symplectomorphisms.*

In this talk, we will present some results on the existence of periodic points of symplectomorphisms which are isotopic to the identity. We will see that, for a certain class of symplectic manifolds, there are infinitely many periodic orbits if we assume some conditions on the symplectomorphism. (Received February 07, 2015)

Session 16

1111-53-449 **Sheila Sandon*** (sandon@math.unistra.fr), IRMA - Universite de Strasbourg, 7, Rue Rene Descartes, 67084 Strasbourg, France. *Translated points of contactomorphisms.*

A point p of a contact manifold (M, ξ) is said to be a translated point of a contactomorphism ϕ (with respect to a contact form α for ξ) if p and $\phi(p)$ lie on the same Reeb orbit and ϕ preserves α at p. For several aspects translated points seems to play a role similar to the one played in symplectic topology by fixed points of symplectic transformations. In particular translated points are key objects in the study of certain rigidity phenomena in contact topology, such as non-squeezing, orderability and existence of bi-invariant metrics and quasimorphisms on the contactomorphism group. Moreover translated points seem to satisfy an analogue in contact topoloy of the Arnold conjecture on fixed points of Hamiltonian symplectomorphisms. In my talk I will report on recent progresses on these topics. (Received February 08, 2015)

Session 16

1111-53-460 **Georgios Dimitroglou Rizell*** (g.dimitroglou@maths.cam.ac.uk), Centre for Mathematical Sciences, University of Cambridge, Wilberforce Road, Cambridge, CB3 0WB. *The classification of monotone Lagrangian tori in a four-dimensional symplectic vectorspace.* Preliminary report.

We prove that there are exactly two monotone Lagrangian tori in a four-dimensional symplectic vectorspace up to Hamiltonian isotopy and rescaling: the Clifford and the Chekanov torus. This is shown by, first, Hamiltonian isotoping the torus to a homotopically non-trivial torus inside $\mathbb{C}^* \times \mathbb{C}^*$ and, second, applying a classification result for homotopically non-trivial Lagrangian tori inside $T^*\mathbb{T}^2$. The latter result follows using methods due to Ivrii. (Received February 08, 2015)

Contr.Session

1111-53-510 **Michal Gaczkowski*** (gaczkowskim@mini.pw.edu.pl), Michal Gaczkowski, ul. Surowieckiego 8 m. 33, 02-785 Warsaw, Poland. *Variable Sobolev spaces on Riemannian manifolds.*

During my talk we are going to introduce variable Sobolev space on Riemannian manifolds. Continuous and compact embedding will be discussed in the case of complete manifold. For non compact manifolds, compact embedding will require a space of functions invariant under the action of some group. As an application we will study the PDE problems involving $p(x)$-Laplacian. The talk is based on results obtained together with P.Górka. (Received February 09, 2015)

Session 15

1111-53-514 **Robert Szoke*** (rszoke@cs.elte.hu), Department of Analysis, Institute of Math., Eotvos L. University, Pazmany P. setany 1/C, Budapest, 1117, Hungary, and **Laszlo Lempert**. *Adapted complex structures and geometric quantization.*
(Received February 09, 2015)

Session 27

1111-53-519 **Qiongling Li*** (qiongling.li@gmail.com) and **Brian Collier**. *Asymptotics of certain families of Higgs bundles.*
For certain Higgs bundles in the $SL(n,\mathbb{R})$-Hitchin component, we study the asymptotics of the Hermitian metrics solving the Higgs bundle equations. This analysis is used to estimate the asymptotics of the corresponding family of flat connections as we scale the differentials by a real parameter. We consider Higgs fields that have only one holomorphic differential q_n of degree n or q_{n-1} of degree $n-1$. The analysis turns out to have strong relation with Toda lattice. We will also discuss some other family of Higgs bundles. (Received February 09, 2015)

Session 22

1111-53-559 **Alessandro Carlotto*** (a.carlotto@imperial.ac.uk), Imperial College - Department of Mathematics, Huxley building, London, SW7 2AZ, United Kingdom. *Variations on the Bernstein problem in asymptotically flat spaces.*
The Bernstein problem, namely the problem of classifying all entire minimal hypergraphs in Euclidean spaces has played a crucial role in the development of Analysis throughout the whole course of the twentieth century. In this talk, I will discuss its natural extension to asymptotically flat manifolds, where it is motivated by the study of the large-scale structure of initial data sets for the Einstein field equation. I will first present the basic non-existence result and its relation to the asymptotic Plateau problem and then mention the application of similar techniques to the study of 1) large CMC spheres and isoperimetric domains (C.-Chodosh-Eichmair), 2) marginally outer-trapped surfaces (C.) and 3) the zero set of static potentials (Galloway-Miao). (Received February 09, 2015)

Session 22

1111-53-567 **Isabel M.C. Salavessa*** (isabel.salavessa@ist.utl.pt), Instituto Superior Tecnico, CeFEMA (e CFIF), Edificio Ciencia, piso 3 (Fisica), Av. Rovisco Pais, P-1049-001 Lisboa, Portugal, and **Ana Cristina Ferreira** (anaferreira@math.uminho.pt), Centro de Matematica, Universidade do Minho, Campus de Gualtar, P-4710-057 Braga, Portugal. *Cheng's type comparison results for the principal eigenvalue of a V-drift Laplacian on a Riemannian manifold.*
On a Riemannian manifold (N,g) we consider a metric connection that has vectorial torsion defined by a vector field V. It turns out that the Laplacian for this connection is just the usual drift Laplacian $\Delta^V u = \Delta u - g(V,\nabla u)$. If V is not a gradient, this is a non L^2-self-adjoint operator for any conformally equivalent metric. We consider the V-Dirichlet problem for this Laplacian on a geodesic ball M of N and its principal eigenvalue. Under conditions on the sectional or Ricci curvatures of M and on V we can compare the corresponding principal eigenvalue of Δ^V on M with the one on a ball of the same radius of a suitable model space. The method relies on the use of some generalized Barta's type inequalities and Godoy-Gossez-Paczka's Rayleigh type minimax formula for the principal eigenvalue for non-self-adjoint Dirichlet problem using weighted Sobolev spaces, to obtain generalized Cheng's eigenvalue comparison theorems, partially following a similar path as in previous work of Freitas-Mao-Salavessa. (Received February 09, 2015)

1111-53-587 **Rui Albuquerque*** (rpa@uevora.pt), CIMA-Universidade de Évora, Rua Romão Ramalho, 59, 671-7000 Évora, Portugal. *The fundamental differential system on the case of 3-manifolds.* Preliminary report.
We deduce several equations of 3-dimensional intrinsic Riemannian geometry related to the fundamental exterior differential system existing always on the tangent sphere bundle of any given oriented Riemannian manifold. The general differential system was found by the author in a recent paper and its first result is the natural generalization of the Cartan structural equations on a global invariant form. It has remarkable consequences in dimension 3. (Received February 09, 2015)

Session 27

1111-53-591 **Mario Garcia-Fernandez*** (mario.garcia@icmat.es), Instituto de Ciencias Matemáticas (ICMAT), Madrid, Spain, and **Julius Ross** (j.ross@dpmms.cam.ac.uk), University of Cambridge, United Kingdom. *Balanced metrics on twisted Higgs Bundles.*
A twisted Higgs bundle on a Kähler manifold X is a pair (E,φ) consisting of a holomorphic vector bundle E and a holomorphic bundle morphism $\varphi\colon E\otimes M\to E$ for some holomorphic vector bundle M. Such objects were

first considered by Hitchin when X is a curve and M is the tangent bundle of X, and also by Simpson for higher dimensional base. The Hitchin-Kobayashi correspondence for such pairs states that (E, φ) is polystable if and only if E admits a hermitian metric solving the Hitchin equation. This correspondence is a powerful tool to decide whether there exists a solution of the equation, but it provides little information as to the actual solution. In this talk we study a quantization of this problem that is expressed in terms of finite dimensional data and balanced metrics that give approximate solutions to the Hitchin equation. We will need the overall assumption that M is globally generated. Motivation for this study comes from work of Donagi–Wijnholt concerning balanced metrics for the Vafa-Witten equations. (Received February 09, 2015)

Session 16

1111-53-619

Roger Casals* (casals.roger@icmat.es), C/Nicolás Cabrera, n. 13-15, Campus de Cantoblanco, 28049 Madrid, Spain. *Geometric criteria for overtwistedness.*

In this talk we provide a characterization of overtwisted contact structures in higher dimensional manifolds. First, we introduce the overtwisted and tight dichotomy in contact topology and define the overtwisted disk according to Borman–Eliashberg–Murphy. Then we explain a criterion to detect whether a contact manifold is overtwisted. It establishes a relation between three and higher–dimensional overtwistedness, existence of a loose chart for the Legendrian unknot and the existence of a negatively stabilized open book supporting the contact structure.

The proof of this criterion combines both algebraic and geometric techniques in symplectic and contact topology, and details are provided along the presentation. In addition, we explore possible consequences and construct explicit examples of overtwisted contact manifolds. This is joint work with E. Murphy and F. Presas. (Received February 09, 2015)

Session 28

1111-53-638

Chenchang Zhu*, CRC, Mathematisches Institut Georg-August-Universi, 37073 Gottingen, Germany. *Higher category for L_∞-groupoids.*

We will establish a higher category for higher groupoids in various pretopologies, including higher (Banach) Lie groupoids. To build a higher category for these objects, one convenient method is to build a sort of category of fibrant objects for them. For this, we need to choose path objects, weak equivalences, and fibrations. It turns out that our choice of weak equivalence, restricting to Lie (1-)groupoids, are the well known weak equivalence for Lie groupoids. Thus the (higher) category built for Lie (1-)groupoids will be the 2-category of Lie groupoids which is equivalent to that of differential stacks. Many of the ideas above are well known to experts in the field, and the talk itself is based on work in progress with Chris Rogers. (Received February 09, 2015)

Contr.Session

1111-53-651

Agnes Gadbled* (agnes.gadbled@fc.up.pt), CMUP - Departamentos de Matematica, Rua do Campo Alegre, 687, 4169-007 Porto, Portugal, and **Miguel Abreu**. *Toric constructions of monotone Lagrangian submanifolds in $\mathbb{CP}^2$ and $\mathbb{CP}^1 \times \mathbb{CP}^1$.*

In a previous work, I proved that two very different constructions of monotone Lagrangian tori are Hamiltonian isotopic inside $\mathbb{CP}^2$ by comparing both of them to a third one called modified Chekanov torus. This modified Chekanov torus has an interesting projection under the standard moment map of $\mathbb{CP}^2$ and motivates a method of construction of (monotone) Lagrangian submanifolds in symplectic toric manifolds. We can get via this method some old and new monotone examples in $\mathbb{CP}^2$ and $\mathbb{CP}^1 \times \mathbb{CP}^1$. This is joint work with Miguel Abreu (IST, Lisbon). (Received February 09, 2015)

Inv.Adresses

1111-53-656

André Arroja Neves* (aneves@imperial.ac.uk). *Min-max methods in Geometry.*

Min-max methods were introduced in Geometry around 100 years ago by Birkhoff.

Recently, with Fernando Marques, we used it to solve the Willmore Conjecture and other long standing open questions in Geometry.

I will survey the method, its applications, and propose new directions in the area. (Received February 09, 2015)

Inv.Adresses

1111-53-663 **Rui Loja Fernandes***, Department of Mathematics, University of Illinois at Urbana-Champaign, 1409 W. Green Street, Urbana, IL 61801. *Global Aspects of Poisson Geometry.*

A Poisson bracket on a manifold is the geometric structure relevant for Hamiltonian dynamics. A Poisson bracket induces a foliation of the manifold by symplectic leaves, which in general is singular: the dimension of the leaves can jump. The study of the global properties of a Poisson bracket combines the symplectic geometry of each leaf, the topology of the leaves and the singularities of the foliation at places where the dimension jumps. In this talk, I will survey some fascinating recent advances in the global geometry of manifolds equipped with a Poisson bracket. (Received February 09, 2015)

Session 16

1111-53-667 **Luis Miguel Diogo*** (ldiogo@columbia.edu), Columbia University, Department of Mathematics, 2990 Broadway, Rm 525, MC 4417, New York, NY 10027. *Symplectic homology via Gromov-Witten theory.*

Symplectic homology is a very useful tool in symplectic topology, but it can be hard to compute. We will describe a procedure for computing symplectic homology using counts of pseudo-holomorphic spheres, which can sometimes be obtained from Gromov-Witten theory. This method is applicable to a class of manifolds that are complements of symplectic hypersurfaces of codimension 2 inside closed symplectic manifolds. This is joint work with Samuel Lisi. (Received February 09, 2015)

Session 28

1111-53-686 **Urs Schreiber*** (urs.schreiber@gmail.com). *Obstruction Theory for Parameterized Higher WZW-Terms.*

I present a general characterization of the obstructions for higher WZW-terms (higher gerbes with connection) defined on some higher (or derived) group stack G/H to have a parameterization over higher Cartan geometries locally modeled on G/H. Applied to the canonical Kostant-Souriau line bundle the construction reproduces metaplectic pre-quantization. For the traditional degree-3 WZW term it reproduces the Green-Schwarz anomaly; for the degree-7 WZW term we get a Fivebrane-analog, for the degree-11 term a Ninebrane-analog. Applied to the exceptional cocycles on extended super-Minkowski spacetimes the construction yields a forgetful infinity-functor on globally defined (classical anomaly free) Green-Schwarz super p-brane sigma models propagating on higher super etale stacks, which sends these to G-structures on these super stacks, for G the higher Heisenberg group stack of the higher WZW term. Specifically for the super-5-brane sigma-model this yields a forgetful infinity-functor from its classical anomaly free backgrounds to super etale 3-stacks satisfying the equations of motion of 11-dimensional supergravity and satisfying a further topological constraint.

Notes are here: http://ncatlab.org/schreiber/show/Obstruction+theory+for+parameterized+higher+WZW+terms (Received February 10, 2015)

Session 16

1111-53-723 **Alexandru Oancea*** (alexandru.oancea@imj-prg.fr), Université Pierre et Marie Curie, 4 place Jussieu, Case 247, 75005 Paris, France. *Symplectic and contact differential graded algebras.*

I will explain a Hamiltonian formulation of the periodic (non-equivariant) contact homology DGA, resp. of the Legendrian contact homology DGA, valid for contact manifolds, resp. Legendrians which are exact fillable. Our DGA differential deforms the Floer differential on the high-energy part of symplectic homology, resp. of wrapped Floer homology. The order k deformation arises as a secondary operation effectively parametrized by the $k-1$-dimensional simplex. This is joint work with Tobias Ekholm. (Received February 10, 2015)

Session 16

1111-53-727 **Richard Keith Hind*** (hind.1@nd.edu), Department of Mathematics, University of Notre Dame, Notre Dame, IN 46556. *Symplectic embeddings of products.*

In their 2012 paper McDuff and Schlenk completely solved the existence problem for symplectic embeddings of 4-dimensional ellipsoids into balls. In other words, they calculated the function

$$c(x) = \inf\{R|E(1,x) \hookrightarrow B^4(R)\}.$$

Here an ellipsoid inside the standard symplectic Euclidean space is written as $E(a,b) = \{\frac{\pi}{a}(p_1^2+q_1^2)+\frac{\pi}{b}(p_2^2+q_2^2) < 1\}$ and $B^4(R) = E(R,R)$ is a ball.

For a fixed $n \geq 3$ we can define the function

$$f(x) = \inf\{R|E(1,x) \times \mathbb{R}^{2(n-2)} \hookrightarrow B^4(R) \times \mathbb{R}^{2(n-2)}\}.$$

I will talk about some constructions and obstructions which give upper and lower bounds respectively for $f(x)$. It is clear that $f(x) \leq c(x)$ but it turns out we have equality precisely when $x \leq \tau^4$, the fourth power of the golden ratio. This is work in progress with Daniel Cristofaro-Gardiner. (Received February 10, 2015)

Contr.Session

1111-53-729 **D. Roytenberg*** (roytenberg.d@gmail.com), , Netherlands, and **D. Carchedi**. *DG-manifolds are derived manifolds.* Preliminary report.

We show that non-positively graded dg-manifolds form a category of fibrant objects in the sense of K. Brown which models the infinity-category of derived smooth manifolds. This is an ongoing joint project with David Carchedi. (Received February 10, 2015)

Session 28

1111-53-742 **Paolo Aschieri***, Universita' Piemonte Orientale, Dipartimento di Scienze, e Innovazione Tecnologica, 15121 Alessandria, Piedmont, Italy, and **Leonardo Castellani**. *Noncommutative Chern-Simons gauge and gravity theories and their geometric Seiberg-Witten map.*

We present a geometric generalization of the Seiberg-Witten map between noncommutative and commutative gauge theories and then apply it to find the expansion of noncommutative Chern-Simons (CS) theory in any odd dimension D and at first order in the noncommutativity parameter θ. This expansion extends the classical CS theory with higher powers of the curvatures and their derivatives. A simple explanation of the equality between noncommutative and commutative CS actions in D=1 and D=3 is obtained. The θ dependent terms are present for $D \geq 5$ and give a higher derivative theory on commutative space reducing to classical CS theory for $\theta \to 0$. As for the Dirac-Born-Infeld action, these terms vanish in the slowly varying field strength approximation: in this case noncommutative and commutative CS actions coincide in any dimension and at every order in the noncommutativity parameter θ. (Received February 10, 2015)

Session 15

1111-53-755 **Steve Zelditch*** (zelditch@math.northwestern.edu), 839 Lincoln St., Evanston, IL 60208. *Complex time Hamilton orbits with applications to geodesics of Kahler metrics and to spectral geometry in Grauert tubes.* Preliminary report.

Analytic continuation in time of Hamilton flows on Kahler manifolds comes up in several types of problems in geometry and spectral theory. One is to geodesics in the space of Kahler metrics. Another is to spectral geometry on Grauert tubes. Several results in each area are presented. The work on geodesics is in part joint with Yanir Rubinstein. (Received February 10, 2015)

Session 28

1111-53-762 **Andreas Deser*** (andreas.deser@itp.uni-hannover.de), Institute for Theoretical Physics, Appelstraße 2, 30167 Hannover, Germany. *Star products on graded manifolds and deformations of Courant algebroids from string theory.*

Deformations of Courant algebroids are of interest in both, string theory and mathematics. It was realized by Roytenberg, that Lie bialgebroids and their associated Courant algebroids can be characterized by a homological vector field on the cotangent bundle of the parity reversed version of the underlying Lie algebroid. This lead to the introduction of the Drinfel'd double of a Lie bialgebroid. In a similar way, we show that the so-called C-bracket, a bi-linear operation governing the gauge algebra of double field theory, can be characterized by the Poisson structure on the Drinfel'd double of the underlying Lie-bialgebroid. Using this result, we are able to apply a graded version of the Moyal-Weyl star product to compute the first order deformation of the C-bracket. Remarkably, these coincide with the first order correction in the string coupling parameter found recently in string theory. (Received February 10, 2015)

Session 39

1111-53-788 **John M Sullivan*** (sullivan@math.tu-berlin.de). *Visualizations of tight knots and links.* Preliminary report.

Suppose a given knot is tied in rope of fixed circular cross-section and pulled tight to minimize its length. The resulting configuration – a tight knot or ropelength minimizer – has interesting mathematical properties. Very few examples are known theoretically, but numerical simulations can give approximations for other tight knots. We discuss ways to use computer graphics to display these in visually informative and aesthetically pleasing ways. (Received February 10, 2015)

Session 22

1111-53-800 **Lu Wang*** (lwang58@jhu.edu), Huxley Building 614, Imperial College London, South Kensington Campus, London, SW7 2AZ, United Kingdom. *Geometry of Two-dimensional Self-shrinkers.* Preliminary report.

In this talk, we discuss the asymptotic and global geometric properties of two-dimensional noncompact properly embedded self-shrinkers. (Received February 10, 2015)

Session 15

1111-53-829 **William D Kirwin*** (will.kirwin@gmail.com), Mathematics Institute, University of Cologne, 50931 Cologne, Germany. *Imaginary-time Hamiltonian flows in Kaehler Geometry and Quantization.*

I will give an overview of imaginary-time Hamiltonian flows. At the classical level, the theory involves, among other things, adapted complex structures and geodesics in the space of Kähler metrics. At the quantum level, the analytic continuation can be understood as a sort of Wick rotation and gives rise to Segal-Bargmann-type transforms. (joint work w/ J Mourão, J Nunes and B Hall) (Received February 11, 2015)

54 ► General topology

Session 35

1111-54-119 **Marithania Silvero*** (marithania@us.es). *Strongly quasipositive links and their Conway polynomials.*

Strongly quasipositive links are those links which can be seen as closures of positive braids in terms of band generators. We give a necessary condition for a link with braid index 3 to be strongly quasipositive, by proving that they have positive Conway polynomial (that is, all its coefficients are non-negative). We also show that this result cannot be extended to a higher number of strands, as we provide a strongly quasipositive braid on 6 strands whose closure has non-positive Conway polynomial. (Received January 26, 2015)

Session 35

1111-54-154 **Heather A Dye** and **Aaron Kaestner***, North Park University, 3225 W Foster Ave, Campus Box 57, Chicago, IL 60625, and **Louis H Kauffman**. *A Rasmussen Invariant for Virtual Knot Cobordisms.*

We derived a generalization of the Rasmussen invariant for virtual knot cobordisms and furthermore generalize Rasmussen's result on the slice genus for positive knots to the case of positive virtual knots. This generalization of the Rasmussen invariant provides an obstruction to knot cobordisms in $S_g \times I \times I$ in the sense of Turaev. (Received January 29, 2015)

Session 7

1111-54-360 **Eva Colebunders** (evacoleb@vub.ac.be), Vrije Universiteit Brussel, Department of Mathematics, Pleinlaan 2, 1050 Brussels, Belgium, **Robert Lowen** (bob.lowen@uantwerpen.be), University of Antwerp, Department of Mathematics & Computer Science, Middelheimlaan 1, 2020 Antwerpen, Belgium, and **Karen Van Opdenbosch*** (karen.van.opdenbosch@vub.ac.be), Vrije Universiteit Brussel, Department of Mathematics, Pleinlaan 2, 1050 Brussels, Belgium. *Approach spaces, functional ideal convergence and Kleisli monoids.*

The objects of App can be described by functional ideals, namely the bounded local approach systems and in that setting convergence of functional ideals is characterized by three axioms [2].

We consider the functional ideal monad $\mathbb{I}$ over Set and show that it is power-enriched. We describe an isomorphism between App and the category $\mathbb{I} - \mathsf{Mon}$ of Kleisli monoids for $\mathbb{I}$.

Considering $\mathbb{I}$ together with its Kleisli extension to Rel one obtains the category $(\mathbb{I}, 2) - \mathsf{Cat}$ of relational algebras for the monad $\mathbb{I}$. For power-enriched monads, this category is known to be isomorphic to $\mathbb{I} - \mathsf{Mon}$ [1]. As a result we get a description of App by two axioms on convergence of functional ideals, namely reflexivity and transitivity. We show how these two axioms relate to the axioms introduced in [2].

References

[1] D. Hofmann, G.J. Seal and W. Tholen (eds.), Monoidal Topology, *Cambridge University Press*, 2014.

[2] R. Lowen, Index Analysis: Approach theory at work, *Springer-Verlag*, 2015.

(Received February 06, 2015)

Session 35

1111-54-639 **Sergei Gukov*** (gukov@theory.caltech.edu), Caltech 452-48, Pasadena, CA 91125. *Categorification of Complex Chern-Simons Theory.* Preliminary report.

In this talk I will discuss the basic building blocks of Chern-Simons TQFT with complex gauge group. Motivated by physics, we will then proceed to construct "categorification" of these building blocks. In particular, we will identify a new grading on the Hilbert space of Chern-Simons theory and propose a "homological lift" of SL(2,C) quantum group invariants that agree with existent mathematical constructions and lead to concrete new predictions. (Received February 09, 2015)

55 ► Algebraic topology

Session 6

1111-55-48 **Martin Raussen*** (raussen@math.aau.dk), Fredrik Bajers Vej 7G, 9220 Aalborg, Denmark. *Combinatorial and topological models for spaces of schedules.*

Higher Dimensional Automata are topological models for concurrent computation in the form of cubical complexes. A schedule gives rise to a directed path (d-path), and d-homotopies (preserving the directions) of such d-paths leave the results of computations invariant.

I shall describe and discuss several models for the homotopy type of the space of traces (schedules up to reparametrization) for particularly simple HDAs: as a prodsimplicial complex – with products of simplices as building blocks – and as a configuration space living in a product of simplices. In favourable cases, these models allow calculations of homology groups and other topological invariants of the trace spaces.

Joint work with Krzysztof Ziemiański (Warsaw) and Roy Meshulam (Technion Haifa). (Received January 13, 2015)

Session 6

1111-55-221 **Massimo Ferri*** (massimo.ferri@unibo.it), Dip. di Matematica, Piazza di Porta S. Donato, 5, 40126 Bologna, BO, Italy. *Biomedical applications of Persistent Homology.*

Algebraic Topology succeeds in formalizing qualitative aspects of spaces. Persistent Homology, in particular, focusses on pairs (X, f) of spaces endowed with a function; this adds the possibility of probing together topological and geometrical features — through the filtration given by sublevel sets — and the possibility of taking the observer's concept of shape into account.

This approach turns out to be particularly convenient when dealing with data of natural origin, in particular in the biomedical domain. This talk will survey some applications in protein docking, analysis of echocardiographic data, classification of leukocytes and of hepatic cells, diagnosis and retrieval of melanocytic lesions. (Received February 03, 2015)

Session 6

1111-55-248 **Matthew Kahle*** (mkahle@math.osu.edu), Dept. of Mathematics, 231 W 18th Ave., Columbus, OH 43202. *The length of the longest bar in random persistent homology.*

In recent years, a number of papers have studied topological features of "random geometric complexes", particularly various facts about their expected homology. One of the motivations for this is establishing a probabilistic null hypothesis for topological data analysis. In practice, however, one usually computes persistent homology over a range of parameter, rather than homology alone. Detailed results for persistent homology of random geometric complexes have been harder to come by.

I will present new work which quantifies the length of the longest bar in persistent homology, up to a constant factor. This is an important step toward quantifying the statistical significance of topological signals in data. This is joint work with Omer Bobrowski and Primoz Skraba. (Received February 03, 2015)

Session 41

1111-55-269 **Marko Stosic*** (mstosic@isr.ist.utl.pt). *Lie superalgebras and double affine Hecke algebras in colored HOMFLYPT knot invariants.*

The quantum polynomial knot invariants are well-known to be directly related to the representation theory of quantum groups. In recent years a lot of work has been done on properties of the colored HOMFLYPT polynomial and its categorification, and from various different viewpoints. We shall present how different results and predictions are related to the representation theory of the double affine Hecke algebras (DAHAs) and Lie superalgebras $gl(n|m)$. (Received February 04, 2015)

Session 6

1111-55-335 **Ana Romero***, ana.romero@unirioja.es. *Zigzag persistence: application to processing stacks of neuronal images.*

The theory of zigzag persistence provides an extension of persistent homology to diagrams of topological spaces which do not define a filtration and has been used in different contexts such as topological bootstrapping, parameter thresholding and real-valued functions.

In this work, a new application of this theory is presented: we use zigzag persistence to determine the objects of interest in stacks of neuronal images, obtained by a microscope as a set of slices corresponding to different levels of the Z-axis. This method allows us, in particular, to recognize some 3D properties of the objects, identifying different dendrites which could appear mixed in the maximal projection image.

The algorithm has been implemented as a plugin in the Fiji/ImageJ framework, a Java image processing package which is used for research in life sciences and biomedicine. This plugin is an auxiliary tool in a more ambitious project, aimed at locating neurons in a low-scale picture of a fragment of the brain. Some results from actual neuronal images will be presented in the talk.

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Session 6

1111-55-338 **Graham Ellis*** (graham.ellis@nuigalway.ie), School of Mathematics, National University Of Ireland, Galway, Galway, Ireland. *Computing with homotopy 2-types.*

The fundamental notions of (i) CW-complex, (ii) simple homotopy type and (iii) crossed module were all introduced by Henry Whitehead in his work on combinatorial homotopy during the 1930s and 1940s. The first two notions are the basis for much recent research in computational topology whereas the third notion seems to be less well known. In this talk I will advertize the notion of crossed module and its suitability for computer calculations. (Received February 06, 2015)

Session 8

1111-55-342 **Louis-Hadrien Robert*** (louis-hadrien.robert@uni-hamburg.de), Fachbereich Mathematik, Bundesstraße 55, 20146 Hamburg, Germany. *The colored $\mathfrak{sl}_3$-homology.*

I will start with a result on $\mathfrak{sl}_3$-representations: I will give an explicit resolution of every simple $\mathfrak{sl}_3$-module in terms of tensor powers of the fundamental representation and its dual. Then I will recall the $\mathfrak{sl}_3$-link homology due to Khovanov and I will explain that the homology of the unknot is naturally endowed with a two structures of $\mathfrak{sl}_3$-representation: the fundamental representation and its dual. I will tell how to use these two facts to construct an homology theory which decategorify on the colored $\mathfrak{sl}_3$-invariant for framed links. While the construction is pretty natural there is a major technical difficulty because the $\mathfrak{sl}_3$-homology is not known to be functorial for foam cobordisms. Finally and if I am not running out of time, I will sketch a way to generalize the first result to $\mathfrak{sl}_n$ (this last part is joint with Matt Hogancamp). (Received February 06, 2015)

Session 28

1111-55-404 **Alberto S Cattaneo*** (alberto.cattaneo@math.uzh.ch), Institut für Mathematik, Universität Zürich-Irchel, Winterthurerstrasse 190, 8057 Zurich, Switzerland. *Perturbative BV-BFV theories on manifolds with boundary.* Preliminary report.

Classical and quantum field theories may be thought of as appropriate functors from (some version of) the cobordism category. In this talk (based on joint work with Mnev and Reshetikhin) I will show how this can be achieved in the context of BF theories by the perturbative expansion of the BV action in the presence of a boundary. The theory associate a complex to the boundary and a cocycle (the state or partition function) to the bulk. I will show how the procedure is compatible with gluing along boundary components. This is a quantization of the classical BV-BFV theory. An outlook to the general case will be presented, time permitting. (Received February 07, 2015)

Session 6

1111-55-531 **Armindo Costa*** (a.costa@qmul.ac.uk). *Topology of random simplicial complexes.*

Random objects often have desirable properties for which explicit examples are hard to construct; eg often random graphs are good expanders and have strong Ramsey properties. The most well-studied model of random graphs is the Erdos-Renyi model G(n,p). In the G(n,p) model one generates a random graph with n vertices by adding each possible edge with independent probability p. Properties of random graphs are often studied asymptotically, ie by having n tend to infinity and the probability parameter p depend on n. A pioneering result of Erdos and Renyi on G(n,p) is topological; it studies in detail the phase transition of connectivity.

In this talk we will look at models of random simplicial complexes. Unlike the graph setup, one can study several interesting topological properties of random complexes. Additionally, by considering the fundamental group of a random complex one also has a model of random groups. (Received February 09, 2015)

Session 6

1111-55-550 **Jose Gabriel Carrasquel-Vera*** (jose.carrasquel@uclouvain.be), Chemin du Cyclotron 2 bte L7.01.02, 1348 Louvain-la-Neuve, Belgium. *On rational topological complexity and related invariants.* Preliminary report.

We will present new advances in the study of Michael Farber's topological complexity of rational spaces. We also study some related invariants such as Rudyak's higher topological complexity and Iwase-Sakai's monoidal topological complexity. This is done by giving a new characterisation of rational sectional category in the spirit of the Jessup-Murillo-Parent conjecture. (Received February 09, 2015)

Session 28

1111-55-574 **Christopher J Schommer-Pries***, Vivatsgasse 7, 53111 Bonn, Germany. *Extended 3-dimensional topological field theories.*

I will survey recent advances in our understanding of extended 3-dimensional topological field theories. I will describe recent work (joint with B. Bartlett, C. Douglas, and J. Vicary) which gives an explicit "generators and relations" classification of partially extended 3D TFTS (assigning values only to 3-manifolds, surfaces, and 1-manifolds). This will be compared to the fully-local case (which has been considered in joint work with C. Douglas and N. Snyder). (Received February 09, 2015)

Session 3

1111-55-595 **Pedro V. Silva*** (pvsilva@fc.up.pt), Department of Mathematics, Rua do Campo Alegre, 687, 4169-007 Porto, Portugal. *The homotopy type of boolean representable simplicial complexes.*

The homotopy type of matroids is known but not every matroid is field representable. On the other hand, even the fundamental group is out of reach for arbitrary simplicial complexes of dimension 2. Boolean representable simplicial complexes (BRSC), introduced in 2011 by Izhakian and Rhodes, and the subject of a very recent monograph [1], constitute a generalization of matroids that keeps many of their combinatorial, topological and geometric features.

In joint work with Stuart Margolis (Bar-Ilan University) and Rhodes (University of California at Berkeley), we could prove that the fundamental group of a BRSC is always free, the rank being determined by the number of connected components of what we call the graph of flats. With respect to homotopy groups of higher dimension, we can characterize the shellable BRSCs of dimension 2 (having thus the homotopy type of a wedge of spheres). Moreover, we can use the matrix representations to produce algorithms of polynomial complexity that make all these computations effective.

[1] J. Rhodes and P. V. Silva, *Boolean Representations of Simplicial Complexes and Matroids*, Springer Monographs in Mathematics, Springer, 208 pages (to appear). (Received February 09, 2015)

Session 28

1111-55-601 **Christopher L Rogers*** (`rogersc@uni-greifswald.de`), Institute for Mathematics & Computer Science, University of Greifswald, Walther-Rathenau-Str. 47, 17487 Greifswald, Germany. *Equivariant cohomology, homotopy moment maps, and gauged sigma models.*

Atiyah and Bott famously observed that cocycles representing degree 2 classes in equivariant de Rham cohomology correspond to moment maps in (pre-)symplectic geometry. From the point of view of geometric quantization, moment maps provide a way to lift infinitesimal symmetries of a classical system to a corresponding quantum one.

In this talk, I will describe a generalization of the Atiyah-Bott correspondence that uses the homotopy theory of L_∞-algebras to produce so-called "homotopy moment maps" from higher degree equivariant classes. I will then discuss the role homotopy moment maps play in gauging bosonic sigma models. This is based on joint work with M. Callies (Goettingen), and separate joint work with K. Waldorf (Greifswald). (Received February 09, 2015)

Session 6

1111-55-606 **Robert Ghrist** and **Sanjeevi Krishnan*** (`sanjeevi@math.upenn.edu`), 209 South 33rd Street, Philadelphia, PA 15217. *Dynamic Sensor Networks.*

A class of pursuit-evasion games, where an evader tries to avoid detection by a time-evolving sensed space, is considered. Earlier results give homological criteria for evasion that are necessary or sufficient, but not both. We give a necessary and sufficient ordered cohomological criterion for evasion in the general case. The main idea is to refine the (n-1)-cohomology of a coverage region with a positive cone encoding orientation, refine the 1-homology of the coverage gaps with a positive cone encoding time, and prove a positive Alexander Duality in homological degree 1. Positive cohomology, the limit of a sheaf of local positive cohomology semigroups on the real number line, can be computed as a linear programming problem. We demonstrate such a calculation for a prototypical case of evasion that eludes ordinary homological criteria. (Received February 09, 2015)

Session 6

1111-55-614 **Jose Manuel Garcia-Calcines*** (`jmgarcal@ull.es`), C/ Astrofisico Fco. Sanchez s/n, Dpto. de Matematicas, Estadistica e I.O., 38271 La Laguna, S/C de Tfe, Spain. *On some approaches of topological complexity.* Preliminary report.

The topological complexity of a space X, $\mathrm{TC}(X)$, is the sectional category (or Schwarz genus) of the end-points evaluation fibration $\pi_X : X^I \to X \times X$, $\pi_X(\alpha) = (\alpha(0), \alpha(1))$. This homotopical invariant was defined by M. Farber in order to give a topological approach to the motion planning problem in robotics. If one regards the topological space X as the configuration space of a mechanical system, the motion planning problem consists of constructing a program which takes pairs of configurations $(A, B) \in X \times X$ as an input and produces as an output a continuous path in X which starts at A and ends at B. Broadly speaking, $\mathrm{TC}(X)$ measures the discontinuity of any motion planner in the space.

In this talk I will explain the use of certain approaches of the topological complexity of a space X and see how they are related. Among such approaches we can mention $\mathrm{wTC}(X)$ the weak topological complexity, $\mathrm{cat}(C_\Delta)$ the Lusternik-Schnirelmann category of the homotopy cofibre of the diagonal map $\Delta : X \to X \times X$, or $\mathrm{TC}^M(X)$ the monoidal topological complexity of X. (Received February 09, 2015)

Session 28

1111-55-623 **Thomas Nikolaus*** (`nikolaus@math.uni-bonn.de`). *Global equivariant homotopy theory.*

We present a new approach to global equivariant homotopy theory which is based on topological stacks. We show that our approach is equivalent to Schwede's approach and we discuss some examples. If time permits we speak about the abstract framework behind that approach and sketch other possible applications. (Received February 09, 2015)

Contr. Session

1111-55-797 **Hisham Sati*** (`hsati@pitt.edu`), Department of Mathematics, University of Pittsburgh, Pittsburgh, PA 15260. *Ninebrane structures.*

We introduce higher connected covers of the orthogonal group beyond String and Fivebrane, which we call "Ninebrane structures" in degree twelve and demonstrate how they capture some anomaly cancellation phenomena in M-theory. We also define certain variants, considered as intermediate cases in degree nine and ten, which we call

"2-Orientation" and "2-Spin structures", respectively. As in the lower degree cases, these can be twisted and admit refinements to differential cohomology. (Received February 10, 2015)

57 ▶ Manifolds and cell complexes

Session 35

1111-57-19 **Greg Brumfiel** and **Hugh M. Hilden*** (mike@math.hawaii.edu), c/o mathematics dept., u. hawaii, 2565 the mall, Honolulu, HI 96822, and **Maite Lozano**, **Jose Montesinos**, **Enrique Ramirez**, **Hamish Short**, **Margarita Toro** and **Debora Tejada**. *Superregular Tessellations and Universal Groups.* Preliminary report.

Essentially, a tessellation of Hyperbolic or Euclidean space of dimension one, two or three is superregular if it induces superregular tessellations in all lower dimensions. (Inductive definition)

A Kleinian group U is universal if, given any closed orientable 3-manifold M, there is a finite index subgroup G of U such that M is homeomorphic to H^3/G.

We study the unique superregular tessellation of H^3, (by regular right angled dodecahedra), and introduce a new universal group associated with the tessellation. We show this group leaves invariant a certain family of hyperbolic planes associated with the tessellation and we explore the consequences of this. (Received December 24, 2014)

Session 35

1111-57-51 **Seiichi Kamada*** (skamada@sci.osaka-cu.ac.jp), Department of Mathematics, Osaka City University, Sumiyoshi, Osaka, 558-8585, Japan, and **Victoria Lebed**. *Qualgebras, branched braids and branched links.*

The coauthor, V. Lebed, introduced the notion of a qualgabra. It is a quandle equipped with a binary operation called a multiplication. We consider colorings of "branched braids" and "branched links" by qualgebras, and their invariants using qualgebra 2-cocycles. We also study braidings of branched links and spatial graphs. (Received January 13, 2015)

Session 35

1111-57-52 **Naoko Kamada*** (kamada@nsc.nagoya-cu.ac.jp), Graduate School of Natural Sciences, Nagoya City University, 1 Yamanohata, Mizuho-cho, Mizuho-ku, Nagoya, Aichi 467-8501, Japan. *A generalization of the JKSS invariant to twisted knots.*

Virtual knots correspond to the stable equivalence classes of knots in thickened orientable surfaces. Jaeger, Kauffman, and Saleur defined an invariant of knots in thickened orientable surfaces, and Sawollek applied it to virtual knots. We call it the JKSS invariant for virtual knots. Bourgoin extended the notion of virtual knots to twisted knots, which correspond to the stable equivalence classes of knots in thickened surfaces that are not necessarily orientable. In this talk, we explain the JKSS invariants for virtual knots and consider a generalization of the invariant to twisted knots. (Received January 14, 2015)

Session 35

1111-57-81 **Heather Ann Dye*** (heatheranndye@gmail.com), 701 College Road, Lebanon, IL 62254. *Bounding the number of components of a state of the Jones polynomial and its dual for knots in surfaces.* Preliminary report.

For knots in surfaces, I compute an upper bound on the number of components of a state of the Jones polynomial and its dual. Some applications of this bound include an extension of the Kauffman-Mursugi-Thistlethwaite Theorem and Naoko Kamada's work the span of the Jones polynomial of virtual knots. (Received January 20, 2015)

Session 35

1111-57-123 **Antonio F Costa*** (acosta@mat.uned.es), Facultad de Ciencias, UNED, Senda del rey, 9, 28040 Madrid, Madrid, Spain, and **Victor González-Aguilera**, Santiago, Santiago, Chile. *Limit points of equisymmetric 1-dimensional families of Riemann surfaces.*

We describe the limit surfaces of some special types of 1- dimensional equisymmetric families of Riemann surfaces in the Deligne- Mumford compactification of moduli space [3], [5] . We provide a description of such nodal Riemann surfaces in terms of the deck group of the coverings defining the family. We apply our method to some wellknown examples [1], [2], [4], [6].

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Session 35 1111-57-156 **Louis H Kauffman*** (kauffman@uic.edu), Math UIC, 851 South Morgan Street, Chicago, IL 60607-7045. *Majorana Particles, Quantum Computing and the Dirac Equation.* Preliminary report.

This talk will discuss how mathematical quantum particles that are their own anti-particles (Majorana particles) are at the base of topological quantum computing. We will also discuss how such states are related to the Dirac equation and we will discuss recent experimental work related to Majorana Fermions. (Received January 29, 2015)

Session 35 1111-57-287 **Jun Ge*** (mathsgejun@163.com), Xiamen, Fujian 361005, Peoples Rep of China, and **Xian'an Jin**, **Louis Hirsch Kauffman**, **Pedro Lopes** and **Lianzhu Zhang**. *Minimal sufficient sets of colors and minimum number of colors.*

For any link and for any modulus m we first introduce an equivalence relation on the set of nontrivial m-colorings of the link. Then we will classify all the color sets with small cardinality which are possible to form a non-trivial p-coloring for some link for $p = 11, 13$ and 17. For any link L with non-zero determinant and any prime $p \geq 17$, we will show that the minimum number of colors mod p is at least 6. Then a positive answer to a question raised by Nakamura, Nakanishi and Satoh will be given. At the end of the talk, we will mention a conjecture related to both determinant of knots and links in knot theory and the number of spanning trees in graph theory. (Received February 04, 2015)

Session 35 1111-57-347 **João M. Nogueira*** (nogueira@mat.uc.pt). *Knots with all surfaces essential in their complements.*

Since the work of Haken and Waldhausen, it is common to study 3-manifolds, and knot complements in particular, by their decomposition into submanifolds. A very important class of surfaces used in these decompositions are the essential surfaces. A particularly interesting occurrence is the existence of knots with the property that their complements have closed essential surfaces of arbitrarily high genus, which were originally given on a classic paper by Lyon. In this talk we will show the first examples of an even stronger phenomenon: the existence of infinitely many prime knots each of which having in their complements closed and meridional essential surfaces of all genus and number of boundary components. (Received February 06, 2015)

Session 8 1111-57-415 **Christian Blanchet*** (christian.blanchet@imj-prg.fr), Université Paris Diderot, Bâtiment Sophie Germain – case 7012, 75205 Paris, France. *Non semisimple TQFTs from nilpotent representations of quantum $sl(2)$.*

A new family of quantum invariants based on nilpotent represention of quantum $sl(2)$ at a root of unity have been constructed by Costantino-Geer-Patureau. We show that the new quantum invariants have graded TQFT extensions. We will describe the underlying representations of mapping class groups using the relevant representation category. Finally we will discuss the categorification question. (Joint work with François Costantino, Nathan Geer and Bertrand Patureau) (Received February 07, 2015)

Session 8 1111-57-547 **Andrew Lobb*** (andrew.lobb@durham.ac.uk), **Dan Jones**, **Patrick Orson** and **Dirk Schuetz**. *Homotopy types and quantum knot cohomologies.*

A stable homotopy type associated to a knot whose cohomology recovers integral Khovanov cohomology was recently defined and explored by Lipshitz and Sarkar. We apply techniques of Morse theory to refine and to manipulate the construction. In particular we shall outline work on and computations of an sl(n) homotopy type. (Received February 09, 2015)

Session 8 1111-57-593 **Raphael Zentner*** (raphael.zentner@mathematik.uni-regensburg.de), Fakultät für Mathematik, Universität Regensburg, 93040 Regensburg, Germany. *A class of knots with simple $SU(2)$-representations.*

We call a knot in the 3-sphere $SU(2)$-simple if all representations of the fundamental group of its complement which map a meridian to a trace-free element in $SU(2)$ are binary dihedral. This is a generalisatino of a 2-bridge knot. Pretzel knots with bridge number ≥ 3 are not $SU(2)$-simple. We provide an infinite family of knots K with bridge number ≥ 3 which are $SU(2)$-simple.

One expects the instanton knot Floer homology $I^\natural(K)$ of a $SU(2)$-simple knot to be as small as it can be – of rank equal to the knot determinant $\det(K)$. In fact, the complex underlying $I^\natural(K)$ is of rank equal to $\det(K)$, provided a genericity assumption holds that is reasonable to expect. Thus formally there is a resemblance to strong L-spaces in Heegaard Floer homology. For the class of $SU(2)$-simple knots that we introduce this formal resemblance is reflected topologically: The branched double covers of these knots are strong L-spaces. In fact, somewhat to our surprise, these knots are alternating. (Received February 09, 2015)

Session 8

1111-57-634 **Lukas Lewark*** (lukas@lewark.de), Mathematisches Institut, Sidlerstrasse 5, 3012 Bern, Switzerland, and **Andrew Lobb** (andrew.lobb@durham.ac.uk), Mathematical Sciences, Durham, DH1 3LE, United Kingdom. *New Quantum Obstructions to Sliceness.*

Khovanov-Rozansky homologies over separable potentials induce lower bounds to the smooth slice genus of knots. Among them are the generalized Rasmussen invariants; but we will see that most of those bounds behave much less nicely, e.g. they are in general not concordance homomorphisms. A potential application is to bound the slice genus of knots whose stable slice genus vanishes, such as amphichiral knots. (Received February 09, 2015)

Session 35

1111-57-760 **Sofia Lambropoulou*** (sofia@math.ntua.gr), Prof. Sofia Lambropoulou, Department of Applied Mathematics, National Technical University of Athens, 15780 Athens, Greece, **Ioannis Diamantis** (diamantis@math.ntua.gr), Dr. Ioannis Diamantis, Department of Applied Mathematics, National Technical University of Athens, 15780 Athens, Greece, and **Dimitrios Kodokostas** (dkodokostas@gmail.com), Dr. Dimitrios Kodokostas, Department of Applied Mathematics, National Technical University of Athens, 15780 Athens, Greece. *The algebraic approach toward the Homflypt skein modules of c.c.o. 3-manifolds described by the unknot or the 2-unlink.* Preliminary report.

In this talk we first give the algebraic braid equivalence for knots and links in a c.c.o. 3-manifold obtained by rational surgery along a framed link in S^3, in terms of the mixed braid groups $B_{m,n}$ with m identity strands, and we provide concrete formuli of the braid equivalences in the lens spaces $L(p,q)$. Then, we describe the braid approach to the Homflypt skein module of the lens spaces $L(p,1)$. This is obtained by giving first a new basis for the Homflypt skein module of the solid torus, compatible with the handle slide moves, via the generalized Hecke algebras of type B, $H_{1,n}$; then, by solving an infinite system of handle sliding equations, by means of a Markov trace defined on the algebras $H_{1,n}$. Finally, for $m = 2$ we construct the quotient algebra $H_{2,n}$ of the mixed braid group $B_{2,n}$, over the quadratic relation of the classical Hecke algebra for the braiding generators. The aim of this work is to provide the algebraic tools for computing Homflypt skein modules of c.c.o. 3-manifolds. (Received February 10, 2015)

58 ► Global analysis, analysis on manifolds

Session 22

1111-58-116 **Joel Fine*** (joel.fine@ulb.ac.be), Département de mathématiques, Université libre de Bruxelles, Boulevard du Triomphe, 1050 Bruxelles, Belgium. *A gauge theoretic approach to Einstein 4-manifolds.*

I will explain a new variational formulation of Einstein's equations in dimension 4, using the language of gauge theory. The new independent variable is an SO(3)-connection over a 4-manifold whose curvature satisfies a certain inequality. The metric can be recovered from the curvature of the connection. The total volume functional is an action for the theory: its critical points are those connections leading to Einstein metrics. There is a topological a priori bound for the action, which is saturated precisely when the resulting Einstein metric is also anti-self-dual. The whole theory can be seen as analogous to Yang-Mills. I will discuss the first steps in using this framework to find Einstein metrics and state some open questions which arise naturally. This is joint work with Dmitri Panov and Kirill Krasnov. (Received January 26, 2015)

Session 22 1111-58-304 **Miguel Abreu*** (mabreu@math.tecnico.ulisboa.pt), Departamento de Matemática, Instituto Superior Técnico, Av. Rovisco Pais, 1049-001 Lisboa, Portugal. *Scalar flat Kähler-Sasaki metrics on toric symplectic cones.*

Let M be a smooth compact symplectic toric manifold carrying a Kähler metric of constant scalar curvature. In this talk I will present an explicit construction of scalar-flat toric Kähler-Sasaki metrics on smooth toric symplectic cones over orbifolds of the form $M \times \mathbb{P}^1_w$, where $\mathbb{P}^1_w$ is a weighted projective line. This gives rise to constant scalar curvature Sasaki metrics on the associated smooth toric contact manifolds. In some special cases, the metrics constructed are Ricci-flat and give rise to new toric Sasaki-Eintein metrics on toric contact manifolds. In particular, the construction yields 1-parameter families of constant scalar curvature Sasaki metrics on $S^2 \times S^3$, which include the Sasaki-Einstein metrics originally constructed by Gauntlett-Martelli-Sparks-Waldram. Joint work with José M. Mourão, João Pimentel Nunes and Rosa Sena-Dias. (Received February 05, 2015)

Session 27 1111-58-329 **Graeme Wilkin***, graeme@nus.edu.sg. *Morse theory for Higgs bundles.*

I will describe how to construct a Morse theory for certain singular spaces with applications to topology of moduli spaces of Higgs bundles. (Received February 05, 2015)

Session 9 1111-58-440 **Jan Slovak*** (slovak@muni.cz), Dept of Mathematics and Statistics, Masaryk University, Kotlarska 2a, Brno, 639 00. *Subriemannian Metrics and some Parabolic Geometries.* Preliminary report.

The talk will report on work in progress, a joint project of David M.J. Calderbank, Vladimir Soucek and myself, devoted to the exploitation of the classical linearization principle known from the projective metrizability problem. In the realm of parabolic geometries, this leads to the quest for subriemannian metric partial connections within the class of the Weyl structures on a given parabolic geometry. I shall pay particular attention to the class of parabolic geometries with quaternionic structures on the defining distributions, i.e. those where we should successfully employ Clifford analysis. (Received February 08, 2015)

Session 22 1111-58-494 **Nancy Hingston*** (hingston@tcnj.edu). *Loop Products, Poincaré Duality, Index Growth, and Dynamics.*

A metric on a compact manifold M gives rise to a length function on the free loop space LM whose critical points are the closed geodesics on M in the given metric. Morse theory gives a link between Hamiltonian dynamics and the topology of loop spaces, between iteration of closed geodesics and the algebraic structure given by the Chas-Sullivan product on the homology of LM. Poincaré Duality reveals the existence of a related product on the cohomology of LM. A number of known results on the existence of closed geodesics are naturally expressed in terms of nilpotence of products. We use products to prove a resonance result for the loop homology of spheres. There are interesting consequences for the length spectrum, and related results in Floer and contact theory. Mark Goresky, Alexandru Oancea, and Hans-Bert Rademacher are collaborators. (Received February 08, 2015)

Session 24 1111-58-712 **Eveline Legendre*** (eveline.legendre@math.univ-toulouse.fr) and **Rosa Sena-Dias** (rsenadias@math.ist.utl.pt). *The first eigenvalue of compact toric Kähler manifold.* Preliminary report.

Toric Kähler geometry is a rich playground, where underlying (symplectic) orbifolds correspond to polytopes and (Kähler) metrics to certain convex functions on these polytopes. In an ongoing joint project with Rosa Sena-Dias, we are studying variations of the first eigenvalue corresponding to variation of the Kähler metric on a fixed symplectic toric orbifold. We prove that the first torus invariant eigenvalue is unbounded, extending work of Abreu and Freitas on the 2 sphere. Using the work of Bourguignon Li Yau we give an explicit bound for the first eigenvalue of compact toric Kähler manifold in terms of the polytope. (Received February 10, 2015)

Session 24 1111-58-714 **Carolyn S. Gordon*** (carolyn.s.gordon@dartmouth.edu), **Peter Herbrich** (peter.herbrich@dartmouth.edu) and **David L. Webb** (david.l.webb@dartmouth.edu). *Isospectrality of Dirichlet-to-Neumann operators.* Preliminary report.

The Dirichlet-to-Neumann operator of a compact Riemannian manifold M with boundary is a linear map $C^\infty(\partial M) \to C^\infty(\partial M)$ that maps the Dirichlet boundary values of each harmonic function f on M to the Neumann boundary values of f. The spectrum of this operator is discrete and is called the Steklov spectrum.

We will discuss joint work with Peter Herbrich and David Webb concerning the construction of pairs of Steklov isospectral bounded domains in a fixed noncompact manifold. The Laplacians on these domains are also isospectral for both the Dirichlet and Neumann boundary problems and the exterior domains are isophasal. The latter result is joint with Peter Perry. (Received February 10, 2015)

Session 24

1111-58-716 **Alexandre Girouard*** (alexandre.girouard@mat.ulaval.ca), **Leonid Parnovski** (leonid@math.ucl.ac.uk), **Iosif Polterovich** (iossif@dms.umontreal.ca) and **David A. Sher** (dsher@umich.edu). *The Steklov spectrum: asymptotics and invariants.*

The Steklov problem is a geometric eigenvalue problem with its spectral parameter at the boundary of a compact Riemannian manifold. In this talk, I will describe a joint work with L. Parnovski (UCL), I. Polterovich (U. Montréal) and D. Sher (U. Michigan) in which we have obtained precise asymptotics for the Steklov eigenvalues on a compact Riemannian surface with boundary. This has led to a proof that the number of connected components of the boundary, as well as their lengths, are invariants of the Steklov spectrum. Consequences include an upper bound for the multiplicity of eigenvalues on planar domains, as well as a spectral rigidity result for the disk. (Received February 10, 2015)

Session 24

1111-58-718 **Craig Sutton*** (craig.j.sutton@dartmouth.edu). *Hearing the length spectrum of a compact Lie group.*

Motivated in part by considerations from quantum mechanics and geometric optics, it is conjectured that the length spectrum of a closed manifold can be recovered from its Laplace spectrum. We demonstrate that the length spectrum of a compact simple Lie group equipped with a bi-invariant metric can be recovered from its Laplace spectrum by computing the singular support of the trace of its associated wave group; that is, we show that the Poisson relation is an equality for such spaces. More generally, we see that the conjecture holds for a split-rank symmetric space $M = G/K$ satisfying any one of the following conditions: (1) M is simply-connected (e.g., a simply-connected Lie group equipped with a bi-invariant metric); (2) the metric on M is the unique up to scaling G-invariant Einstein metric (e.g., a compact semi-simple Lie group equipped with the bi-invariant metric induced by the Killing form), or (3) the universal cover of M is a product of irreducible split-rank factors coming from certain infinite families (e.g., certain infinite families of compact semi-simple Lie groups equipped with a bi-invariant metric). (Received February 10, 2015)

Session 50

1111-58-757 **Pedro Duarte*** (pedromiguel.duarte@gmail.com), Dep. de Matemática, Faculdade de Ciências, Universidade de Lisboa, Campo Grande, Edifício C6, Piso 2, Lisboa, Portugal, and **Silvius Klein** (silviusaklein@gmail.com), , Norway. *Large deviation estimates for Markovian cocycles.*

We derive large deviation estimates for Markovian cocycles satisfying an irreducibility assumption, using an approach due to S. Nagaev, further developed by E. Le Page and P. Bougerol to prove limit theorems for Bernoulli and Markovian cocycles. A connection with the continuity of Lyapunov exponents is established. (Received February 10, 2015)

Contr.Session

1111-58-792 **Antonio Rieser***, Department of Electrical Engineering, Technion - Israel Institute of Technology, 32000 Haifa, Israel. *Title: A Topological Approach to Data Clustering.* Preliminary report.

Topological and geometric techniques are increasingly becoming an important part of the analysis of high-dimensional, complex data sets. We present current work-in-progress of a new approach to data clustering through approximating the heat flow on a point-cloud. In particular, given samples from a probability distribution on a submanifold M of Euclidean space, we construct a family of approximations to the heat operator, and then use model-selection techniques in order to pick a 'topologically good' approximation to the number of connected components of M. We then use this to assign each point to one of the components to obtain a clustering of the space. We present several numerical examples, giving experimental support to the conjecture that, for a large number of points, the technique produces a correct clustering with high probability from a uniform distribution on a manifold. (Received February 10, 2015)

Session 24

1111-58-816 **Alexander Engel** (alexander.engel@mathematik.uni-regensburg.de) and **Martin Weilandt*** (martin.weilandt@ufsc.br). *Isospectral Alexandrov Spaces.*

We construct the first non-trivial examples of compact non-isometric Alexandrov spaces which are isospectral with respect to the Laplacian and not isometric to Riemannian orbifolds. This construction generalizes independent earlier results by the authors based on Schüth's version of the torus method. (Received February 10, 2015)

Session 15

1111-58-820 **Dan Burns*** (dburns@umich.edu), **Ernesto Lupercio** (lupercio@math.cinvestav.mx) and **Alejandro Uribe** (uribe@umich.edu). *The exponential map of the complexification of Ham in the real-analytic case.*

Let (M, ω, J) be a Kähler manifold and $\mathcal{K}$ its group of hamiltonian symplectomorphisms. The complexification of $\mathcal{K}$, introduced by Donaldson, is to a group, only a "formal Lie group". However, it still makes sense to talk about the exponential map in the complexification. We give a geometric construction of the exponential map for small time in the case of real analytic data. The construction is motivated by, but does not use, semiclassical analysis.

We also compare natural compactifications of the gobal complexifications used in our constructions when M is a homogeneous Kähler manifold. In particular we compare the equivariant "wonderful compactification" of an affine symmetric space and a related equivariant compactification introduced by Donaldson. This is joint work with Richard Hind. (Received February 10, 2015)

60 ► Probability theory and stochastic processes

Session 5

1111-60-10 **Carlos A. Braumann*** (braumann@uevora.pt), Centro Investigacao Matematica e Aplicacoes, Universidade de Evora, Rua Romao Ramalho 59, 7000-671 Evora, Portugal. *Can populations live forever?*

Both sampling variations in births and deaths (demographic stochasticity, modeled through branching processes or birth and death processes) and random fluctuations in environmental conditions (environmental stochasticity, modeled through stochastic differential equations - SDE) affect population growth.

We will compare the two sources of stochasticity w.r.t. population extinction, existence of stationary distributions and local behavior, using as benchmark Malthusian models (density-independent growth), namely the Galton-Watson process and the simple birth and death process for demographic stochasticity and the Malthusian SDE growth model (geometric Brownian motion) for environmental stochasticity. Under certain conditions, populations can live forever.

However, since resources are limited, growth of natural populations is density-dependent. Can populations, under this more natural setting, still live forever?

We review our main results on SDE density-dependent growth models. They are robust w.r.t. the shape of the density-dependence since we use general models instead of the commonly used specific models (like the logistic).

For the demographic stochasticity models, we review some results on specific models and speculate on potential results for general models. (Received December 17, 2014)

Session 52

1111-60-92 **Aurélien Alfonsi*** (alfonsi@cermics.enpc.fr), **Benjamin Jourdain** and **Arturo Kohatsu-Higa**. *Optimal transport bounds between the time-marginals of a multidimensional diffusion and its Euler scheme.*

We prove that the time supremum of the Wasserstein distance between the time-marginals of a uniformly elliptic multidimensional diffusion with coefficients bounded together with their derivatives up to the order 2 in the spatial variables and Holder continuous with exponent γ with respect to the time variable and its Euler scheme with N uniform time-steps is smaller than $C(1 + 1_{\{\gamma=1\}}\sqrt{\log(N)})/N^{\gamma}$. To do so, we use the theory of optimal transport. More precisely, we investigate how to apply the theory by Ambrosio, Gigli and Savaré to compute the time derivative of the Wasserstein distance between the time-marginals. We deduce a stability inequality for the Wasserstein distance which finally leads to the desired estimation. (Received January 21, 2015)

Session 52

1111-60-128 **Tigran Nagapetyan*** (nagapetyan@wias-berlin.de) and **Denis Belomestny** (denis.belomestny@uni-due.de). *Variance reduced Monte Carlo path simulation method.* Preliminary report.

In this talk we present a specially designed control variates for estimating smooth terminal functionals of discretized paths, arising from SDE path approximation. Our control variates decrease the variance of the functional down to the order of discretization step in certain power, which allows us under certain regularity conditions to improve significantly the computational cost / error relation for both Multilevel and Singlelevel Monte Carlo (SMC) path simulation methods. We discuss the additional gains, one can achieve via using weak schemes combined with our control variates for SMC path simulation method. Our results are illustrated with several numerical examples. (Received January 27, 2015)

Session 52

1111-60-215 **P. Parczewski*** (parczewski@math.uni-mannheim.de), Mannheim University, A5, 6, D-68131 Mannheim, D-68131 Mannheim, Germany. *On optimal approximation of Skorohod integrals.*

We study the optimal approximation of Skorohod integrals $I := \int_0^1 f(s, W_s, W_{t_1} \ldots, W_{t_K}) dW_s$ for fixed $t_1, \ldots, t_K \in [0,1]$ with respect to an equidistant discretization of the underlying Brownian motion $(W_s)_{s\in[0,1]}$. We characterize those integrands which can be simulated exactly. Extending results for Itô integrals of [Przybyłowicz, P. *J. Comput. Appl. Math.* 245, 10-29 (2013)], under weaker smoothness assumptions, we obtain an asymptotic convergence rate of the mean square error of the type $\mathbb{E}[(I - \mathbb{E}[I|\{W_{1/n}, \ldots, W_1, W_{t_1} \ldots, W_{t_K}\}])^2]^{1/2} \sim c\,n^{-1}$. In contrast to this and in the worst case scenario, due to the nonadapted terms, we obtain $\mathbb{E}[(I - \mathbb{E}[I|\{W_{1/n}, \ldots, W_1\}])^2]^{1/2} \sim c\,n^{-1/2}$. We specify these constants above. Moreover, we study the optimal approximation of rather irregular integrands and infinite nonadapted input which give convergence rates less than $n^{-1/2}$. Finally, we present asymptotically optimal approximation methods based on extended Wagner-Platen schemes. (Received February 03, 2015)

Session 52

1111-60-258 **Francisco Bernal*** (francisco.bernal@ist.utl.pt), Avenida Rovisco Pais 1, Lisbon, 1049-001, and **Juan Antonio Acebrón** (juan.acebron@ist.utl.pt). *Extrapolation of higher-order numerical integrators for bounded diffusions.*

Time-stepping schemes for the numerical integration of stochastic differential equations in bounded domains have a weak order of convergence of the bias with respect to the time step of only $\mathcal{O}(h^{1/2})$, leading to lengthy Monte Carlo simulations. (This compares unfavourably with diffusions in free space, where even the Euler-Maruyama scheme has a linear weak order of convergence.) By carefully managing the interaction of the diffusion's trajectory with the boundary, however, the weak order 1/2 can in practice be lifted and, in some cases, be theoretically predicted as linear. We survey a variety of such schemes for stopped and reflecting boundary conditions. Moreover, we exploit those schemes with linear bias convergence by inserting many realizations at different time steps into a regression algorithm, which can be proven to yield a substantial speedup (up to hundreds of times faster). (Received February 04, 2015)

Session 52

1111-60-285 **Adrien Richou*** (adrien.richou@math.u-bordeaux.fr) and **Jean-François Chassagneux** (j.chassagneux@imperial.ac.uk). *Numerical stability analysis of the Euler scheme for Backward Stochastic Differential Equations.*

Backward Stochastic Differential Equations (BSDEs) enable to obtain a Feynman-Kac formula for semi-linear parabolic PDEs. So, solving numerically BSDEs provides a stochastic method for solving such PDEs. In this talk, we study the qualitative behaviour of approximation schemes for BSDEs by introducing a new notion of numerical stability. For the Euler scheme, we provide sufficient conditions in the one dimensional and multidimensional case to guarantee the numerical stability. We then perform a classical Von-Neumann stability analysis in the case of linear generator and exhibits necessary condition to get stability in this case. Finally, we illustrate our results with numerical applications. (Received February 04, 2015)

Session 5

1111-60-381 **Fabien Campillo*** (fabien.campillo@inria.fr), Inria, Bât 5, 860 rue Saint-Priest, 34095 Montpellier, France. *Stochastic differential equations in population dynamics, between discrete and deterministic models.*

In the context of biology and ecology, stochastic differential equations (SDE) can be seen as an intermediate modeling tool between macroscopic dynamics, usually deterministic and continuous, and microscopic dynamics, usually discrete and random. Ordinary differential equations used as modeling tools for macroscopic dynamics are relatively well understood; their numerical simulation is also well developed. Pure jump Markov processes are usually used for modeling microscopic dynamics; they are also relatively well understood and can be efficiently simulated (at least in small population sizes). We also have a good comprehension of SDE's as well as their simulation algorithms. However, hybridization of these different types of models and their interconnections in a rigorous framework in terms of analysis, as well as simulation, still remain an open question. We will introduce this problem and discuss a number of promising leads. (Received February 06, 2015)

Session 5

1111-60-554 **Jose Cruz** and **Raquel M. Gaspar***, ISEG and CEMAPRE, Universidade de Lisboa, Rua Miguel Lupi 20, room 101, 1249-078 Lisboa, Portugal. *Interbank Adjustments for FRAs.*

The real world interbank market is not populated by riskless banks. This became particularly obvious after the financial crisis of 2007-2009. Nonetheless, most theoretical interest rate models, assume the risk in the interbank lending market is negligible, using interest rate sensitive products to build zero-coupon bonds curves. Here we take a different approach and consider LIBOR rates are no longer good approximations to theoretical default-free interest rates. Thus, the value of contracts having as underlying LIBOR rates, should be adjusted to correct for the existent counterparty risk. We call this adjustment an *interbank adjustment*. In this paper we explicitly compute the interbank adjustments for FRAs (Forward Rate Agreements), combining the classical affine term structure (ATS) framework with reduced-form shot-noise credit risk models to capture the counterparty risk of interbank contracts. (Received February 09, 2015)

Session 52

1111-60-558 **Lukasz Szpruch*** (l.szpruch@ed.ac.uk), Edinburgh, and **Plamen Turkedjiev** (turkedjiev@cmap.polytechnique.fr). *Robbins-Monro algorithm for the approximation of backward stochastic differential equations.* Preliminary report.

To approximate the solution of backward stochastic differential equations (BSDEs) one needs to be able to numerically evaluate conditional expectations. This is very challenging and usually very computationally expensive task, particularly for high dimensional systems. In this talk we introduce a regression type approximation for the conditional expectations based on classical Robbins-Monro algorithm. The structure of the the algorithm allows to construct efficient variance reduction techniques and therefore offers an interesting alternative to the more standard algorithms that are used in BSDEs setting. (Received February 09, 2015)

Contr.Session

1111-60-566 **J Beleza Sousa***, ISEL - ADEETC, Rua Conselheiro Emídio Navarro, 1, 1959-007 Lisboa, Portugal, and **Manuel Esquível** and **Raquel Gaspar**. *Machine Learning Gaussian Short Rate.*

One key issue in using Gaussian processes for machine learning regression is to have enough prior information on data, in order to specify mean and covariance functions. Provided that parametric mean and covariance functions families are specified, and that no noise is assumed on the observations, the model exactly fits the observations.

Under the Vasicek short rate model the logarithm of zero coupon bond prices is Gaussian. Also, the parametric mean and covariance functions of such values can be determined analytically from the SDE solution. One key issue in using this model is that the term structure of zero coupon bond rates follows a deterministic function. Therefore, the model can not fit the term structure of interest rates observed in the market.

In this paper we develop a Gaussian short rate model by using the Vasicek short rate model as a prior for Gaussian processes for machine learning regression. The developed model overcomes both issues above. Regarding the Gaussian processes for machine learning regression issue, the parametric mean and covariance functions families are specified. Regarding the Vasicek fitting issue, the resulting model exactly fits all zero coupon bond prices observed in the market, regardless of the parameters values. (Received February 09, 2015)

Session 5

1111-60-597 **Antoine Lejay*** (antoine.lejay@univ-lorraine.fr), IECL, Campus scientifique, BP 70239, 54500 Nancy, France. *Probabilistic representation of diffusions in media semi-permeable barrier.*

In this talk, we present a probabilistic model for a particle in a diffusive media with a semi-permeable membrane such as the one arising in brain imaging for example. This model relies on the use of a diffusion process, called the Snapping Out Brownian motion, which is the limit of some SDE with local times at the interfaces of a thin layer. An exact simulation method is then built from this representation. (Received February 09, 2015)

Session 52

1111-60-653 **P Turkedjiev***, CMAP Ecole Polytechnique, Route de Saclay, 91128 Palaiseau, France, and **E Gobet**. *Importance sampling for variance reduction in linear regression algorithms for backward stochastic differential equations.*

Given a solution (Y,Z) to a backward stochastic differential equation, let $M_t = L_t^{-1}$ where $\frac{dL_t}{L_t} := Z_t Y_t^{-1} dW_t$ define the Radon-Nikodym derivative for a change of probability measure. Under this probability measure, we demonstrate that the statistical error of a semi-discrete linear regression scheme to approximate (Y,Z) is asymptotically zero. We demonstrate an order $1/2$ reduction of the number of simulations required for the algorithm compared to calculations under the historical probability measure, which is substantial. (Received February 09, 2015)

Session 37

1111-60-658 **Nico Stollenwerk*** (nico.biomath@gmail.com), CMAF-CIO, University of Lisbon, Avenida Professor Gama Pinto, 2, 1649-003 Lisbon, Portugal. *Chaos and noise in population biology: the case study of dengue fever epidemiology, modelling and data analysis.*

Based on some recent work (Stollenwerk, N., & and Jansen, V. (2011) *Population Biology and Criticality: From critical birth–death processes to self-organized criticality in mutation pathogen systems* (Imperial College Press, World Scientific, London), Stollenwerk, N., Aguiar, M., Ballesteros, S., Boto, J., Kooi, W. B., & Mateus, L. (2012) Dynamic noise, chaos and parameter estimation in population biology, *J. Royal Soc. Interface Focus*, **2**, 156–169, Mateus, L., Stollenwerk, N., & Zambrini, J.C. (2013) Stochastic Models in Population Biology: From Dynamic Noise to Bayesian Description and Model Comparison for Given Data Sets, *Int. Journal. Computer Math.*, **90**, 2161–2173, etc.) new results on understanding the epidemiology of dengue fever as a prime example of complex dynamics in the interplay between chaos and noise will be presented. Recent advances in modelling and data analysis will be shown within a framework, which is applicable to investigate many population biological systems. (Received February 09, 2015)

Session 5

1111-60-715 **Massimiliano Tamborrino*** (massimiliano.tamborrino@jku.at), **Susanne Ditlevsen** and **Petr Lansky**. *Parameter inference from hitting times for perturbed stochastic processes: analytical method and applications.*

Assume a latent process describes the state of some system, e.g. the strength of an industrial component, or the health status of a person. When the process reaches a predefined threshold, an observable event occurs, e.g. the industrial component breaks down, or the person dies. Imagine an intervention, e.g., maintenance of a component, or a medical treatment, is initiated before the event occurs and changes in the state of the system are measured. How can we evaluate the effect of the intervention? We describe the effect through parameter changes of the law governing the latent process. Moreover, covariates and handling of censored observations can be incorporated into the statistical model.

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(Received February 10, 2015)

Session 5

1111-60-736 **Ana Prior*** (afpontes@adm.isel.pt) and **Paula Milheiro-Oliveira**. *Change-point testing of a 2-regime and 2-dimension Ornstein-Uhlenbeck process modelling the dynamics of an engineering structure.*

We consider a 2-dimension Ornstein-Uhlenbeck process assuming two possible regimes in a given time interval. The diffusion process may switch from one regime to the other at an unknown time. The regimes differ in the value of a parameter in the drift matrix that characterizes an engineering structural model, known as the stiffness coefficient. The stochastic forces acting on the system are assumed to be driven by a Wiener process. The state space engineering model, describing displacements and velocities with time, is assumed to be completely observed, observations being taken in discrete times. We investigate the problem of detecting the change point using all available data. The method uses the ML estimates of the model parameters computed at any given time. The test statistics is a log-likelihood ratio whose asymptotic distribution is proved to be a Brownian bridge. The study includes an example of a simulated structure that possibly suffered from a loss in stiffness of unknown amount, after a certain time. From the collected data concerning displacements and velocities along the time, one estimates the previous and actual values of the stiffness coefficient, the damping coefficient and of the change-point. Errors of type I and II are estimated based on the simulations. (Received February 10, 2015)

Session 5

1111-60-761 **Manuel L. Esquivel*** (mle@fct.unl.pt), Dept. Mathematics, Faculdade de Ciências e Tecnologia UNL, Quinta da Torre, 2829-516 Monte de Caparica, Portugal, and **Pedro P. Mota** (pjpm@fct.unl.pt), Dept. Mathematics, Faculdade de Ciências e Tecnologia UNL, Quinta da Torre, 2829-516 Monte de Caparica, Portugal. *On a Price-Liquidity Threshold Regime Switching Diffusion Model.*

In this paper, using references [2] and [3], we extend to coupled systems of diffusions, such as the one introduced in reference [1], the results obtained for single diffusions. Namely, existence of solutions for the stochastic differential equations with crossed regime switching conditions, conditions for arbitrage free and complete market models, estimation techniques; we apply the results to simulation studies and benchmark studies with real data against alternative models.

References:

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Session 5

1111-60-764 **C Marchetti*** (charlesmarchetti@yahoo.com), Bagneux, France. *An approximation of the solution of Kalman filter in a problem of stabilized platform with an inertial measurement unit.*

We are interested in the problem of the determination of the vertical of a platform on which one put an inertial measurement unit. The measured vertical is that of the local vertical of the Local Geographical Trihedron. It is related to fell vulgar gravity. It takes into account neither the local anomalies nor the force of inertia of training due to terrestrial rotation.

The vertical is mesured by the accelerometers being of the horizontal plane which are used like detecteurs of level or inclinometers. Both accelerometers are placed the stabilized heart. Their mecanic environment is reduced, which allows to limit the band-width of tens of Hz. According to the scale factor, we get an approximation of the solution of Kalman filter which is used to determine the vertical. (Received February 10, 2015)

Session 5

1111-60-774 **J. Peinke*** (peinke@uni-oldenburg.de), Institute of Physics & ForWind -, Centre of Wind Energy Research, 26129 Oldenburg, Germany, and **A. Hadjihosseini**, **M. Wächter**, **P. Lind** and **M.R.R. Taber**. *Stochastic models for real-world processes.*

We show how from empirical and measured data the underlying stochastic process can be reconstructed via the numerical estimation of Kramers Moyal coefficients. Methods to verify the Markow property are discussed as well as the estimation of the deterministic and the noisy part such as drift and diffusion coefficients. As real-world data are often not ideal, problems like finite sampling steps and spoiling by other noise sources, like measurement noise, will be discussed.

Besides these more basic considerations several applications will be shown. On one side time dependent processes from car traffic to the energy conversion process of wind turbines will be discussed. Here a new quality of system modeling can be derived, which have many applications like for monitoring tasks of wind turbines.

On the other side it will be shown how multi scale processes can be grasped by stochastic processes evolving in scale. As examples the analysis of turbulence, financial data and rouge waves are given. The tendency to form extreme events will be discussed .

Literature: R. Friedrich, J. Peinke, M. Sahimi and M. Reza Rahimi Tabar : Approaching Complexity by Stochastic Processes: From Biological Systems to Turbulence, Phys. Report, 506, 87-162 (2011) (Received February 10, 2015)

Session 44

1111-60-793 **Francine Diener**, Université de Nice Sophia Antipolis, Laboratoire de Maths J-A Dieudonné, Parc Valrose, 06108 Nice cedex 2, France, **Marc Diener*** (diener@unice.fr), Université de Nice Sophia Antipolis, Laboratoire de Maths J-A Dieudonné, Parc Valrose, 06108 Nice cedex 2, France, and **Jasmin Mae Santos** (jasminmae.santos@gmail.com), Université de Nice Sophia Antipolis, Laboratoire de Maths J-A Dieudonné, Parc Valrose, 06108 Nice cedex 2, France. *Distribution of implicit interest rate for microcredit.*

In his book [**?**], Muhammad Yunus gives the example of the repayment of a loan by 50 weekly settlements. The flat rate is 10% but Yunus points out that the actual rate in this case is nearly 20%. One of the caracteristics of microcredit is that if one weekly settlement can't take place all the following settlements are postponed of one week, if no other accident takes place. In this way, the actual rate becomes random and lower than the above 20%. We give an approach of the distribution of this random interest rate based on Non Standard Analysis: we assume that the number of settlements is infinitely large and give asymptotic approximations of the distribution in the case of one or more settlement delays. (Received February 10, 2015)

Session 52

1111-60-831 **Jose H Blanchet*** (jose.blanchet@columbia.edu), 500 W 120th St., Mudd Building, IEOR, 3rd Floor., New York, NY 10027. *Exact Sampling and Conditional Simulation of Max-Stable Processes.*

Max-stable processes are of great importance in extreme value analysis because of their ability to model extremes under spatial dependence. Predictive inference in the context of these models, clearly of importance in applications, requires access to conditional distributions given observed values at some space-time locations. Unfortunately, such conditional distributions are challenging to compute explicitly because max-stable processes are expressed as the maxima of infinitely many stochastic processes. We provide the first class of unbiased estimators for conditional expectations for a large class of max-stable processes, namely, so-called Brown-Resnick fields. Our results built upon optimal-running time algorithms for exact sampling (simulation without bias) of

Brown-Resnick processes which improve upon the work of Dieker and Mikosch (2014). (Joint work with Z. Liu, T. Dieker, and T. Mikosch.) (Received February 11, 2015)

62 ► Statistics

Session 5

1111-62-239 **Maud Delattre*** (maud.delattre@agroparistech.fr) and **Marc Lavielle**. *Population pharmacokinetics and stochastic differential equations: model and methods.*

Models based on stochastic differential equations (SDEs) have an interest in population pharmacokinetics (PK), since they allow a better consideration of the variability occuring within any individual kinetics than classical PK models based on ordinary differential equations (ODEs). One extension of the traditional PK models consists in adding a system noise to the ODEs. However, these SDE systems do not comply with some constraints on the biological dynamics, resulting in an overly erratic description of the evolution of the drug concentrations within the compartments of the human body. We rather assume that the diffusion process randomly perturbs the transfer rate constants of the system. Estimating the population parameters in such SDE models is however not straightforward. Indeed, in a population approach, the model needs to account for the between-subjects variability. Then, we consider that the parameters of the model are random variables, resulting in a mixed-effects models. Specific procedures are required to make inference in mixed-effects models. Here, we suggest estimating the population parameters by combining the SAEM algorithm with the extended Kalman filter. This methodology was tested on some simulated basic examples and gives encouraging results. (Received February 03, 2015)

Session 5

1111-62-298 **Umberto Picchini*** (umberto@maths.lth.se), Centre for Mathematical Statistics, Lund University, Lund, Sweden, **Julie Forman**, Department of Biostatistics, University of Copenhagen, Copenhagen, Denmark, and **Rachele Anderson**, Centre for Mathematical Sciences, Lund University, Lund, Sweden. *Maximum likelihood estimation of state-space SDE models using data-cloning approximate Bayesian computation.* Preliminary report.

Approximate Bayesian computation (ABC) enable statistical inference for complex models, including stochastic differential equation models, by avoiding having a readily available likelihood function. ABC repeatedly simulate trajectories x from the state-space SDE model conditionally to a parameter θ. When x is approximately matching the actual measurements y we consider the conditioning θ as generated from an approximated posterior distribution on θ. However the threshold δ used in ABC algorithms, regulating the closeness of x to y, in practice cannot be set to an arbitrarily small value as we otherwise incur into high rejection rates. We compensate for the inability to decrease δ by sampling from an increasingly peaked version of the approximate posterior. This can be performed using so-called MCMC "data cloning". In this talk we discuss how to enable data-cloning for an ABC-MCMC sampler: the procedure returns approximate MLEs for θ and confidence intervals. This is useful for when a typical ABC-MCMC sampler is able to locate the approximate maxima but not return a sufficiently good approximation for the whole posterior surface. Applications to stochastic differential equation models will be considered. (Received February 06, 2015)

Session 29

1111-62-378 **Ana Patrícia Martins*** (anapatmartins@gmail.com), Escola Superior de Educação de Viseu, Rua Maximiano Aragão, Viseu, 3504-501. *Portuguese life assurance companies in the 19th century: contributions by Cláudio Adriano da Costa on premium tables. A pioneering case?*

The first Portuguese life assurance companies were created in 1835 and 1845 -Fidelidade and Providência- and Cláudio Adriano da Costa (1795-1866) is responsible for both the initiatives. The inexistence of Portuguese mortality tables or mortality statistics that could be used to adapt foreign monetary tables forced the Board of Fidelidade to adopt, with slight differences, premium tables of a British company operating in Lisbon, Norwich Union. But for Providência Costa presents 29 tables for which he asks the monopoly of its use over a period of 15 years, claiming for originality. He was aware of life assurance industry in Europe and knew the necessary theoretical background. Nevertheless in the 1850s Providência was liquidated and Fidelidade ceased life assurance coverage. It was not until 1907 that life assurance coverage was systematically applied in Portugal, with a new regulation for the insurance industry, and only after 1920 it assumed significant importance. We will present the results of an on-going study about the originality of Costa's tables, which can give him the title of pioneer in the introduction of actuarial techniques in Portugal, reflecting about its relevance in the development of Actuarial Calculus in Portugal in the first half of the 19th century. (Received February 06, 2015)

Contr.Session

1111-62-431 **Carla Santos*** (carla.santos@ipbeja.pt), , Portugal, and **Célia Nunes**, **Cristina Dias**, **Francisco Carvalho** and **João Tiago Mexia**. *OBS estimation and condensation.*

A mixed model where variance-covariance matrices are all the $\sum_{j=1}^{m} \gamma_j.Q_j$ with $\gamma_j \geq 0, j = 1, ..., m$, and the $Q_1, ..., Q_m$ pairwise orthogonal orthogonal projection matrices that add up to I_n has orthogonal block structure,OBS.

We now use the algebraic structure of these models to obtain models also with OBS and the same parameters but with less (probably much less) observations. The good properties of estimators for models with OBS clearly hold for the condensed models since these also have OBS. (Received February 07, 2015)

Session 5

1111-62-621 **Helle Sørensen*** (helle@math.ku.dk), Department of Mathematical Sciences University of Copenhagen, 2100 Copenhagen East, Denmark. *Stochastic differential equations with random effects.*

We consider data consisting of discretely observed diffusion processes for several subjects. The model set-up is hierarchical: (1) For each subject, the diffusion process is defined by a parametric stochastic differential equation; and (2) the parameters — or at least some of them — are random. The talk is about estimation of the parameters in the model, including those for the random effects. We suggest to replace the correct one-step-ahead transition densities in the likelihood function with Gaussian approximations and maximise the corresponding pseudo-likelihood. Numerical studies will be presented for the square-root (Cox-Ingersoll-Ross) process, and an analysis will be carried out on data concerning growth of pigs. This is joint work with Susanne Ditlevsen. (Received February 09, 2015)

Contr.Session

1111-62-695 **Cristina Silva Dias** (cpsilvadias@gmail.com), Rua Raúl Mesnier du Ponsard, n°15, 2°D, 1750-242 Lisboa, Lisbon, Portugal, and **Carla Lopes Santos*** (carla.santos@ipbeja.pt), Évora, Portugal. *The k-degree models for symmetric stochastic matrices.* Preliminary report.

In this paper we studied that as the degree (k) of the model is given by the mean matrix characteristic, the model study involves all k eigenvalues. For the models with a degree k>1, we still considered the possibility of truncating the model, when there are eigenvalues, much greater than the other myth. (Received February 10, 2015)

65 ► Numerical analysis

Session 52

1111-65-38 **Zhenjie Ren**, CMAP, Ecole Polytechnique, 91128 Palaiseau, France, and **Xiaolu Tan***, CEREMADE Université PARIS - DAUPHINE, Place du Maréchal De Lattre De Tassigny, 75775 Paris, France. *On the convergence of monotone scheme for fullly nonlinear path-dependent PDEs.* Preliminary report.

We propose a reformulation of the convergence theorem of monotone numerical schemes provided by Zhang and Zhuo for viscosity solution of path-dependent PDE (PPDE), which extends the seminal work of Barles and Souganidis for the viscosity solution of PDE. Our formulation of the theorem requires similar conditions as in the classical theorem, which are satisfied by all, to the best of our knowledge, classical monotone numerical schemes in the context of stochastic control theory. In particular, it provides a unified approach to prove the convergence of numerical schemes for nonMarkovian stochastic control problems, second order BSDEs, stochastic differential games etc. (Received January 09, 2015)

Session 52

1111-65-112 **Arnaud Lionnet*** (arnaud.lionnet@inria.fr), INRIA Rocquencourt, Domaine de Voluceau, Boite Postale 105, Le Chesnay, 78153. *Discretization of monotone BSDEs with polynomial drivers.*

We discuss the time discretization of Backward Stochastic Differential Equations with non-Lipschitz drivers. Precisely, we deal with drivers having polynomial growth and satisfying a monotonicity condition, which guarantees that the continuous-time BSDEs are well-posed. However, due to the super-linearity of the driver, the naive time-discretization of those equation does not always lead to a converging scheme, and extra care must therefore be taken.

While the implicit Euler scheme is stable, we find that the standard explicit scheme tends to explode. To remedy to this we propose several solutions, which aim at taming the super-linear growth. (Received January 25, 2015)

Contr.Session

1111-65-226 **Betul Hicdurmaz*** (betulhicdurmaz@gmail.com), Kocaeli, and **Allaberen Ashyralyev**, Istanbul. *Stability Analysis for Time Fractional Schrödinger Differential Equations.* Preliminary report.

Numerical solution of time fractional Schrödinger differential equations is a popular subject. Since exact solutions for time fractional Schrödinger differential equations are formulated in terms of special functions, properties of time fractional Schrödinger differential equations are investigated by different authors. The present paper gives the stability results on a time fractional Schrödinger differential equation. Additionally, applications of the stability theorems are presented in an order.

References

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[2] Ashyralyev A., Hicdurmaz B., A note on the numerical solution of fractional Schrödinger differential equations, AIP Conf. Proc. 1470, 92-94, 2012.

[3] Garrappa R.,Moret I., Popolizio M., Solving the time-fractional Schrödinger equation by Krylov projection methods, J. Comput. Phys., doi:10.1016/j.jcp.2014.09.023, 2014. (Received February 03, 2015)

Session 52

1111-65-240 **Jean-François P Chassagneux*** (j.chassagneux@imperial.ac.uk), Department of Mathematics, Imperial College London, 180 Queen's Gate, London, SW72AZ, United Kingdom, and **A Richou**. *Numerical approximation of switching problems.* Preliminary report.

We use the representation of Switching Problems as obliquely reflected BSDEs to obtain a numerical approximation of the solution. We thus focus on the discretization of the obliquely reflected BSDEs. By proving a stability result for the Euler scheme associated to the BSDEs, we are able to obtain convergence result in the case where the driver of the BSDE depends on z. This is a joint work with A. Richou. (Received February 03, 2015)

Session 52

1111-65-260 **Denis Belomestny*** (denis.belomestny@gmail.com), Thea-Leymann-Str. 9, 35, D-45127 Essen, Germany. *Multilevel Monte Carlo path simulation for weak approximation schemes.* Preliminary report.

In this talk we discuss the possibility of using multilevel Monte Carlo (MLMC) methods for weak approximation schemes. It turns out that by means of a simple coupling between consecutive time discretisation levels, one can achieve the same complexity gain as under the presence of a strong convergence. We exemplify this general idea in the case of weak Euler scheme for Lévy driven stochastic differential equations. The numerical performance of the new "weak" MLMC method is illustrated by several numerical examples. (Received February 04, 2015)

Session 52

1111-65-292 **Goncalo dos Reis*** (g.dosreis@ed.ac.uk), School of Mathematics, University of Edinburgh, Peter Guthrie Tait Road, Edinburgh, EH9 3FD, United Kingdom, and **L. Szpruch** and **Arnaud Lionnet**. *Customized numerical schemes for FBSDEs.* Preliminary report.

In this talk we introduce a family of explicit numerical approximations for the forward backward stochastic differential equations (FBSDEs). We show that newly developed methodology allows to analyse BSDEs with drivers having polynomial growth and that are also monotone in the state variable. This offers a probabilistic scheme for wide class of reaction-diffusion PDEs. Proposed schemes preserve qualitative properties of the solutions to the FBSDEs for all ranges of time-step (Received February 05, 2015)

Session 49

1111-65-532 **Lars Diening*** (diening@math.lmu.de), Osnabrueck, GA, Germany. *Numerical analysis for variable exponent problems.*

Variable exponents appear in the study of electrorheological fluids. These are special fluids, where the non-linear viscosity is strongly influenced by the application of an electrical field. The used model (due to Ruzicka and Rajagopal) belongs to the class of power-law fluids, where the power now depends on the electrical field. We discuss the numerical analysis of the finite element solutions. This requires a stronger version of the so-called keyestimate, which also plays a major role in the boundedness of the Hardy-Littlewood maximal operator. (Received February 09, 2015)

Session 48

1111-65-549 **Christiane Helzel*** (christiane.helzel@hhu.de), Institute of Mathematics, Heinrich-Heine-University Düsseldorf, Universitätsstr. 1, 40225 Düsseldorf, Germany. *High-order finite volume methods for hyperbolic PDEs on Cartesian grids with embedded boundaries.*

We discuss finite volume methods for hyperbolic pdes on Cartesian grids with embedded boundaries. Embedded boundary methods are very attractive for several reasons: The grid generation is simple even in the presence of complicated geometries. Furthermore, such an approach allows the use of regular Cartesian grid methods away from the embedded boundary, which are much simpler to construct and more accurate than unstructured grid methods. In embedded boundary grids with cut cells adjacent to the boundary, the cut cell volumes can be orders of magnitude smaller than a regular Cartesian grid cell volume. The use of standard difference procedures would lead to an unacceptably small integration time step. Both accuracy and stability are issues that need to be addressed at these highly irregular cut cells adjacent to solid bodies. The goal is to construct a method which is stable for time steps that are appropriate for the regular part of the mesh and at the same time do not lead to a loss of accuracy.

I will present some resent results toward the construction of higher order cut cell methods. (Received February 09, 2015)

Session 48

1111-65-553 **Manuel J Castro Díaz*** (castro@anamat.cie.uma.es), Dpto. Análisis Matemático, Campus de Teatinos S/N, Málaga, Málaga 29071, **Marc de la Asunción** (marcah@uma.es), Dpto. Análisis Matemático, Campus de Teatinos, S/N, Málaga, Málaga 29071, **Carlos Sánchez Linares** (csl@uma.es), Dpto Análisis Matemático, Campus de Teatinos, S/N, Málaga, Málaga 29700, **Siddhartha Mishra** (siddhartha.mishra@sam.math.ethz.ch), Departement Mathematik, HG G 57.2 Rämistrasse 101, Zürich, Zürich 8092, and **Jonas Sukys** (jonas.sukys@sam.math.ethz.ch), Departement Mathematik, HG G 57.2 Rämistrasse 101, Zürich, Zürich 8092. *Uncertainty quantification on geophysical flows by means of Multi-level Monte Carlo method: some examples concerning tsunami modeling.*

In this talk, Multi-level Monte Carlo (MLMC) method for approximating the stochastic hyperbolic PDEs appearing on the simulation of geophysical flows is presented. This entails discretizing space, time as well as the probability space. For spatio-temporal discretization, we will employ a path-conservative finite volume scheme and the probabilistic space is discretized by means of MLMC method.

MLMC methods were introduced by S. Heinrich for numerical quadrature and developed by M. Giles to enhance the efficiency of path simulations for Itô stochastic ordinary differential equations. More recently, MLMC finite element methods for elliptic problems with stochastic coefficients were introduced by Barth, Schwab and Zollinger and extended to finite volume methods for hyperbolic and balance laws by Schwab and Mishra.

An efficient implementation of the algorithm using GPUs is presented and some numerical test will be shown to check the efficiency of the proposed method in tsunami modeling (Received February 09, 2015)

Session 48

1111-65-809 **Andrea Cangiani*** (andrea.cangiani@le.ac.uk), Department of Mathematics, University fo Leicester, University Road, Leicester, LE1 7RH. *Adaptive numerical solution of nonlinear convection-diffusion problems.*

Real-life models are often characterized by complex geometries and solution features. These make the design of accurate numerical solutions challenging, or even out of reach unless computational resources are smartly allocated. Finite Element Methods (FEM) are well know for their flexibility, still they are mainly limited to somehow standard partitions of the solution domain. We propose the following framework: new FEM approaches allowing for more general partitioning of the computational domain combined with automatic adaptive meshing. We present two approaches extendig the FEM to general meshes while maintaining the ease of implementation and computational cost comparable to that of standard FEM: the Virtual Element Method (VEM) and a discontinuous Galerkin method. Both also naturally permit the local adaptation of the discrete space (eg. polynomial degree). The next step is to exploit such great generality in an automatic fashion. We propose time-space adaptive algorithms based on rigorous a posteriori error bounds. This approach will be demonstrated on nonlinear evolution problems with localised features modelling population dynamics, convection-diffusion mass transfer through semi-permeable membranes, and blow up detection. (Received February 10, 2015)

68 ► Computer science

Session 4

1111-68-546 **Laure Daviaud*** (laure.daviaud@lif.univ-mrs.fr). *Classes of languages generated by the Kleene star of a word.*

Equational descriptions of regular languages is a successful and long-standing approach to obtain characterisations of classes of regular languages. One of the first results is Schützenberger's Theorem on aperiodic monoids. In the case of a variety of regular languages, Reiterman's Theorem guarantees the existence of a characteristic set of profinite equations. This theorem has been extended to several kinds of classes of languages, including lattices and Boolean algebras.

The aim of this talk is to study the four classes of regular languages obtained respectively as the lattice, Boolean algebra, lattice closed under quotient and Boolean algebra closed under quotient generated by the class of all languages of the form u*, where u is a word.

Our main result is an equational characterisation for each of these four classes. These equational characterisations being effective, they give as a counterpart the decidability of the membership problem: One can decide whether a given regular language belongs to one of these classes. In addition, our results also provide a general form for the languages belonging to each of these classes.

This is a joint work with Charles Paperman. (Received February 09, 2015)

Session 4

1111-68-673 **Marc Zeitoun*** (mz@labri.fr), LaBRI, Université de Bordeaux, 351 Cours de la Libération, Talence, 33400. *A survey on separation problems.*

One central question in formal language theory is the membership problem. Its purpose is to capture the expressiveness of a given specification formalism. On finite words, it has been successfully solved for several important fragments of first order logic. All known solutions require abstracting properties of the class under investigation within an algebraic framework.

In the two last decades, stronger properties emerged as means to extract even more information as what is requested by the membership problem, in order to solve it for hard classes. This talk will survey results about these separation properties, and present recent progress they imply for the membership problem.

Talk based on recent joint work with Thomas Place. (Received February 10, 2015)

Session 39

1111-68-748 **Penousal Machado***, Rua Silvio Lima, Univ. Coimbra - Polo II, Coimbra, Portugal, and **Pedro Martins**. *Evolutionary Art: Beyond Interactive Evolution.*

We make a survey of evolutionary art, reviewing some of the most influential work. This introduction sets the tone for the discussion of two key issues in evolutionary art research: representation and evaluation. We will briefly discuss the strengths and limitations of the most popular representations in the field of evolutionary art, emphasizing on the implications of the representation in the outcome of the evolutionary process. Then we focus on the main topic of this presentation, overviewing the most relevant approaches to evaluation. These include the use of: hardwired fitness functions, machine learning approaches, co-evolution, novelty search, fitness function design. The discussion is enriched by examples illustrating the results attained using different evaluation and representation techniques. (Received February 10, 2015)

Session 7

1111-68-778 **J N Oliveira***, Campus de Gualtar, Braga, Portugal. *Why category theory matters: a functional programmer's perspective.* Preliminary report.

Since the early days of LISP, functional programming (FP) has evolved into what can be regarded nowadays as one of the most solid paradigms for producing software. By solid I mean "scientifically valid".

How did this happen? A look into the past shows that, smoothly, FP has evolved thanks to the inspiration of category theory. The integration of the concept of a "monad" in main-stream FP is surely one of the major "turning points" in this process, admitted even by category-theory "non aficionados".

In this talk I will address some of the most recent trends in category-theory-inspired FP, namely the role of adjunctions in structuring and reasoning functional programs and the role of Kleisli enriched categories to perform calculational proofs about FP programs. (Received February 10, 2015)

74 ► Mechanics of deformable solids

Session 38

1111-74-136 **Robert Beig*** (robert.beig@univie.ac.at), Gravitational Physics, Faculty of Physics, University of Vienna, A-1090 Vienna, Vienna, Austria. *Relativistic celestial mechanics of elastic bodies.*

We construct time independent configurations in relativistic elasticity corresponding to a body moving on an approximately circular orbit in the gravitational field of a stationary axisymmetric source. Our method is a variant of the Liapunov-Schmidt procedure of bifurcation theory. This is joint work with B.G.Schmidt and S.Broda. (Received January 28, 2015)

Session 36

1111-74-184 **Matteo Negri*** (matteo.negri@unipv.it), Via A. Ferrata 1, 27100 Pavia, Italy. *BV evolutions in phase field fracture.*

We consider a phase-field description for brittle fracture provided by a separately quadratic energy of Ambrosio-Tortorelli type. We study a couple of quasi-static evolutions, both obtained by sequences of time-discrete incremental minimization problems. Our goals are the characterization of the time-continuous limits as parametrized BV-evolutions.

The first is a locally minimizing movement in the phase field variable with respect to the H^1 or L^2 norm. Its limit evolutions satisfy equilibrium and energy balance (in terms of energy release) in the stable regimes and a gradient flow for the phase-field variable in the unstable ones.

The second is instead obtained by the alternate minimization scheme. Its limit evolutions enjoy equilibrium and energy balance, in the stable regimes, and a gradient flow for the field variable together with a visco-elastic flow for the displacement. In this case the scheme and the separately quadratic energy induce a "family of intrinsic norms" for the BV evolution.

In general both the evolutions are thermodynamically consistent, as far as the irreversibility constraint, only in the stable regimes of propagation. (Received February 02, 2015)

Session 36

1111-74-689 **Luca Deseri*** (deseri@andrew.cmu.edu), DICAM, via Mesiano 77, Trento, TN 38123, **P Pollaci** (pietro.pollaci@unitn.it), 38123 Trento, TH, Italy, **Massimiliano Zingales** (massimiliano.zingales@unipa.it), LBNMS-Mediterranean Center of Human Health, and Advanced Biotechnologies, 90128 Palermo, PA, Italy, and **Kaushik Dayal**, Pittsburgh, PA 15213. *Fractional Viscoelasticity of Lipid Membranes.* Preliminary report.

Long tail time-memory of lipid bilayers relative to their life time have been experimentally showed in the literature. A dimension reduction procedure on the three dimensional dissipation functional of transversely unimodular lipid membranes supporting shear stresses only through their in-plane fractional viscosity is investigated. Reduced equilibrium elasticity is accounted for in the treatment and effective hereditariness of the resulting free energy is obtained. Squeezing modes are explored to investigate the influence of relaxation/creep on the thinning phase transition exhibited by lipid bilayers. Furthermore, small perturbed equilibria about a largely strained, (quasi) homogeneous configuration, are investigated to understand the onset of the phase transition governed by the effective response of the membrane. The onset of the loss of homogeneous configuration is possible even in the purely elastic case thanks to the interplay between the local and the nonlocal part of the response. Hereditariness influences such onset, because the time dependence of the external loading (possibly induced by temperature changes) may change the quality of the solution of the balance of linear momentum. (Received February 10, 2015)

76 ► Fluid mechanics

Session 48

1111-76-264 **Tomas Morales de Luna*** (tomas.morales@uco.es), Dpto de Matemáticas. Campus de Rabanales., Universidad de Córdoba, 14071 Córdoba, Spain. *Modeling sediment transport in shallow waters.*

Sediment can be transported in several ways by the action of a river: sliding and rolling over the surface of the bed or can be entrained into suspension, traveling significant distances before being deposed again.

We revisit here some of the models based on shallow water equations in order to simulate these phenomena. The usual approach is to couple this model with transport equations for sediment in suspension and a morphodynamical component for the bedload transport, which depends on an empirical flux.

In what concerns bedload transport, different empirical formulae have been proposed. Based on these formulae, one can prove that the resulting system is hyperbolic at least for most physical situations. The model can be completed in order to take into account gravity effects or by including explicitly the thickness of the moving sediment layer.

Concerning suspended sediment transport, one could include transport equations for each sediment species. Nevertheless, the drawback of this model is that it only takes into account the mean depth-average concentration of each sediment species in suspension and we lose the vertical distribution of sediment within the fluid. A multi-layer approach may be used in order to keep the vertical information of the variables. (Received February 04, 2015)

Session 46

1111-76-324 **P. Zhevandrov*** (pzhevand@gmail.com), Universidad Michoacana, 58060 Morelia, Mich., Mexico, and **F. Garibay** (fgaribay@gmail.com), Universidad Michoacana, 58060 Morelia, Mich., Mexico. *Water waves trapped by thin horizontal cylinders in one- and two-layer fluid.*

The phenomenon of trapping of water waves by submerged cylinders was discovered by Ursell back in 1951 for cylinders with circular cross-section of small radius. Their frequencies are eigenvalues of the Dirichlet-Neumann operator corresponding to the problem for the velocity potential. Ursell's result was generalized to thin cylinders with arbitrary cross-section symmetric with respect to a vertical plane parallel to the axis of the cylinder by P. McIver in 1990. He used the technique of matching asymptotic expansions in order to obtain explicit formulas for the eigenvalues. We remove the assumption concerning the symmetry of the cylinder cross-section by means of solving the corresponding integral equations on the boundary and obtaining exact solutions in the form of convergent series in powers of the small parameter involved. Generalizations to the case of a cylinder submerged in a two-layer fluid are also presented. (Received February 05, 2015)

Session 35

1111-76-376 **De Witt L Sumners*** (sumners@math.fsu.edu), Department of Mathematics, Florida State University, 1017 Academic Way, Tallahassee, FL 32306-4510. *Reconnection in Physics and Biology.*

Reconnection is a fundamental event in many areas of science, including interaction of fluid vortices and flux tubes in fluid mechanics and magnetohydronamics, and site-specific recombination in DNA. This talk will discuss the similarities between reconnection events in biology and physics, and the relationship between iterated reconnection and changes in curve topology. The helicity of a flux tube is a measure of knotting and linking of field lines in the tube, and the absolute value of the helicity is a lower bound for the energy. A theorem of Moffatt and Ricca computes the helicity of a flux tube in terms of the writhe of the tube centerline and the twist of a ribbon determined by the centerline and one of the other field lines in the tube. We prove that the writhe is conserved in an antiparallel reconnection event. Hence, for a pair of interacting tubes of equal flux, if the twist of the reconnected tube is the sum of twists of the individual tubes, then helicity is conserved in a reconnection event. This is joint work with Christian Laing and Renzo Ricca, and will appear in Nature Scientific Reports with the title "Conservation of Writhe Helicity under Anti-Parallel Reconnection". (Received February 06, 2015)

Session 48

1111-76-533 **Stefano Spirito*** (stefano.spirito@gssi.infn.it), Viale Francesco Crispi 7, 67100 L'Aquila, AQ, Italy, and **Gianluca Crippa**. *Renormalized solutions of 2D Euler equations.*

In this talk I will discuss a problem concerning the conservation of enstrophy for solutions of two dimensional Euler equations. In particular, I will present a result in collaboration with Gianluca Crippa (University of Basel) in which we proved that in a low regularity setting weak solutions obtained as a vanishing viscosity limit of solutions of Navier-Stokes equations are renormalized and then conservation of esntrophy holds. The proof relies deeply on the theory of renormalized solutions for transport equations. (Received February 09, 2015)

81 ► Quantum theory

Session 28

1111-81-40 **Christoph Schweigert*** (christoph.schweigert@uni-hamburg.de), Bereich AZ, Fachbereich Mathematik, Bundesstrasse 55, 20146 Hamburg, Germany, and **Jurgen Fuchs**, Universitetsgatan 21, 65188 Karlstad, Sweden. *Symmetries and defects in three-dimensional topological field theory.*

Boundary conditions and defects of any codimension are natural parts of any quantum field theory.Surface defects in three-dimensional topological field theories of Turaev-Reshetikhin type have applications to two-dimensional conformal field theories, in solid state physics and in quantum computing. We explain an obstruction to the existence of surface defects that takes values in a Witt group. We then turn to surface defects in Dijkgraaf-Witten theories and their construction in terms of relative bundles; this allows one to exhibit Brauer-Picard groups as symmetry groups of three-dimensional topological field theories. (Received January 09, 2015)

Session 25

1111-81-68 **Katrin A.M. Wendland*** (katrin.wendland@math.uni-freiburg.de), Mathematisches Institut, Abt. Reine Mathem., Albert-Ludwigs-Universität Freiburg, Eckerstrasse 1, 79104 Freiburg i.Br., Germany. *Supersymmetry decomposes the virtual bundle that underlies the elliptic genus.*

The elliptic genus of a compact Calabi-Yau manifold Y is a weak Jacobi form of weight 0. It also arises as part of the partition function of appropriate N=(2,2) superconformal field theories, which then are viewed as "associated to" the Calabi-Yau manifold Y. If the theory enjoys extended supersymmetry, then the induced decomposition of the elliptic genus reveals additional structure, which so far lacks a geometric interpretation. An example of this are the so-called Mathieu Moonshine phenomena in the case where Y is a K3 surface.

We state and prove a novel decomposition of the virtual bundle which underlies the elliptic genus of K3 and discuss its properties. The decomposition is induced by the N=(4,4) supersymmetry of the associated superconformal field theories and is expected to generalize to other manifolds with special holonomy. (Received January 17, 2015)

Session 8

1111-81-166 **Antonio Sartori*** (antonio.sartori@math.uni-freiburg.de), Mathematisches Institut, Albert-Ludwigs-Universität Freiburg, Eckerstr. 1, Freiburg im Breisgau, 79104. *Mixed super skew Howe duality.*

Skew Howe duality for the general linear group enables to describe the braiding of $\mathfrak{gl}(m)$-representations using a dual quantum group corresponding to $\mathfrak{gl}(k)$. This is extremely useful for the combinatorial study as well as for categorification purposes. In the talk, I will present an extension of skew Howe duality in which the vector representation of $\mathfrak{gl}(m|n)$ and its dual appear at the same time. This is joint work with H. Queffelec, and should hopefully be of great help for understanding categorification of $\mathfrak{gl}(m|n)$-representations. (Received January 31, 2015)

Session 25

1111-81-190 **Susanne Reffert*** (susanne.reffert@cern.ch). *Deformed supersymmetric gauge theories from string and M-theory.*

Deformed supersymmetric gauge theories have met with a lot of interest in the recent literature. A prominent example is Omega–deformed super Yang–Mills theory in four dimensions. The fluxtrap background in string theory provides a transparent and algorithmic way of constructing supersymmetric gauge theories with both mass and Omega-type deformations in various dimensions. I will discuss a number of deformed supersymmetric gauge theories in two and four dimensions which can be obtained via the fluxtrap background from string or M–theory. (Received February 02, 2015)

Session 25

1111-81-220 **Sergei Alexandrov*** (salexand@univ-montp2.fr), L2C, Département Physique Théorique, Université Montpellier 2, Place Eugène Bataillon - CC070, 34095 Montpellier, France. *Symmetries of string compactifications and generalization of Freed-Witten anomaly.*

I consider the problem of consistent implementation of symmetries at the non-perturbative level in type II string theory compactified on a Calabi-Yau threefold. After inclusion of all quantum corrections, all continuous isometries of the classical moduli space are broken to discrete subgroups. I show that the naive choice of these subgroups does not generate a consistent group action, which however can be achieved by taking into account various subtle contributions determined by topological data on the Calabi-Yau. In particular, the monodromy transformations of the RR-fields should acquire anomalous terms, which seem to have a similar origin as the Freed-Witten anomaly for open strings ending on D-branes. (Received February 03, 2015)

Session 25

1111-81-222 **Constantinos Papageorgakis*** (c.papageorgakis@qmul.ac.uk), School of Physics and Astronomy, Queen Mary University of London, London, E1 4NS, United Kingdom. *Instanton operators in 5D gauge theories.*

We will discuss instanton operators in 5D Yang-Mills gauge theories. These are defined as local operators which create a non-vanishing second Chern class on a four-sphere surrounding their insertion point. As such they may be thought of as higher-dimensional analogues of 3D monopole (or 't Hooft) operators. We argue that they play an important role in the enhancement of the Lorentz symmetry for maximally supersymmetric Yang-Mills to SO(1, 5) at strong coupling. (Received February 03, 2015)

Session 25

1111-81-227 **Lotte Hollands*** (hollands@maths.ox.ac.uk). *Opers, spectral networks and the T3 theory.*

The variety of opers forms a Lagrangian subspace of the Hitchin moduli space, which is naturally isomorphic to the base of the Hitchin fibration. Nekrasov, Rosly and Shatashvili have proposed that the generating function of the variety of PSL(2) opers on a Riemann surface C has a distinguished physical meaning, as a certain superpotential for a two-dimensional SU(2) gauge theory associated to C. Crucial to this claim is that the generating function needs to be expressed in terms of complex Fenchel-Nielsen coordinates. In this talk I will attempt to generalize this proposal to higher rank, based on work in progress with Andy Neitzke. This requires a generalization of the notion of Fenchel-Nielsen coordinates to moduli spaces of higher rank complex flat connections. We will find such coordinates from a certain network of trajectories on the Riemann surface C, generated by a generalized Strebel differential. (Received February 03, 2015)

Session 28 1111-81-352 **I Runkel***, Fachbereich Mathematik, Univ. Hamburg, Bundesstr. 55, 22559 Hamburg, Germany. *Defects, orbifolds and spin.*

Defects in two-dimensional quantum field theories are lines across which fields of the theory may have discontinuities. Such defects are called "topological" if their precise location does not matter when evaluating correlators. Topological defects contain a lot of information about the field theory in question. In this talk I will concentrate on two-dimensional topological and conformal field theories, and I would like to explain how two superficially quite different constructions turn out to be closely related when formulated via defects. These are 1) the orbifolding procedure, and 2) building field theories on surfaces with spin structure. (Received February 06, 2015)

Session 25 1111-81-408 **Stefano Cremonesi*** (`stefano.cremonesi@kcl.ac.uk`). *The Coulomb branch of 3d N=4 gauge theories and the moduli space of instantons.*

I will review recent progress in characterising the Coulomb branch of the moduli space of vacua of three-dimensional N=4 supersymmetric gauge theories by means of 't Hooft monopole operators. I will present an exact formula for the Hilbert series of the Coulomb branch and its application to moduli spaces of instantons for any simple Lie group. (Received February 07, 2015)

Session 25 1111-81-435 **Abhijit B Gadde*** (`abhijitgadde@gmail.com`), 233 Von Neumann Drive, Princeton, NJ 08540. *Exact Solutions of 2d Supersymmetric Gauge Theories.*

We study the dynamics of two-dimensional non-abelian gauge theories with N=(0,2) supersymmetry that include the supersymmetric QCD and its generalizations. Multiple theories of this class exhibit identical physics at low energies. Interestingly, as it turns out, the constraints imposed by two dimensional conformal symmetry along with modular invariance are sufficient to completely solve for the low energy physics. (Received February 07, 2015)

Session 25 1111-81-439 **Anindya Dey*** (`anindya@physics.utexas.edu`). *Mirror Symmetry, Partition Function and Gauged Linear Quivers.*

The tools of localization provide a particularly efficient way to look for new organizing principles for dualities in Supersymmetric Quantum Field Theories in various space-time dimensions. I will discuss one such organizing principle in the context of three-dimensional Mirror Symmetry by demonstrating how an extremely large class of quiver gauge theories and their mirror duals can be generated from mirror pairs involving only linear quivers, by a simple set of operations. Infinite families of mirror pairs including various quivers of D and E-type and their affine extensions, star-shaped quivers, and quivers with symplectic gauge groups can all be obtained in this fashion. In certain cases where the mirror dual of a given theory is "bad" in the Gaiotto-Witten sense, our program curiously provides a way to obtain a "good" mirror. (Received February 08, 2015)

Inv.Adresses 1111-81-464 **Mikhail Khovanov*** (`khovanov@math.columbia.edu`), 2990 Broadway, Department of mathematics, Columbia University, New York, NY 10463. *Categorification at a prime root of unity.*

Rings important in quantum theory, such as quantum groups and Hecke algebras, exhibit different behaviours when the parameter q is generic and when a root of unity. Upon categorification, generic parameter q becomes a grading shift or, more generally, an automorphism of a triangulated category. How categorification works at a root of unity is a much more subtle and mostly unsolved problem, In this talk we'll discuss categorifications when the degree of a root of unity is a prime number and categorification happens over a field of characteristic p, including a categorification of the small quantum sl(2). (Received February 08, 2015)

Session 15

1111-81-613 **Eva-Maria Graefe***, Department of Mathematics, Imperial College London, London, SW7 2AZ, United Kingdom. *The semiclassical limit of complexified quantum dynamics.*

In recent years there has been growing interest in complexified quantum systems described by non-Hermitian Hamiltonians in various fields. Examples are scattering systems and the effective description of absorption and amplification. The classical counterparts of complexified quantum systems, however, remained illusive. In this talk I present some results on the quantum evolution of Gaussian wave packets generated by a non-Hermitian Hamiltonian in the semiclassical limit of small $\hbar$. This yields a generalisation of the Ehrenfest theorem for the dynamics of observable expectation values. The resulting equations of motion for dynamical variables are coupled to an equation of motion for the phase-space metric—a phenomenon having no analogue in Hermitian theories. The results have been obtained in collaboration with Roman Schubert of the University of Bristol. (Received February 09, 2015)

Session 35

1111-81-628 **Catherine Meusburger*** (`catherine.meusburger@math.uni-erlangen.de`), Department Mathematik, Universitat Erlangen-Nurnberg, Cauerstrasse 11, 91058 Erlangen, Germany. *Topological lattice models as quantum gauge theories.*

Nonabelian lattice models are investigated in topological quantum computing, condensed matter physics and, more recently, in the context of (extended) topological quantum field theory. The most general such models are based on the representation theory of weak Hopf algebras and include excitations and domain walls decorated with higher categorical data. In the talk, we focus on lattice models based on weak Hopf algebras. We develop an algebraic formulation of these models in terms of quantum connections and quantum gauge transformations and relate them to the quantisation of symplectic structures on moduli spaces of flat connections. (Received February 09, 2015)

Session 25

1111-81-640 **Sergei Gukov*** (`gukov@theory.caltech.edu`), Caltech 452-48, Pasadena, CA 91125, and **Du Pei** (`pei@caltech.edu`), Caltech 452-48, Pasadena, CA 91125. *Equivariant Verlinde formula from fivebranes and vortices.* Preliminary report.

We study complex Chern-Simons theory on a Seifert manifold M3 by embedding it into string theory. We show that complex Chern-Simons theory on M3 is equivalent to a topologically twisted supersymmetric theory and its partition function can be naturally regularized by turning on a mass parameter. We find that the dimensional reduction of this theory to 2d gives the low energy dynamics of vortices in four-dimensional gauge theory, the fact apparently overlooked in the vortex literature. We also generalize the relations between 1) the Verlinde algebra, 2) quantum cohomology of the Grassmannian, 3) Chern-Simons theory on $\Sigma\times S1$ and 4) index of a spinc Dirac operator on the moduli space of flat connections to a new set of relations between 1) the "equivariant Verlinde algebra" for a complex group, 2) the equivariant quantum K-theory of vortex moduli spaces, 3) complex Chern-Simons theory on $\Sigma\times S1$ and 4) the equivariant index of a spinc Dirac operator on the moduli space of Higgs bundles. Based on a joint work with Du Pei. (Received February 09, 2015)

Session 35

1111-81-677 **Jamie Vicary*** (`jamie.vicary@cs.ox.ac.uk`), Department of Computer Science, University of Oxford, Oxford, OX1 3QD, United Kingdom. *Topological Foundations for Quantum Computation.*

I will show how some fundamental computational processes, including encrypted communication and quantum teleportation, can be defined in terms of defects between low-dimensional topological cobordisms, giving insight into fundamental questions in classical and quantum computation. (Received February 10, 2015)

Session 25

1111-81-685 **Hans Jockers*** (`jockers@uni-bonn.de`), Bethe Center for Theoretical Physics, Nussallee 12, 53115 Bonn, Germany. *Phases of Gauged Linear Sigma Models and Homological Projective Duality for Calabi-Yau manifolds.*

Using non-Abelian gauged linear sigma model techniques, I present a novel class of examples that realizes phase transitions between pairs of Calabi-Yau manifolds that are not birational to each other. These pairs of Calabi-Yau manifolds arise from a non-trivial duality transformation of the underlying two-dimensional sigma model. I argue that this duality relation provides for another non-trivial instance of homological projective duality among Calabi-Yau manifolds as introduced by Kuznetsov. Finding agreement of the sphere partition function of dual sigma models gives evidence in favor of the presented proposal. (Received February 10, 2015)

Session 15

1111-81-780 **Thomas Thiemann*** (thomas.thiemann@gravity.fau.de). *Complexifier Coherent States in Loop Quantum Gravity.*

We review applications of complexifier coherent states in physics, in particular Loop Quantum Gravity (Received February 10, 2015)

Session 41

1111-81-813 **Mikhail Khovanov*** (khovanov@math.columbia.edu), Department of Mathematics, Columbia University, 2990 Broadway, New York, NY 10027, and **Alexander Ellis**. *Odd symmetric functions.*

We will review a joint work with Alexander Ellis on the Hopf algebra of odd symmetric functions. (Received February 10, 2015)

Session 35

1111-81-821 **Mina Aganagic***, Mathematics and Physics Departments. *Knots and Mirror Symmetry.*
I will describe a conjecture relating knot theory and mirror symmetry. To every knot K, one can associate a Calabi-Yau manifold YK, which depends only on the homotopy type of the knot. The conjecture states that one should be able to recover the colored HOMFLY invariants of the knot, by an appropriate quantization procedure, from YK. Every Calabi-Yau YK that arises in this way is mirror to the conifold, generalizing the Strominger-Yau-Zaslov mirror symmetry conjecture. (Received February 11, 2015)

Session 35

1111-81-823 **John Barrett***, School of Mathematical Sciences, University Park, Nottingham, NG7"RD, United Kingdom. *State sum models and spin structures.*

The state sum models in two dimensions introduced by Fukuma, Hosono and Kawai are generalised by allowing algebraic data from a non-symmetric Frobenius algebra. Without any further data, this leads to a state sum model on the sphere. When the data is augmented with a crossing map, the partition function is defined for any oriented surface with a spin structure. An algebraic condition that is necessary for the state sum model to be sensitive to spin structure is determined. Some examples of state sum models that distinguish topologically-inequivalent spin structures are calculated. (Received February 11, 2015)

Contr.Session

1111-81-824 **John Barrett***, School of Mathematical Sciences, University Park, Nottingham, NG72RD, United Kingdom. *Matrix geometries and fuzzy spaces as finite spectral triples.*

The purpose of this paper is to define and investigate a class of real spectral triples called matrix geometries that are similar in structure to Riemannian manifolds but are finite-dimensional and non-commutative. As an example, new definition for the Dirac operator for a fuzzy sphere is made using four-component spinors and with a chirality operator. This obeys all of the axioms of a real spectral triple. It is compared with the commutative case and with the existing literature on fuzzy spheres. (Received February 11, 2015)

82 ► Statistical mechanics, structure of matter

Session 10

1111-82-73 **José A Cañizo*** (canizo@ugr.es), Dep. Matemática Aplicada, Facultad de Ciencias, Granada, 18071. *Cercignani's conjecture for the Boltzmann equation and analogs for the Becker-Döring system.*

We present some recent progress on entropy-entropy production inequalities for the Boltzmann equation, also known as Cercignani's conjecture: we show that Cercignani's conjecture holds for functions bounded above and below by a multiple of the equilibrium. We discuss some consequences for related conjectures regarding the Becker-Döring equation, looking particularly for new results on its asymptotic behaviour. (Received January 19, 2015)

Inv.Adresses

1111-82-85 **Sylvia Serfaty***, 4 place Jussieu, Paris, France. *Questions of crystallization in systems with Coulomb and Riesz interactions.*

We are interested in systems of points with Coulomb, logarithmic or more generally Riesz interactions (i.e. inverse powers of the distance). They arise in various settings: an instance is the classical Coulomb gas which in some cases happens to be a random matrix ensemble, another is vortices in the Ginzburg-Landau model of superconductivity, where one observes in certain regimes the emergence of densely packed point vortices forming perfect triangular lattice patterns named Abrikosov lattices, a third is the study of Fekete points which arise in approximation theory. After rescaling we deal with a microscopic quantity, the associated empirical point process, for which we give a large deviation principle whose rate function is the sum of a relative entropy and of a renormalized energy that governs microscopic patterns of points. The former favors disorder, while the latter is expected to favor cristalline configurations. This is based on joint works with Etienne Sandier, Simona Rota Nodari, Nicolas Rougerie, Mircea Petrache, and Thomas Leblé. (Received January 20, 2015)

Session 10

1111-82-635 **Michael Helmers*** (helmers@iam.uni-bonn.de), Institute for Applied Mathematics, University of Bonn, Endenicher Allee 60, 53115 Bonn, Germany. *A simple model for coarsening in infinite particle systems.*

We consider coarsening dynamics in an infinite particle system governed by nearest-neighbor interactions between particles of positive size, which resemble a one-dimensional discrete backward-parabolic PDE. Despite its simplicity, our system shares many interesting features with well-known, more complex coarsening models.

In the talk, we present the first steps of a rigorous treatment of the particle system. To this end, we discuss key dynamic properties, in particular the transport of mass, screening and long-range interactions, which substantially influence the statistical behavior as well as the mathematical analysis of the system. (Received February 09, 2015)

83 ► Relativity and gravitational theory

Session 25

1111-83-261 **Joao Gomes*** (joaomvg@gmail.com), Wilberforce Road, Cambridge, CB3 0WA, United Kingdom. *Localization in Supergravity and Exact Holography.*

I will review how we can use localization to compute the partition function of supergravity on AdS spaces and its importance in the study of holography beyond the usual large N limit. In the case of supersymmetric black holes the path integral on $AdS_2 \times S^2$ computes the exact degeneracy of states. It can be shown that the path integral reduces to a finite dimensional integral which also includes the contribution from number theoretic objects called Kloosterman sums. The final answer gives an integer as expected from the quantum theory. By the same token we can also address the computation of the partition function of M-theory on $AdS_4 \times S^7$ and show that the path integral reduces to an Airy function in agreement with the dual ABJM computation at any order in $1/N$. These results constitute an extremely important step in studying holography at the quantum level and more generally in understanding string theory on curved spaces. (Received February 04, 2015)

Session 38

1111-83-362 **Pedro Martins Girão*** (pgirao@math.ist.utl.pt), Math. Department, IST, Av. Rovisco Pais, Lisbon, 1049-001. *Price's law and uniqueness for the Einstein-Maxwell-scalar field system with a cosmological constant.*

In this talk we will consider spherically symmetric characteristic initial data for the Einstein-Maxwell-scalar field system with a cosmological constant, with initial data on the outgoing initial null hypersurface satisfying a Price law, and we will study the extendibility of the corresponding maximal globally hyperbolic development. (Received February 06, 2015)

Session 38

1111-83-385 **Jorge Drumond Silva*** (jsilva@math.tecnico.ulisboa.pt), Departamento de Matematica, Instituto Superior Tecnico, Av. Rovisco Pais, 1049-001 Lisboa, Portugal. *On the global uniqueness for the Einstein-Maxwell-scalar field system with a cosmological constant.*

In this talk, we present recent results on the future extendibility of the maximal globally hyperbolic development for the Einstein-Maxwell-scalar field system with a cosmological constant Λ, with spherically symmetric characteristic initial data given by a subextremal Reissner-Nordström black hole event horizon along the outgoing initial null hypersurface.

We first establish the well posedness of the characteristic problem and study the stability of the radius function at the Cauchy horizon. Then, we show that, depending on the decay rate of the initial data, mass inflation may or may not occur. Under certain conditions, extensions of the spacetime can actually be obtained across the Cauchy horizon, as classical solutions of the Einstein equations.

We conclude by discussing how these results relate to the strong cosmic censorship conjecture.

This is joint work with João L. Costa, Pedro M. Girão and José Natário. (Received February 06, 2015)

Session 38

1111-83-407 **José M M Senovilla***, Física Teórica, Universidad del País Vasco, 48080 Bilbao, Spain. *Umbilical properties of co-dimension two submanifolds.*

Co-dimension two submanifolds which are umbilical along some normal direction are studied in Lorentzian manifolds. New characterizations and properties will be presented. They may arise in many situations of physical interest, such as isolated horizons, conformal Killing vectors, algebraically special solutions, etc. Time permitting, relevant examples will be discussed. (Received February 07, 2015)

Session 38 1111-83-476 **S. Beheshti*** (s.beheshti@qmul.ac.uk), School of Mathematics, Queen Mary University of London, Mile End Road, London, E1 4NS, United Kingdom, and **S. Tahvildar-Zadeh**. *Harmonic Maps, the Xanthopoulos Conjecture and Analysis of Singularities in General Relativity.*

Integrability and dressing techniques have been extensively utilized in the construction and analysis of exact solutions to the Einstein's Equations. On the other hand, harmonic maps have provided deep insight into important mathematical and physical problems, ranging from classical differential geometry to supergravity.

Joint work with S. Tahvildar-Zadeh answers the question "when is a harmonic map integrable?" for a class of mappings having noncompact symmetric space targets. The framework includes application of control-theory techniques to a generalized solution-generating mechanism. This gives rise to surprising new evidence for existence–and possible non-existence– of certain singular configurations for solutions to Einstein's Equations. In conjunction with previous work on compact targets by Uhlenbeck and Terng, the techniques also suggest the first inroads in answering the Xanthopoulos Conjecture. (Received February 08, 2015)

Session 38 1111-83-594 **Borja Reina** and **Raül Vera*** (raul.vera@ehu.eus), Dept. Theoretical Physics and H. of Science, Faculty of Science and Technology, UPV/EHU, Apt. 644, 48080 Bilbao, Spain. *Revisiting Hartle's model using perturbed matching theory to second order: amending the change in mass.*

Hartle's model describes the equilibrium configuration of a rotating isolated compact body to second order in perturbation theory in GR. The interior is a perfect fluid with a barotropic equation of state, no convective motions and rigid rotation, which is matched across its surface to an asymptotically flat vacuum exterior. Perturbations are taken around a static and spherically symmetric background configuration. Apart from the explicit assumptions, the model is built upon some implicit premises, as the continuity of the functions describing the perturbation in terms of some radial coordinate. We have revisited the model within a recent consistent theory of perturbative matchings to second order, independent of the coordinates and gauges used in the two regions. The matching conditions are explored up to second order in full, and put on firm grounds. However we find that the second order radial function m_0 in the original work, contrary to the original assumption, presents a jump at the surface of the star proportional to the value of the energy density of the background configuration there. As a consequence, the change in mass δM needed by the perturbed configuration to keep the value of the central energy density unchanged must be amended. (Received February 09, 2015)

Session 38 1111-83-600 **Philippe G. LeFloch*** (contact@philippelefloch.org), Laboratoire Jacques-Louis Lions, University Pierre et Marie Curie, 75158 PARIS, France. *Weak solutions to the Einstein equations in spherical or T2 symmetry.*

I will discuss the initial value problem for self-gravitating compressible fluids under the assumption of spherical or T2 symmetry. My standpoint is that weak solutions to the Einstein equations at the lowest possible regularity level should be sought for. Indeed, the proposed theory solely requires that the total mass-energy of the initial data set is finite, and encompasses a variety of geometric and fluid singularities: impulsive gravitational waves, shock waves, area-radius function approaching zero (in spherical symmetry), and vacuum regions for the mass-energy density. With this method, the global causal geometry of maximal Cauchy developments can be studied within the proposed class of weakly regular spacetimes. (Received February 09, 2015)

Session 38 1111-83-744 **David Fajman*** (david.fajman@univie.ac.at), Institut für Physik, Universität Wien, Boltzmanngasse 5, 1090 Vienna, 1090 Vienna, Vienna, Austria. *Nonlinear Stability for the Einstein-Vlasov system in 2+1 dimensions.*

We address the nonlinear stability problem for Robertson-Walker type solutions of the Einstein-Vlasov system in 2+1 dimensions. The Einstein-Vlasov system models space-times with ensembles of collisionless particles. We prove that small perturbations of isotropic initial data yield a future development which is future geodesically complete and remains close to the corresponding background solution. Similar problems have so far only been treated under additional symmetry assumptions or the presence of a positive cosmological constant. Essential aspects of the proof are energy estimates for the distribution function modeling the particle distribution. These estimates heavily use the geometric structure of the tangent bundle of space time and allow for the control of non-symmetric perturbations in a general setting. Moreover, we discuss the relevance of the topology of the spatial slices and construct non-vacuum solutions which have no vacuum counterparts for the case of spherical spacelike topology. (Received February 10, 2015)

90 ► Operations research, mathematical programming

91 ► Game theory, economics, social and behavioral sciences

Session 19

1111-91-193 **Elvio Accinelli*** (elvioaccinelli@hotmail.com), Facultad de Economia de la UASLP, Mexico, and **Enrique Covarrubias** (enriquecovarr@gmail.com), Banco de Mexico, Mexico. *The Imitation Game: a model of endogenous technological jumps.*

This paper is concerned with a private ownership production economy that evolvesb continuously along an equilibrium manifold, i.e, at each moment, prices,b profits of firms and demands of the consumers correspond to a Walrasian equilibrium. The evolution is determined by managers looking to maximize profits. Its solutions are determined by the initial conditions and they determine the equilibrium path along which the economy evolves. Since, the available information for each manager on the future states of the economy is not perfect, the imitation of the most successful competitors appears like a natural process.

Next, we analyze the main characteristics of the stationary states of this dynamical system. We show that, the transition process, evolves on a Walrasian equilibrium manifold. Since the economies are generically regular, along this evolution, there will be not discontinuities from one period to another. We identify singular economies as the thresholds of economic crises. (Received February 02, 2015)

Session 19

1111-91-223 **Alberto Adrego Pinto*** (aapinto1@gmail.com), **Mohammad Choubdar**, **Edson Faria** and **Flávio Ferreira**. *Uncertainty costs on an international duopoly with tariffs.*

We consider two firms located in different countries selling the same homogeneous good in both coun- tries. In each country there is a tariff on imports of the good produced in the other country. We compute the Bayesian-Nash equilibrium and we analyse the effect of the production costs uncertainty on the profits of the firms and on the welfare of the governments. We show that the expected profit of the firms and the expected welfare of the governments increase with the variances of the production costs of both firms. When the production costs of the firms are similar, we show that this international trade model is like the Prisoner's Dilemma in the sense that the Bayesian-Nash equilibrium consists in both governments to impose tariffs but if both governments do not impose any tariff then both countries will have a higher welfare. (Received February 03, 2015)

Session 19

1111-91-243 **Alberto Adrego Pinto** and **Jorge Fernando Soares*** (jsoares235@gmail.com). *Price Dynamics in Hotelling Model.*

In 1929 Hotelling presented a model for spacial competition between firms in which they compete in two-stage game. First both firms choose their location and after they choose their price. In this work we assume that the establishement of prices hapens in a dynamic way instead of a static one. We will use a certain type of dynamics and our main goal will be to study the stability of the Nash Price Equilibrium. In particular we study the conditions that make the sef of prices with local market structure, that is every firm has a non-empty market share, a forward invariant set. Two cases will be studied, the Hotteling line model in terms of linear dependence on the transportation costs and the Hotteling line model in terms of quadratic dependence on the transportation costs.

(Received February 03, 2015)

Session 19

1111-91-484 **José Martins*** (jmmartins@ipleiria.pt), School of Technology and Management, Polytechnic Institute of Leiria, Campus 2, Morro do Lena - Alto do Vieiro, 2411-901 Leiria, Portugal, and **Alberto Pinto**. *An economical model for international expansion with and without make dumping.*

The expansion of large companies across frontiers often leads to the phenomena of dumping and not always increases the profit of the firms due to antidumping duties. Here, we consider an economic model in which one firm has the monopoly of a certain market in its own country and divides another market in a foreign country with a firm of the foreign country. We study two possible strategies for the firm that is selling in both countries to increase its profit: the firm increases the production quantities to decrease the selling prices in both countries and avoid dumping; the firm only increases the production quantity to decrease the selling price in the foreign country and makes dumping. To do our analysis we use a duopoly model and we characterize the parameters that define the most profitable strategy. (Received February 09, 2015)

Session 37 1111-91-486 **José Martins*** (jmmartins@ipleiria.pt), School of Technology and Management, Polytechnic Institute of Leiria, Campus 2, Morro do Lena - Alto do Vieiro, 2411-901 Leiria, Portugal, and **Alberto Pinto**. *A game theoretical analyzes of vaccination games.*

In general, the vaccination morbidity risks are over valorized regarding the vaccination benefits. When individuals have to choose between to vaccinate or not, the decision is influenced by the morbidity risks of vaccination but also by the morbidity risks of infection, by the probability of to become infected and by the decisions of all other individuals. We study the individual's decisions depending on the perceived morbidity risks and we analyze the effects of reinfection on these decisions. We study the impact of vaccination scares in the perceived morbidity risks and the corresponding changes in the individual's vaccination strategies, as well as the impact of the vaccination campaigns. (Received February 09, 2015)

Session 19 1111-91-618 **Alberto A Álvarez-López*** (aalvarez@cee.uned.es), Dep. Quantitative Applied Economics II, Faculty of Economics - UNED, Paseo Senda del Rey, 11, 28040 Madrid, Madrid, Spain, and **Inmaculada Rodríguez-Puerta** (irodpue@upo.es), Dep. Economics, Quantitative Methods, and Economic History, Carretera de Utrera Km.1, 41013 Seville, Seville, Spain. *Decision analysis under uncertainty in a model of sports economics.* Preliminary report.

We consider a model, due to Andersen and Nielsen, concerning the behavior of a risk-averse sports team under uncertainty in demand: the team chooses a value for the price of its ticket, but the ticket demand is stochastic at the moment of decision.

For this model, we carry out a decision analysis by studying several comparative-static effects not considered by the authors in their paper. Specifically, we examine the effect of changes in the team's risk aversion, and also the effect of a variation in the risk of the random demand. Furthermore, we enhance the model by considering a proportional profit tax, and we study the effect of a variation in the tax rate. We derive some conditions under which the sports team finds optimal to reduce the ticket price as a consequence of a rise in the tax rate.

We also try to drop the assumption of unlimited capacity for the stadium. (Received February 09, 2015)

92 ► Biology and other natural sciences

Session 37 1111-92-43 **Gabriela Gomes*** (ggomes@igc.pt), **Marc Lipsitch**, **Andrew Wargo**, **Gael Kurath**, **Carlota Rebelo**, **Graham Medley** and **Antonio Coutinho**. *A missing dimension in measures of disease intervention impacts.*

Immunological protection, acquired from either natural infection or vaccine, varies between hosts, affecting population level protection. Distributions of susceptibility and protection can be inferred by adequately representing the dose dimension in the study design. The two extreme distributions of vaccine protection have been termed leaky (equally protects all hosts) and all-or-nothing (totally protects a proportion of hosts). Leaky vaccines are predicted to allow greater pathogen prevalence. These extreme distributions can be distinguished in vaccine field trials from the time dependence of infections. However, results are not comparable across regions unless there is explicit control for baseline transmission. We provide a rationale for how comparability can be attained, by adopting study designs and estimation procedures that integrate multiple populations, covering a wide range of transmission intensities. Distributions of host susceptibility, and acquired protection, can be estimated from dose-response data generated under controlled experimental conditions or natural settings. These distributions enable model validity across the entire range of transmission intensities. We argue that a shift to a dose-dimension paradigm is needed in community health research. (Received January 10, 2015)

Session 19 1111-92-208 **Filipe Martins*** (philip_m90@hotmail.com), **Jim Cushing**, **Alberto Adrego Pinto** and **Amy Veprauskas**. *A Bifurcation Theorem for evolutionary matrix models with multiple evolutionary traits.*

One fundamental question in biology is population extinction and persistance, i.e., stability or instability of the extinction equilibrium and of non-extinction equilibria. A bifurcation theorem answers this question for the case of a primitive projection matrix, showing the existence of a bifurcating branch of positive equilibria, bifurcating from the extinction equilibrium when the inherent population growth rate passes through 1, and characterizing its stability, which is determined by the direction of the bifurcation. In this paper we consider an evolutionary game theoretic version of this model so that we include the dynamics of a vector of phenotypic traits, with possible correlations between them, that possess an heritable component that is subject to natural selection, and we establish a fundamental bifurcation theorem to this evolutionary model. (Received February 02, 2015)

Session 37 1111-92-238 **Ana R Carvalho***, Rua do Campo Alegre s/n, 4440-452 Porto, Portugal, and **Carla M Pinto**, Rua Dr António Bernardino de Almeida, 431, 4200-072 Porto, Portugal. *Effects of treatment, awareness and condom use in a coinfection model for HIV and HCV in MSM.*

We develop a new a coinfection model for hepatitis C virus (HCV) and the human immunodefficiency virus (HIV).We consider treatment for both diseases, screening, unawareness and awareness of HIV infection, and the use of condom. We study the local stability of the disease-free equilibria for the full model and for the two submodels (HCV only and HIV only submodels). We sketch bifurcation diagrams for different parameters, such as the probabilities that a contact will result in a HIV or an HCV infection. We present numerical simulations of the full model where the HIV, HCV and double endemic equilibria can be observed. We also show numerically the qualitative changes of the dynamical behavior of the full model for variation of relevant parameters. We extrapolate the results from the model for actual measures that could be implemented in order to reduce the number of infected individuals. (Received February 03, 2015)

Session 37 1111-92-281 **Nicolas Bacaer*** (`nicolas.bacaer@ird.fr`). *A stochastic epidemic model in a periodic environment.*

The stochastic SIS epidemic model is studied when the environment is periodic in time. The mean time to extinction grows exponentially in the supercritical case, the growth rate being linked to a time-periodic Hamilton-Jacobi equation. Approximate formulas for the growth rate can be obtained using methods developed in the physics literature. (Received February 04, 2015)

Session 37 1111-92-301 **Helio Schechtman*** (`h.schechtman@fiocruz.br`), Programa de Computação Científica, Fundação Oswaldo Cruz, Avenida Brasil 4365, Residência Oficial, Rio de Janeiro, RJ 21040-900, Brazil, and **Daniel Villela** and **Max O Souza**. *Stage-Structured Model for Aedes Aegypti and Wolbachia Interaction.*

We describe the population dynamics of *Aedes aegypti*, the main vector for Dengue, using a density-dependent model comprising five stages, *i.e.* eggs, larvae, pupae, non-parous, and parous winged mosquitos. *Wolbachia*-transinfected mosquitoes, which might be impervious to the Dengue virus, were considered to be less fit, *i.e.* produced less off-springs and were more prone to death.

Interaction between *Wolbachia*-infected and non-infected mosquitoes was considered to comprise full cytoplasmic incompatibility and vertical transmission of the bacteria. Oviposition was modelled as a result of random non-preferential mating, under a 1:1 sex ratio, in large homogeneous populations.

The model ODE's and its computational implementation are flexible enough to allow testing of various strategies for introducing *Wolbachia*-transinfected mosquitoes, such as releases of eggs or parous adults.

Results predict invasion by *Wolbachia*-infected mosquitoes for single and 52 consecutive weekly releases. Albeit, with largely different numbers of released individuals and time delays. (Received February 08, 2015)

Session 37 1111-92-322 **Flávio Codeço Coelho***, praia de Botafogo, 190, Rio de Janeiro, RJ 22250900, Brazil, and **L M Carvalho**. *Estimating the Attack Ratio of Dengue Epidemics under Time-varying Force of Infection using Aggregated Notification Data.*

Quantifying the attack ratio of disease is key to epidemiological inference and Public Health planning. For multi-serotype pathogens, however, different levels of serotype-specific immunity make it difficult to assess the population at risk. In this paper we propose a Bayesian method for estimation of the attack ratio of an epidemic and the initial fraction of susceptibles using aggregated incidence data. We derive the probability distribution of the effective reproductive number, R_t, and use MCMC to obtain posterior distributions of the parameters of a single-strain SIR transmission model with time-varying force of infection. Our method is showcased in a data set consisting of 18 years of dengue incidence in the city of Rio de Janeiro, Brazil. We demonstrate that it is possible to learn about the initial fraction of susceptibles and the attack ratio even in the absence of serotype specific data. On the other hand, the information provided by this approach is limited, stressing the need for detailed serological surveys to characterise the distribution of serotype-specific immunity in the population. (Received February 05, 2015)

Session 37

1111-92-388 **Daniel Villela*** (dvillela@fiocruz.br). *Mathematical Model of Imperfect Testing of Individuals for Infectious Diseases.*

Testing symptomatic individuals for a disease can deliver treatment resources, if tests' results turn positive, which speeds up their treatment and might also decrease individuals' contacts to other ones. An imperfect test, however, might incorrectly consider susceptible individuals to be infected (false positives). In this case, testing reduces the epidemic in the expense of potentially misclassifying individuals. We present a mathematical model (ODE system) that describes the dynamics of an infectious disease and its testing. Susceptible individuals turn to "susceptible but deemed infected" at rate θ. Infected individuals go to a state "infected and tested positive" at rate α. Both rates are functions of test's sensitivity and specificity. Analysis of the model permits us to derive an expression for R_0 and to find the conditions for reaching $R_0 < 1$, i.e., when the disease–free equilibrium is stable. We find that under certain conditions it is possible to get $R_0 < 1$, when originally, i.e., without testing, we would have $R_0 > 1$. We also present numerical results to cover interesting scenarios such as using different tests and to compare these results. (Received February 06, 2015)

Session 37

1111-92-399 **Claudia Torres Codeço*** (codeco@fiocruz.br), Avenida Brasil, 4365 Manguinhos, Programa de Computação Científica, Fiocruz, Rio de Janeiro, RJ 21040900, Brazil. *Mathematical models for dengue nowcasting.*

In the last decade, the application of mathematical epidemiology theory to guide public health interventions has increased considerably. In these applications, the estimation of the basic reproductive number, R0, or its time-varying counterpart, Rt, is almost aways a requirement. R0 is the expected number of cases generated by a primary case in a susceptible population and its precise estimation is important to issue alerts and to choose between optimal strategies. Many methods, derived from epidemic models, have been proposed to estimate R0 and Rt from case counts for directly transmitted diseases, as SARS, and influenza. For vectorborne diseases, the theory is much less developed. In this talk, I address the problem of continuously estimating dengue reproductive number from case notification data. The context is Rio de Janeiro, Brazil, where a real time outbreak warning system (info.dengue.mat.br) was implemented to guide public health policies. Estimation uncertainty is investigated, specially considering the problems posed by 1) the delay in case notification; 2) the shape of the generation time distribution and; 3) dependence on environmental variables. I conclude with some considerations regarding modeling challenges for dengue nowcasting. (Received February 06, 2015)

Session 37

1111-92-605 **Paulo Doutor*** (pjd@fct.unl.pt), **Paula Rodrigues**, **Fábio Chalub** and **Maria do Céu Soares**. *Vaccination in seasonal epidemics with temporary immunity: optimal strategy and rational behavior.*

For a SIR model with temporary immunity and time dependent transmission rate it is natural to also assume time dependent vaccination. We define two types of vaccination strategies:

- the optimal vaccination strategy in the sense that it minimizes the effort of vaccination in the set of preventive vaccination strategies, defined as vaccination strategies for which, for any sufficiently small initial condition, the number of infectious individuals monotonically decreases;
- voluntary vaccination, where individuals choose to be or not vaccinated upon the risk of vaccination versus the risk of the disease. This is a game theory formulation and we were able to define a Nash equilibrium vaccination strategy such that all individuals behave in a rational manner.

We were able to show the existence of both an optimal and Nash strategies in a general setting. In general, these strategies will not be functions but Radon measures. For specific forms of the transmission rate, we provide explicit formulas for the optimal and the Nash vaccination functions. (Received February 09, 2015)

Session 10

1111-92-627 **John A Mackenzie*** (j.a.mackenzie@strath.ac.uk), Department of Mathematics and Statistics, University of Strathclyde, 26 Richmond St, Glasgow, G1 1XH, United Kingdom, and **K Broadfoot**. *A growth-fragmentation model of the branching mechanism in the filamentous bacteria Streptomyces coelicolor.* Preliminary report.

Streptomyces coelicolor is a soil-dwelling Gram-positive bacterium which is used to produce the majority of antibiotics applied in human and veterinary medicine and agriculture, as well as anti-parasitic agents, herbicides, pharmacologically active metabolites (e.g. immuno-suppressants) and several enzymes important in the food and other industries. Early in the life cycle of Steptomyces coelicolor the bacteria forms a mycelium of branching hyphae. Little however is know about the regulation of the branching process. Recent experimental evidence however has indicated that oligomers of the essential protein DivIVA locate at hyphal tips and that new branches are generated by a novel oligomer splitting mechanism. Interestingly, a simpliar process has also been observed for hyphal branching in the fungus Neurospora crassa. In this talk I will present a growth-fragmentation mathematical model for the growth and binary fragmentation of a population of developing DivIVA oligomers. Numerical simulations of the model will be presented which indicate that distribution of oligomers evolves towards a state with a separable structure with an exponential growth in the number of foci and a steady state distribution of foci sizes throughout the mycelium. (Received February 09, 2015)

Session 37 1111-92-724 **Nicholas F. Britton*** (n.f.britton@bath.ac.uk). *Controlling infectious disease in a structured population.* Preliminary report.

We investigate the problem of controlling an infectious disease in a recently infected population with a household structure. The distribution of the exposed and infectious periods of the disease is taken into account, as well as the size distribution of the households. (Received February 10, 2015)

Contr.Session 1111-92-768 **Abderrahman Iggidr**, **Gautheir Sallet** and **Max Souza*** (maxsouza@id.uff.br). *Vector-borne disease dynamics with host circulation.*

We study the dynamics for a class of multi-group models for vector-borne diseases that can be obtained, in an appropriate limit, from more general meta-population models that accounts for host circulation. In this model, the movement network topology gives rise to a contact network topology, corresponding to a bipartite graph. Under the assumption that the contact network is strongly connected, we can define a basic reproductive number R_0 and show that this system has at most two equilibria: the disease-free equilibrium (DFE) which always exist, and a unique endemic equilibrium (EE) that exists if, and only if, $R_0 > 1|$. When $R_0 \leq 1$, the DFE is globally asymptotically stable (GAS), while if $R_0 > 1$ the EE is GAS. (Received February 10, 2015)

93 ► Systems theory; control

Session 37 1111-93-246 **Abderrahman Iggidr*** (abderrahman.iggidr@inria.fr), Inria, IECL University of Lorraine, and CNRS, ISGMP, Bat. A, Ile du Saulcy, 57045 Metz, France, and **Max Souza** (maxsouza@id.uff.br), Niteroi, RJ , Brazil. *On the estimation of susceptible proportions in a dengue epidemic system.*

The classical Dietz-Bailey (The Mathematical Theory of Infectious Diseases and its Applications, 1975) model that describes the evolution of dengue infection is a SIR for humans and SI for vectors (mosquitos). Using proportions and multi-scaling techniques, a simpler model has been recently derived by M. Souza (Multiscale analysis for a vector-borne epidemic model, JMB 2014). Using this multi-scaled dengue system, we construct a simple observer to estimate the dynamics of the disease. The nature of both the observer and the multi-scaled system allows to estimate both the proportion of susceptible and recovered hosts, as well as to provide information on the vector population, using only infected population data. We compare our observer with the classical High-Gain observer. We apply this observer using data of the city of Rio de Janeiro (from 2000 to 2008) to dynamically estimate the proportion of susceptible during this period. (Received February 03, 2015)

Session 21

1111-93-438 **Manuel D Ortigueira*** (mdo@fct.unl.pt), Campus da FCT, Quinta da Torre, 2829-516 Caparica, Portugal, **Delfim FM Torres**, Aveiro, Portugal, **Margarita Rivero**, La Laguna, Spain, and **Juan J Trujillo**, La Laguna, Spain. *Exponentials and transforms on regular time scales.*

The two derivatives - nabla and delta - have the so-called nabla and delta exponentials as eigenfunctions. With these exponentials two generalised discrete-time Laplace transforms are deduced and their properties studied. These transforms are back compatible with the current Laplace and Z transforms. They are used to study the discrete-time linear differential equations. These equations mimmic the usual continuous-time equations that are uniformly approximated when the jump interval becomes small. Green function and transfer function notions are introduced and obtained. This implies a unified mathematical framework that allows us to approximate the classic continuous-time case when the sampling rate is high or obtain the current discrete-time case based on difference equation when the jump becomes constant. (Received February 08, 2015)

97 ► Mathematics education

Session 39

1111-97-250 **Carlota Simões*** (carlota@mat.uc.pt) and **Carlos Santos**. *Camoens, Ovid and Mathematics.*

The Lusiads, the Portuguese epic poem by Camoens, published in 1572, describes the discovery of a sea route to India by Vasco da Gama. The 16th century is well known for the flourishing of Renaissance, which included an obsessive use of the divine proportion. It is possible that Camoens used the golden ratio in his masterpiece?

Aphrodite (or Venus) was the chosen one to receive the Golden Apple of Discord from Paris, episode that led to the Trojan War. Strangely enough, this apple allows one to relate Venus the goddess to Venus the planet, if, in the way, we search for the pentagram shape.

In Ovid's Metamorphoses we learn the myth of Callisto, condemned to stay in the heaven and not dip in the pure waters of the ocean. Indeed, in Ovid's time, the constellations Ursa Minor and Ursa Major were above the sea in all northern places above latitude 30^oN, which includes Ovid's Rome. But the precession of the equinoxes will give an end to Callisto's curse, and we will calculate when.

In this talk we propose to give a mathematical look into a few literature classics, enlightened with multimedia models. (Received February 03, 2015)

Contr.Session

1111-97-766 **Maria-da-Graça Marques*** (gmarques@ualg.pt) and **Marília Pires** (mpires@ualg.pt). *Elementary functions can become art.*

In this talk we want to show how elementary functions can be used to create some kind of art and how this can be a good pedagogical approach for teaching.

In fact, during basic and secondary education, a lot of work is done concerning the study of real functions of real variable and its graphs. Much time is devoted to the study of lines, parabolas and sinusoidal curves including the variations occurring in their graphs when some coefficients in the function expression are changed. Geometric transformations (reflections, translations and homotheties and their compositions) are also deeply studied. Very often, students don't understand the purpose of studying all these topics with detail and it is difficult to motivate them.

Using function graphs to create cartoon images – which it is possible to do using appropriate dynamic geometry software – can be a good motivation for students and can be a good introduction to the understanding of what mathematic modelling is.

We present some mathematic models for cartoons of objects or animals, in a static or animated form, using function graphs and geometric transformations. We show how this modeling requires mobilizing expertise in several math topics and promotes the acquisition of skills in a playful way. (Received February 10, 2015)