
# Book

**of**

# Abstracts

Organized by

**Faculty of Mathematics and Computer Science, University of Bucharest**

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## Brief History

In 1864, the year when the University of Bucharest was founded, the Faculty of Sciences - founded itself in 1863 - represented one of the three faculties composing the University of Bucharest and since 1866 it split into two departments, namely the Department of Physical and Mathematical Sciences and the Department of Physical and Natural Sciences, respectively. The former department became itself an autonomous faculty, i.e. the Faculty of Mathematics and Physics, in 1948, whilst in 1961 it split again into two faculties, namely the Faculty of Mathematics and Mechanics and the Faculty of Physics. In the period of time 1974-2001, the Faculty of Mathematics and Mechanics was known as the Faculty of Mathematics and finally renamed as the Faculty of Mathematics and Computer Science in 2001.

A first landmark in the history of the Faculty of Mathematics and Computer Science was represented by the employment of Spiru Haret, David Emmanuel, Constantin Gogu and Nicolae Coculescu as professors of the faculty, all of them after having been awarded a PhD in mathematics in Paris, France, and hence being the first Romanian mathematicians in this position. Apart from David Emmanuel, whose PhD thesis was devoted to Abelian integrals of the third kind, the aforementioned professors dealt, in their theses, with celestial mechanics problems. Spiru Haret was not only a brilliant professor of Rational Mechanics, but also, most likely, the most important Romanian Minister of Education, at the same time being the truly reformist of the Romanian educational system through the law promoted in 1898. David Emmanuel was also considerd by prominent Romanian mathematicians, such as Ţiţeica, Lalescu, Stoilow etc, as their mentor.

The next stage of the evolution of mathematics in Bucharest, which can be named as the recognition stage, belongs to the great creators who, after completing their PhD in Paris, mostly with distinction, returned to Bucharest in order to achieve impressive scientific and academic works. With respect to the aforementioned stage, it is worth mentioning Gheorghe Ţiţeica, Dimitrie Pompeiu and Traian Lalescu as outstanding personalities of the Faculty in the first four decades of the twentieth, followed by Victor Vâlcovici and Octav Onicescu. A remarkable moment in the history of our faculty is given by the appointment by the Faculty of Mathematics of renowned professors previously affiliated with the University of Cernăuţi (Simion Stoilow, Gheorghe

Vrânceanu, Miron Nicolescu), the University of Iaşi (Grigore C. Moisil) or the University of Cluj (Caius Iacob). This clearly represented, for the following years, a turning point in the modernization of mathematical higher education at the University of Bucharest. Also, other professors, such as Alexandru Ghika, Dan Barbilian, Gheorghe Mihoc, Nicolae Teodorescu, Alexandru Froda, Călin Popoviciu and Ştefan Gheorghiţă, joined the previously mentioned ones in their effort. With respect to the last period of time, one should mention, as active participants in the modernization of the mathematical higher education and research, Professors Gheorghe Marinescu, Martin Jurchescu, Nicolae Radu, Aristide Halanay, Dragoş Lazăr, Costache Teleman, Eugen Sóos. There are numerous mathematicians who sadly passed away, lived in the twentieth century and brought important contributions to the development of our faculty, as well as mathematics in Romania, and whose photographs are displayed on the corridor inside the Deans Office.

# 1. Algebra and Number Theory

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## From the irrationality of sums of radicals to a standard undergraduate algebra exercise, and then, to some evocations

***Toma Albu***

First, we discuss some older and newer facts as well as open questions on transcendental and irrational numbers. After that, by using the form of primitive elements of G-Cogalois field extensions, we present a three-line proof of a nice folklore result establishing when is an irrational number a sum of radicals of positive rational numbers. Further, we relate this result with a standard undergraduate algebra exercise concerning the effective calculation of the degree of the algebraic number field obtained by adjoining such radicals to the field of rational numbers. Finally, we evoke some of our professors and colleagues from the faculty that have been mentioned in the presented results.

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## On $p$-adic analytic continuation with applications to generating elements

***Victor Alexandru, Marian Vâjâitu, Alexandru Zaharescu***

Given a prime number $p$ and the Galois orbit $O(T)$ of an integral transcendental element $T$ of $\mathbb{C}_p$, the topological completion of the algebraic closure of the field of $p$-adic numbers, we study the $p$-adic analytic continuation around $O(T)$ of functions defined by limits of sequences of restricted power series with $p$-adic integer coefficients. We are also interested in applications to generating elements for $\mathbb{C}_p$ or for some classes of closed subfields of $\mathbb{C}_p$.

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## Reciprocity laws for Legendre symbols of the type $(a+b\sqrt{m}|p)$

***Constantin N. Beli***

If $p$ is a prime $a, b, m$ are integers such that $(m|p) = (a^2 - b^2 m|p) = 1$ then one can define the Legendre symbol $(a + b\sqrt{m}|p) := (a + b\alpha|p)$, where $\alpha$ is a solution of the congruence equation $X^2 \equiv m \pmod{p}$.

A partiicular case of such Legendre symbol is the so called rational quartic or biquadratic simbol, $(m|p)_4 := (\sqrt{m}|p)$, which is defined when $(m|p) = (-1|p) = 1$. Various mathematicians, such as Gauss, Dirichlet, Burde, Scholz, E. Lehmer, Lemmermeyer etc., have obtained results involving the symbol $(m|p)_4$. These are called *rational quartic reciprocity laws.*

In the present paper we give a very general result involving the symbols $(a+b\sqrt{m}|p)$, from which almost all previous reciprocity laws can be deduced.

We give some examples of how older results can be recovered from our main theorem and we give some hints about the proof.

Our result is the case $F = \mathbb{Q}$ of a more general theorem that holds for every number field $F$. It was discovered as a consequence of some results from the theory of spinor genera of quadratic forms. However there is an independent proof using the Brauer group $\mathrm{Br}(F)$ and the exact sequence

$$0 \to \mathrm{Br}(F) \to \bigoplus_{\mathfrak{p} \in \Omega_F} \mathrm{Br}(F_{\mathfrak{p}}) \to \mathbb{Q}/\mathbb{Z} \to 0.$$

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## Prime numbers and irreducible polynomials

***Nicolae Ciprian Bonciocat***

We present several methods to construct irreducible polynomials by using prime numbers. The famous irreducibility criteria of Schönemann-Eisenstein and Dumas rely on information on the divisibility of the coefficients of a polynomial by a single prime number. The first method that we will present relies on the study of the canonical decomposition of the coefficients, and provides Schönemann-Eisenstein-Dumas type irreducibility criteria that are given by some divisibility conditions with respect to arbitrarily many prime numbers. The second method relies on the study of

the canonical decomposition of the values that a given polynomial takes at some specified arguments. The third method that we will present relies on the study of the canonical decomposition of the resultant of two polynomials, and provides irreducibility criteria for pairs of polynomials. The fourth method provides irreducibility criteria for linear combinations of relatively prime polynomials, for compositions of polynomials, and for multiplicative convolutions of polynomials. We will also provide analogous results for multivariate polynomials over arbitrary fields.

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## On the Grothendieck ring structure of the quantum double of a fusion category

***Sebastian Burciu***

In this talk we study Grothendieck's rings of certain equivariantized fusion categories. We show that the Grothendieck ring of the quantum double of a fusion category has the structure of a certain class of Green rings obtained by Dress constructions. These rings were introduced independently by Witherspoon and Bouc. The Hochschild cohomology ring, the (crossed) Burnside ring and the Grothendieck rings of co-central abelian extensions are already known examples of rings with such structures.

In order to obtain this structure first we give a new classification of all simple objects of equivariantizations under some special group actions (called coherent) on graded fusion categories. With this description we write down the fusion rules of such equivariantizations using results from the joint work with S. Natale "Fusion rules of equivariantizations of fusion categories" J. Math. Phys.54, 013511 (2013). We also show that group actions on fusion categories give rise to new Green functors.

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## $D(n)$-$m$-sets

***Mihai Cipu***

One of the oldest problems still stirring interest among number theorists originates with Diophantus of Alexandria. In the third century he presented

triples of rational numbers with the property that adding 1 to the product of any two of them results in a perfect square. Later on, Fermat and Euler found quadruples of integers having the same property. In the present terminology, for specified commutative ring $R$ and integer $n$, a set consisting of elements $a_1,\ a_2, \ldots, a_m$ of $R$ such that for any $1 \leq i < j \leq m$ one has $a_i a_j + n = x_{ij}^2$ for some $x_{ij} \in R$ is called $D(n)$-$m$-set in $R$.

The talk will focus on the question of existence of such objects. We shall examine what properties of $n$ ensure or prevent the existence of $D(n)$-$m$-sets. We shall present answers to several basic questions: For fixed $n$, how large can $m$ be? How many sets of maximal cardinality are there? Are there bounds on the relative or absolute size of elements of $D(n)$-$m$-sets? Can the $a_i$ be selected from the terms of some "interesting" (familiar, famous) sequence? Connections with several classes of Diophantine equations and a few open problems in other areas of number theory are pointed out. Time permitting, variations on the original theme will be indicated.

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## Primes in arithmetic geometry

***Alina C. Cojocaru***

Many remarkable classical questions about prime numbers have natural analogues in the context of elliptic curves. We will give a brief introduction to the theory of elliptic curves and discuss how "higher dimensional" analogues of open questions about prime numbers appear naturally in the study of the reductions of an elliptic curve. In particular, we will discuss progress towards the resolution of the Lang-Trotter Conjectures from the 1970s and the Koblitz Conjecture from the 1980s. We will also broaden our perspective to include analogues of these questions arising in the theory of abelian varieties and of Drinfeld modules.

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## Frobenius algebras of corepresentations: gradings

***Sorin Dăscălescu, Constantin Năstăsescu, Laura Năstăsescu***

We consider Frobenius algebras in the monoidal category of right comodules over a Hopf algebra $H$. If $H$ is a group Hopf algebra, we study a

more general Frobenius type property and uncover the structure of graded Frobenius algebras. Graded symmetric algebras are also investigated.

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## On Higher Moments of Quadratic Dirichlet L-Functions

***Adrian Diaconu***

In this talk we give a cohomological description of the "p-parts" of the multiple Dirichlet series attached to moments of quadratic L-series over a number field. We expect that the Eisenstein Conjecture of Bump, Brubaker and Friedberg extends to the relevant Kac-Moody groups in our situation, and that the multiple Dirichlet series we contruct occurs (perhaps, up to a normalization) in a Fourier-Whittaker coefficient of a (Kac-Moody) Eisenstein series.

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## Schreier type conditions in integral domains

***Tiberiu Dumitrescu***

As defined by P.M Cohn, an integral domain $D$ is called a Schreier domain if $D$ is integrally closed and every intersection of two principal ideals of $D$ is a directed union of principal ideals.The talk will give a survey on several extensions of this concept.

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## Binomial edge ideals

***Viviana Ene***

In this talk we discuss about binomial ideals arising from graphs. Given a simple graph $G$ on the vertex set $[n]$, one may associate with it a binomial ideal $J_G$ in the polynomial ring $K[X]$ over a field $K$, where $X = \begin{pmatrix} x_1 & x_2 & \dots & x_n \\ y_1 & y_2 & \dots & y_n \end{pmatrix}$. $J_G$ is generated by maximal minors of $X$, $f_{ij} = x_iy_j - x_jy_i$ with $\{i,j\}$ edge of $G$, and is called the *binomial edge ideal* of $G$. Later on, the notion of binomial edge ideal was generalized to a pair of graphs. The interest in studying (generalized) binomial edge ideals partially comes from the fact that they turned out to have applications in statistics. In our talk, we are going to discuss various algebraic and homological properties of binomial edge ideals. We mainly focus on some recent results obtained in joint papers with J. Herzog, T. Hibi, F. Mohammadi, A. Qureshi, A. Zarojanu.

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## Some interesting numbers

***Alexandru Gica***

The aim of this talk is to present a survey on the following problem: which are the positive integers $n$ such that $\omega(n+x^2) \leq 2$ for any odd integer $x$ such that $x^2 \leq n$? As usual, $\omega(m)$ counts the distinct prime divisors of the positive integer $m$. I was able to solve almost completely the problem in the case when $n$ is a prime number. The main idea of the proof is the computation of the class number for the quadratic imaginary field $\mathbb{Q}(i\sqrt{n})$. The only case which is not completely solved is $n \equiv 7 \pmod 8$. In this case we proved that besides the numbers 7, 23, 31, 47, 79, 103, 127, 151, 223, 463, 487, 823, 1087, 1423 there is at most one number. When droping the condition that $n$ is a prime number, the problem is much harder and it is still work in progress.

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## An open problem in Commutative Algebra

***Cristodor Ionescu***

The Evolution Problem is one of the most exciting open problems in Commutative Algebra. It appeared during the efforts of Wiles to prove Fermat's Last Theorem. The theorem was proved but the problem remained open. It was revigorated some years later by a paper of Eisenbud and Mazur. We shall present the problem, several formulations of it, what is known and what is not known.

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## The Glauberman correspondence and graded equivalences

***Andrei Marcus***

In this talk we discuss the existence of graded Morita equivalences over small fields 'lying above' the Glauberman-Watanabe correspondence. Let $\mathcal{K}$ be a finite extension of the field $\mathbb{Q}_p$ of $p$-adic numbers, and let $\mathcal{O}$ be the ring of integers in $\mathcal{K}$. Let $S$ be a solvable group acting of the finite group $N$, and let $C := C_N(S)$. Assume that the orders $|N|$ and $|S|$ are coprime. Let $b$ be an $S$-stable block of $\mathcal{O}N$ with defect group $P \subseteq C_N(S)$. Denote by $c$ the block of $\mathcal{O}N$ corresponding to $b$ via the Glauberman-Watanabe correspondence. Assume that that the semidirect product $SN$ is a normal subgroup of a finite group $H$. Let $G = H/N \simeq N_H(S)/C_N(S)$. Then we show that if $S$ is a $p$-group, then there is a $G$-graded Morita equivalence between $\mathcal{O}Hb$ and $\mathcal{O}N_H(S)c$.

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## Pseudosymmetric braided categories

***Florin Panaite***

A twine (respectively a strong twine) on a monoidal category is a family of natural isomorphisms on the category satisfying certain axioms. If $c$ is a braiding on the category, the double braiding $c^2$ is always a twine. If $c^2$ is a strong twine, then $c$ is called *pseudosymmetric*; this boils down to the fact that $c$ satisfies a sort of modified braid relation. Every symmetric braiding is pseudosymmetric. A quasitriangular structure on a Hopf

algebra is called *pseudotriangular* if it satisfies a sort of modified quantum Yang-Baxter equation; every triangular structure is pseudotriangular. We will discuss various examples of pseudosymmetric braidings and pseudotriangular structures. We define a certain group, called the *pseudosymmetric group*, denoted by $PS_n$, that plays for pseudosymmetric braidings the same role played by the braid group (respectively symmetric group) for braidings (respectively symmetric braidings). It turns out that $PS_n$ is isomorphic to the quotient of the braid group $B_n$ by the commutator subgroup $[P_n, P_n]$ of the pure braid group $P_n$.
(joint work with Mihai D. Staic and Fred Van Oystaeyen).

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## The arithmetic of special values

***Cristian D. Popescu***

The well-known analytic class number formula, linking the special value at $s = 0$ of the Dedekind zeta function of a number field to its class number and regulator, has been the foundation and prototype for the highly conjectural theory of special values of $L$–functions for close to two centuries. We will discuss certain generalizations of the class number formula to the context of equivariant Artin $L$–functions which capture refinements of the Brumer-Stark and Coates-Sinnott conjectures. These generalizations relate various algebraic-geometric invariants associated to a global field, e.g. its Quillen $K$–groups and étale cohomology groups, to various special values of its Galois-equivariant $L$–functions. This is based on joint work with Greither, Banaszak and Dodge.

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## Around Stanley's Conjecture on monomial ideals

***Dorin Popescu***

Let $K$ be a field, $S = K[x_1, \ldots, x_n]$ be the polynomial algebra in $n$ variables over $K$ and $I \subset J$ two square free monomial ideals of $S$. Assume that $I$ is generated by square free monomials of degrees $\geq d$, for some $d \in \mathbf{N}$, $d \geq 1$. We may suppose that either $J = 0$, or $J$ is generated in degrees $\geq d + 1$ after a multigraded isomorphism. After Herzog, Vladoiu,

Zheng $\text{depth}_S I/J \geq d$. Let $P_{I/J}$ be the poset of all square free monomials of $I \setminus J$ (a finite set) with the order given by the divisibility. Let $P$ be a partition of $P_{I/J}$ in intervals $[u, v] = \{w \in P_{I/J} : u \leq w \leq v\}$, let us say $P_{I/J} = \cup_i [u_i, v_i]$, the union being disjoint.

Define sdepth $P = \min_i \deg v_i$. The *Stanley depth* of $I/J$ is given by $\text{sdepth}_S I/J = \max_P \text{sdepth } P$, where $P$ runs over the set of all partitions of $P_{I \setminus J}$. *Stanley's Conjecture* says that $\text{sdepth}_S I/J \geq \text{depth}_S I/J$. Many people believe that this conjecture holds and tried to prove directly some of its consequences. For example in this way a lower bound of depth given by Lyubeznik was extended by Herzog, myself and Vladoiu for sdepth. Some numerical upper bounds of sdepth give also upper bounds of depth as we proved directly, and Shen showed in a more general form one month later.

If $\text{sdepth}_S I/J = d$ then we proved that $\text{depth}_S I/J = d$ too, and recently we showed together with A. Zarojanu that $\text{sdepth}_S I/J = d + 1$ implies in some cases $\text{depth}_S I/J \leq d+1$, which means that Stanley's Conjecture holds in these cases.

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## Positiveness bounds for real roots of polynomials

***Doru Ştefănescu***

The computation of the real roots of univariate polynomials with real coefficients is done using several algorithmic devices. Many of them are based on the isolation of the real roots, i.e. the computation of a finite number of intervals with the property that each of them contains exactly one root. One of the steps is that of cumputing bounds for the roots. This can be realized using classical bounds for the absolute values of complex roots. However there exist bounds specific to real roots, for example those of Lagrange, Kioustelidis, Hong and Ştefănescu.

We construct new bounds for positive roots of polynomials and give a method for obtaining bounds of absolute positivenes. We obtain a device for computing absolute positiveness bounds for the real roots. The method is based on an improvement of the results of D. Ştefănescu on upper bounds for positive roots. Our results allow the computation of absolute values for real and complex roots of polynomials in one indeterminate with complex coefficients.

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# 2. Mathematical Analysis

Organizer:

*Lucian Beznea:* e-mail: Lucian.Beznea@imar.ro

## Continued fractions, Farey fractions, and ergodic theory

***Florin Boca***

This talk will discuss some connections between continued fractions, Farey fractions, and ergodic properties of the geodesic and horocycle flows on the unit tangent bundle of the modular surface.

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## Boundary behavior of mappings satisfying inverse modular inequalities

***Mihai Cristea***

We study the geometric properties of the mappings for which generalized inverse modular inequalities hold. We extend in this way known theorems from the theory of analytic mappings and the theory of quasiregular mappings, like the theorems of Fatou, Riesz, and Beurling and their generalizations given for quasiregular mappings by Martio, Rickman, and Vuorinen.

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## Weak solutions for a degenerate elliptic Dirichlet problem

***Aurelian Gheondea***

Abstract: We formulate a Dirichlet problem for a degenerate elliptic partial differential operator and, using the formalism of triplets of closely embedded Hilbert spaces, we calculate the underlying spaces. Using an abstract theorem for these generalized triplets, we prove the existence of weak solutions for the Dirichlet problem.

This talk reports research carried in collaboration with P. Cojuhari.

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## Billiard models in the plane

***Radu Gologan***

We present a review of the results obtained on the last decade by F. Boca, A. Zaharescu, and the speaker, on the Lorenz model on the two-dimensional torus, together with some non-solved problems on the matter.

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## Non existence of real Levi flat hypersurfaces in the complex projective space

***Andrei Iordan***

A classical theorem of Poincaré-Bendixson states that every leaf of a foliation of the real projective plane accumulates on a compact leaf or on a singularity of the foliation. As a holomorphic foliation $\mathcal{F}$ of codimension 1 of the $n$-dimensional complex projective space $\mathbb{CP}_n$, $n \geqslant 2$, does not contain any compact leaf and its singular set $Sing\ \mathcal{F}$ is not empty, a major problem in foliation theory is the following: can $\mathcal{F}$ contain a leaf $F$ such that $\overline{F} \cap Sing\ \mathcal{F} = \emptyset$? If this is the case, then there exists a nonempty compact set $K$ called exceptional minimal, invariant by $\mathcal{F}$ and minimal for the inclusion such that $K \cap Sing\ \mathcal{F} = \emptyset$.

For $n \geqslant 3$, the non existence of an exceptional minimal for holomorphic foliations of codimension 1 of $\mathbb{CP}_n$ was proved in 1999 by A. Lins Neto, but the problem is still open for $n = 2$.

In 1993 D. Cerveau proved a dichotomy which showed that the existence of an exceptional minimal for a holomorphic foliation of codimension 1 of $\mathbb{CP}_n$ is strongly related to the existence of a real analytic Levi flat hypersurface in $\mathbb{CP}_n$. This gave rise to the conjecture of the non-existence of smooth Levi flat hypersurfaces in $\mathbb{CP}_n$, $n \geqslant 2$.

In this talk we will give a survey of the known results in dimension $\geq 3$ related to the conjecture of the non existence of a smooth or real analytic

Levi flat hypersurface in the complex projective plane.

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## Dispersion estimates for the wave equation in domains

***Oana Ivanovici***

Rezumat: In recent years, following results on dispersive estimates for low regularity metrics, substantial progress has been made on dispersive estimates for the wave and Schrodinger equations on domains. Here we report on recent work to obtain a sharp dispersion estimate. For this, we rely on a precise description of the wave front (or the pseudo-spheres, e.g. surfaces reached by light emanating from a point after a fixed amount of time) and on a suitable microlocal parametrix construction near the boundary, for the wave equation inside strictly convex domains, subject to Dirichlet boundary condition. Such a parametrix allows to follow wave packets propagating along the boundary with a large number of reflections. In the process, we encounter Fourier Integral Operators whose canonical forms correspond to cusp and swallowtail singularities, and which account for the loss (compared to the boundary less case) in dispersive estimates. This is joint work with Gilles Lebeau and Fabrice Planchon.

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## On the parametrization of germs of two-dimensional singularities

***Cezar Joiţa***

We give a complete characterization of germs of 2-dimensional complex singularities $(X, x_0)$, irreducible at $x_0$ for which there exist a surjective holomorphic map $f : (\mathbb{C}^2, 0) \to (X, x_0)$. This is joint work with Mihnea Colţoiu.

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## Higher order Calderón programs

***Camil Muscalu***

There is a very natural way to extend Calderón calculations, which generated his commutators and the Cauchy integral on Lipschitz curves, to include operators of multiplication with functions of arbitrary polynomial growth. The plan of the talk is to describe some examples of such calculations and to concentrate on a particular case which goes beyond the classical "Calderón Program".

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## Lagrange Through Time: A New Look at Old Themes

***Constantin P. Niculescu***

April 10, 2013 marked the 200th anniversary of the death of Joseph-Louis Lagrange, one of the most outstanding mathematicians and mechanicians of all times. The Mathematics Genealogy Project mentions that Lagrange has 75508 descendants (as of June 30, 2013). An impressive figure that increases every week and made us curious to get a closer look at his *Oeuvres.* The writings of Lagrange are not very easy to read, being far from the nowadays standards of rigor. However the alert reader is rewarded by the abundance of valuable ideas that can be found there. The old advice "Read the masters", proves once more its importance. Many of his ideas are still waiting to be continued! The present talk put his famous algebraic identity in a larger context that provides a direct link to convex functions theory. It is unlikely that such a generalization could appear at the end of eighteenth century but we should mention that all ingredients involved in our approach were perfectly known to Lagrange.

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## Regularity results for the eigenfunctions of the n-electron Scrhoedinger operator

***Victor Nistor***

I will present a global regularity result for the eigenfunctions of the n-electron Schroedinger operator. More precisely, let $(-\Delta + V)u = \lambda u$, with $u$ square integrable and $V$ of Coulomb type. Let $r$ be the distance to the singularities of $V$. Then $r^{|\alpha|}\partial^\alpha u$ is square integrable for all multi-indices $\alpha$. The fact that we obtain global results and that there are no restrictions on $\alpha$ allows us to obtain higher order approximation (numerical) methods for eigenfunctions. I will explain this in detail in a particular case of interest for Density Functional Theory. This is joint work with Catarina Carvalho and Bernd Ammann. Some extensions are joint work with Vladimir Georgescu.

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## Sofic groups and sofic actions

***Liviu Păunescu***

Sofic groups were introduced by Gromov in 1999. A group is sofic if it can be approximated in a certain sense by finite objects. Although no counter example is known, the sofic property of a group proved to be quite fruitful in various areas like geometric group theory, dynamical systems or operator algebras. A theorem by Elek and Szabo states that a group is amenable iff it has essentially only one sofic approximation. We shall see how we can improve on this result in order to prove that free product of sofic groups with amalgamation over amenable groups is again sofic.

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## A twisted pseudodifferential calculus associated to quantum systems with magnetic fields

***Viorel Iftimie, Radu Purice, Marius Măntoiu***

We present a twisted pseudodifferential calculus and the twisted Moyal algebra associated to it, that represent the natural gauge invariant formalism associated to the algebra of observables of a quantum system in a bounded smooth stationary magnetic field. Results of the type of the Calderon-Vaillancourt Theorem, Beals' Theorem and self-adjoint criteria are obtained for this calculus.

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## Recent advances in global polynomial optimization

***Mihai Putinar***

The last decade was marked by a remarkably simple and far reaching idea in polynomial optimization, known as Lasserre's relaxation method. The

lecture will be devoted to some theoretical details on the subject, derived from a functional analytic point of view. Several striking applications will also be mentioned.

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## Operator Algebra Representations of the Hecke Algebra associated to the Modular Group

***Florin Rădulescu***

Using representations of the modular group, and their matrix coefficients we construct new representations for the Hecke Algebra associated to the modular group. We derive various Number Theory consequences, e.g., Ramanujan-Petersson precise estimates for the essential spectrum of the Hecke operators on Maass forms.

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## Truncated moments and interpolation

***Florian Vasilescu***

The aim of this talk is to present a new approach to truncated moment problems, based on the use of the space of characters of some associated finite dimensional commutative Banach algebras.

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# 3. Geometry and Topology

Organizer:

*Liviu Ornea:* e-mail: lornea@gta.math.unibuc.ro

## An injectivity theorem

***Florin Ambro***

The injectivity theorem of Esnault and Viehweg is a powerful but little known statement which generalizes Kodaira vanishing. In this talk I shall present their result and a generalization, with applications to the combinatorial structure of Calabi-Yau log varieties and to the restriction of adjoint linear systems to inductive strata.

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## Ulrich bundles on K3 surfaces

***Marian Aprodu***

An Ulrich bundle is an algebraic vector bundle, on a complex $n$-dimensional projective manifold, that satisfies the same vanishing properties as the trivial bundle on the $n$-dimensional projective space. The existence of Ulrich bundles reflects well in the associated Chow form, for instance, the equation of a hypersurface with a rank-one, or a rank-two, Ulrich bundle is determinantal, respectively Pfaffian. We prove the existence of Ulrich bundles for K3 surfaces with a mild Brill-Noether property. The talk is based on a joint work with Gavril Farkas and Angela Ortega.

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## Seshadri positive submanifolds of polarized manifolds

***Lucian Bădescu***

Let $Y$ be a submanifold of dimension $y$ of a polarized complex manifold $(X, A)$ of dimension $k \geq 2$, with $1 \leq y \leq k-1$. We define and study two positivity conditions on $Y$ in $(X, A)$, called Seshadri A-bigness and (a stronger one) Seshadri A-ampleness. In this way we get the natural

generalization of the theory initiated by Paoletti in 1995 (which corresponds to the case $(k, y) = (3, 1)$) and subsequently generalized and completed in a joint paper with Beltrametti and Francia in 1997 (regarding curves in a polarized manifold of arbitrary dimension). The theory presented here, which is new even if $y = k - 1$, is motivated by a reasonably large area of examples.

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## Conformal geometry, projective curves and Hill's equation

***Florin Belgun***

We show that to a periodic immersion of $\mathbb{R}$ in a conformal manifold of dimension $n \geq 3$ one can associate in a canonical way a Hill's equation $x'' + Fx = 0$, with $F$ periodic, which is equivalent with a projective structure on the image of the immersion, independently of the parametrization. We show that all equivalence classes of projective structures on curves can be realized by such immersions. We also find examples of convex curves in the Euclidean plane that can realize a great part of these equivalence classes, some of them being non-homogeneous w.r.t. the projective automorphisms group.

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## A bimodule structure on the Križ model of a projective manifold

***Barbu Berceanu***

Hodge theory defines an $\mathfrak{sl}_2(\mathbb{C})$ structure on the cohomology algebra of a projective manifold $X$. We extend this action on the Križ model of the configuration space $F(X; n)$ of $n$ points on $X$. We study the relations between the $\mathfrak{sl}_2(\mathbb{C})$ action, the natural action of the symmetric group $S_n$ on the Križ model $E(X; n)$, and the differential of the model.

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## Vector bundles on non-Kaehler elliptic fibrations

***Vasile Brînzănescu***

We shall describe moduli spaces of semi-stable vector bundles on non-Kaehler elliptic surfaces and on elliptic principal bundles of arbitrary dimension. The main tools are a twisted Fourier-Mukai transform and spectral covers.

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## Degenerate elliptic systems on CR manifolds

***Sorin Dragomir***

We review several recent results on subelliptic harmonic maps (cf. E. Barletta et. al., L. Capogna & N. Garofalo) and their ramifications within the theory of $X$-elliptic equations (due to E. Lanconelli et al.) with an emphasis on the relationship to complex analysis in several complex variables (e.g. the theory of proper holomorphic maps, cf. H. Alexander, J. D'Angelo, J.J. Faran, S. Webster).

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## Some special Fano manifolds

***Paltin Ionescu***

We will present joint work with F. Russo on some remarkable examples of embedded Fano manifolds having high index or small codimension. This includes the classification problem of conic-connected, quadratic and defective manifolds, as well as special cases of the Hartshorne Conjecture. The key technique is to use the geometry of the lines contained in our given manifold.

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## Pencil type line arrangements of low degree and monodromy

***Anca Măcinic***

We give the complete list, up to lattice isomorphism, of $(3,3)$ and $(3,4)$ nets. New examples of pencil type line arrangements are provided.

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## Fundamental groups of complex algebraic varieties and singularity links

***Daniel Matei***

We will be concerned with the global and local topology of complex algebraic varieties. We will be particularly interested in the following two questions. Which groups appear as fundamental groups of quasi-projective varieties with mild singularities? Which topological spaces can be links of complex algebraic singularities?

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## The renormalized volume of odd-dimensional asymptotically hyperbolic Einstein manifolds

***Sergiu Moroianu***

This talk will present some joint results with Colin Guillarmou and Jean-Marc Schlenker on the moduli space of conformal structures on the ideal boundary $M$ of an asymptotically hyperbolic Einstein manifold $X$. The main feature is the existence of a "renormalized volume" functional on the space of Riemannian metrics on $M$, invariant under isotopies, which is maximized at metrics satisfying an uniformization condition on their curvature tensor. In dimension 4, this condition is that the second symmetric function on the Schouten tensor be constant as a function on $M$. We recall the corresponding results from dimension $2+1$ leading to a Kähler potential on Teichmüller space, and extend them to higher dimensions.

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## (Co-)CR quaternionic manifolds

***Radu Pantilie***

I shall present some recent developments in Quaternionic Geometry, motivated by the following problems:

(i) Is there a quaternionic version of the notion of CR manifold ?

(ii) Find the geometric structure corresponding, through the Twistor Theory, to the complex manifolds endowed with a locally complete family of Riemann spheres each of whose Birkhoff-Grothendieck decomposition of its normal bundle contains only terms of Chern number at least one.

(iii) What are the morphisms of Quaternionic Geometry ?

Based on joint work with S. Ianuş, S. Marchiafava, and L. Ornea.

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## Homogeneous Clifford Structures

***Mihaela Pilca***

Clifford structures on Riemannian manifolds are in some sense dual to spin structures and generalize almost Hermitian and quaternion-Hermitian structures. In this talk I shall present some recent results on homogeneous Clifford structures. In particular we will show that there exists an upper bound for their rank oncompact manifolds of non-vanishing Euler characteristic. Furthermore, we shall give the complete description of the limiting cases of highest possible rank, as well as of rank 3 Clifford structures, i.e. of homogeneous almost quaternion-Hermitian manifolds.

The talk is based on joint work together with Andrei Moroianu and Uwe Semmelmann.

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## Towards the classification of class VII surfaces

***Andrei Teleman***

The classification of complex surfaces is not finished yet. The most important gap in the Kodaira-Enriques classification table concerns the Kodaira class VII, e.g. the class of surfaces $X$ having $\mathrm{kod}(X) = -\infty$ and

$b_1(X) = 1$. These surfaces are interesting from a differential topological point of view, because they are non-simply connected 4-manifolds with definite intersection form. The main conjecture which (if true) would complete the classification of class VII surfaces, states that any minimal class VII surface with $b_2 > 0$ contains $b_2$ holomorphic curves. We explain our program, based on ideas from Donaldson theory, to prove existence of curves on class VII surfaces, and the newest results obtained recently using this program.

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## Moduli spaces of vector bundles on projective manifolds

***Matei Toma***

Two different compactifications of the moduli space of stable algebraic vector bundles on a complex projective manifold are in use. These are the Gieseker-Maruyama and the Donaldson-Uhlenbeck compactifications. While the first one is a projective scheme, the second one has only a topological structure a priori. In this talk we present a candidate for an algebraic structure on the Donaldson-Uhlenbeck moduli space, which should work in all dimensions. One issue is related to questions on the connectedness of the Hilbert scheme.

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## Two results concerning cut loci on surfaces

***Costin Vîlcu***

Let $S = (S, g)$ be a complete, compact and connected 2-dimensional differentiable manifold without boundary, endowed with a Riemannian metric $g$. The *cut locus* $C(x)$ *of the point* $x$ in $S$ is the set of all extremities (different from $x$) of maximal (with respect to inclusion) *segments* (i.e., shortest geodesics) starting at $x$. Denote by $\rho$ the intrinsic distance on $S$, and by $\rho_x$ the *distance function* from $x \in S$, $\rho_x(y) = \rho(x, y)$. A point $y \in S$ is called *critical* with respect to $\rho_x$ (or to $x$), if for any tangent direction $v$ to $S$ at $y$ there exists a segment from $y$ to $x$ whose tangent direction at $y$ makes an angle $\alpha \leq \pi/2$ with $v$.

The talk will consist of two parts. In the first part, based on [2]-[4], I will show that every finite and connected graph can be realized as a cut

locus. In the second part, based on [1] and [5], I will show that every point on every surface is critical with respect to another point of that surface. Further developments of these two results will also be presented.

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## Recent results in locally conformally Kähler geometry

***Victor Vuletescu***

Locally conformally Kähler metrics (LCK for short) were introduced by I. Vaisman in the mid 70's. Since then, by the effort of many people it was shown that *almost* all non-Kähler compact complex surfaces do admit LCK metrics. This suggests that there shoud be many examples also in higher dimensions. But, due to the fact that no general techniques for building such metrics are known, there is still a rather small number of classes of LCK manifolds.

The aim of the talk is to present a state-of-the art in the direction of existence (or non-existence) of LCK metrics on some explicit manifolds or on some constructed using some classical techniques - like blowing-up submanifolds, or taking fibrations.

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## Cut locus and critical points

***Tudor Zamfirescu***

We shall see that, on a surface, even on a convex one, the cut locus can be huge. It can contain the majority of points. In the same time, the set of critical points may never exceed certain limits, and we shall describe these limits in the convex case and in other cases.

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# 4. Computer Science

Organizer:
*Gheorghe Ştefănescu:* e-mail: ghstef@gmail.com

## The Epistemic $\mu$-calculus.

***Rodica Bozianu, Cătălin Dima, Constantin Enea***

The epistemic $\mu$-calculus K$\mu$ is an enrichment of the $\mu$-calculus on trees with individual epistemic modalities $K_a$ (and its dual, denoted $P_a$). The epistemic $\mu$-calculus is more expressive than linear or branching temporal epistemic logics [6, 9], propositional dynamic epistemic logics [10], or the alternating epistemic $\mu$-calculus [4].

Though K$\mu$ is designed with the aim that, like the classical modal $\mu$-calculus, it would subsume most combinations of temporal and epistemic logics, some gaps in the expressive power seem to exist, as witnessed by the lack of fix point expansions of coalition-until operators in the *Alternating Temporal Logic* with incomplete information ($ATL_{iR}$ or variants). Though, as we show, single-agent formulas in $ATL$ can be translated into the $\mu$-calculus, the translation cannot be generalized for two-agent coalitions. Note also that recent results in [4] show that formulas like $\ll a \gg p_1 \mathcal{U} p_2$ are not expressible in the Alternating Epistemic $\mu$-calculus.

On the other hand, $ATL_{iR}$ can be translated into a generalization of the monadic second-order logic over trees ($MSO$), with binary predicates encoding identical history observations. Combining these observations with the fac that $MSO$ with the equal-level predicate has an undecidable satisfiability problem, while the single-agent $K_\mu$ has a decidable satisfiability problem, we may conjecture that $K_\mu$ is less expressive than $MSO$ with identical history observations.

We then give two generalizations of alternating tree automata with level constraints that are equivalent with $K_\mu$, resp. $MSO$ with identical history observations. Two simple (non-alternating) subclasses are shown to encode the Linear Temporal Logic of Knowledge ($LTLK$ or $KL_n$), resp. the Computational Tree Logic of Knowledge ($CTLK$ or $KB_n$).

The model-checking problem for $K_\mu$ is undecidable in the presence of a semantics with perfect recall, as it is more expressive than combinations of temporal epistemic logics that include the common knowledge operator. We present a fragment of $K_\mu$ in which an epistemic modality $K_a$ is applied to a non-closed $\mu$- calculus formula $\Phi$ in such a way that avoids expressing properties that construct any variant of common knowledge for two or more agents.

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## Anytime Algorithms with Algorithmic Incompressibility Resource Cut-Off

***Cristian Calude***

Algorithms that exchange execution time for quality of results are called anytime algorithms. The cut-off is the time when the execution of the algorithm is stopped.

We sketch a theory of anytime algorithms in which the cut-off is expressed in terms of algorithmic incompressibility and we illustrate it with a probabilistic solution of the halting problem. Finally we show that the results can be extended from the time complexity to any computational complexity measure.

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## Modelling and Verification with Membrane Systems

***Marian Gheorghe***

In this talk some variants of membrane systems (also called P systems) will be discussed. These will be used to model and formally verify synchronization problems and synthetic biology constructs.

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## Model Learning and Test Generation using Cover Automata

***Florentin Ipate***

Testing is a major part of system development and has a great impact on the quality of the delivered product. Model-based test generation involves the use of a system model for selecting test data and offers the potential for automation. We propose an approach which, given a state-transition model of a system, constructs, in parallel, an *approximate automaton* model and a *test suite* for the system. The approximate model construction relies on a variant of Angluin's automata learning algorithm, adapted to finite cover automata. A *finite cover automaton* represents an approximation of the system which only considers sequences of length up to an established upper bound $\ell$. Crucially, the size of the cover automaton, which normally depends on $\ell$, can be significantly lower than the size of the exact automaton model. Thus, controlling $\ell$, the state explosion problem normally associated with constructing and checking state based models can be mitigated. The proposed approach also allows for a gradual construction of the model and of the associated test suite, with complexity and time savings.

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## Proof mining and applications in nonlinear ergodic theory

***Ulrich Kohlenbach, Laurenţiu Leuştean, Adriana Nicolae***

By *proof mining* we mean the extraction of hidden finitary content from proofs that make use of highly infinitary principles. The new information is obtained after a logical analysis, using proof-theoretic tools, and can be both of quantitative nature, such as algorithms and effective bounds, as well as of qualitative nature, such as uniformities in the bounds. This line of research, developed by Kohlenbach in the 90's, has its roots in Georg Kreisel's program on *unwinding of proofs*, put forward in the 50's.

This talk reports on recent applications of proof mining in nonlinear ergodic theory [1, 2, 3]. We present effective and highly uniform rates of metastability (in the sense of Terence Tao) on nonlinear generalizations of the classical von Neumann mean ergodic theorem obtained for uniformly smooth Banach spaces, CAT(0) spaces and CAT($\kappa$) spaces (with $\kappa > 0$).

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## A propositional logic related to the Pierce-Birkhoff conjecture

***Serafina Lapenta, Ioana Leuştean***

*The Pierce-Birkhoff conjecture* [2] asserts that any continuous piecewise-polynomial function $f : \mathbb{R}^n \to \mathbb{R}$ can be expressed as a maximum of minima of a finite family of polynomials in $n$ variables.

*MV-algebras* [1] are structures $(A, \oplus, ^*, 0)$ and they stand to Łukasiewicz logic as boolean algebras stand to classical logic: an equation holds in any MV-algebra if and only if it holds in the standard MV-algebra $([0,1], \oplus, ^*, 0)$, where $x \oplus y = (x+y) \wedge 1$ and $x^* = 1 - x$ for any $x$, $y \in [0,1]$.

Adding a product operation to the signature of MV-algebras was a natural step, which led to fruitful results, both in logic and algebra. In [3], we introduce and study in the class of *$f$-MV-algebras*, which are MV-algebras endowed with an internal and an external product.

We present ongoing work on a logical system whose class of models is a proper quasi-variety of $f$-MV-algebras and whose normal formal theorem is a variant of the Pierce-Birkhoff conjecture.

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## Hidden structures in words

***Florin Manea***

The notions of repetition and primitivity are fundamental concepts on sequences used in a number of fields, among them being stringology and algebraic coding theory. A word is a *repetition* if it can de written as a repeated concatenation of one of its prefixes to itself. Generalising this concept, a word $w$ is called *pseudo-repetition* if it can be written as a repeated concatenation of one of its prefixes $t$ and its image $f(t)$ under some morphism or antimorphism (for short "anti-/morphism") $f$, thus $w \in t\{t, f(t)\}^+$. Basically, while the structure of repetitions is obvious, pseudo-repetitions can be seen as strings with intrinsic (yet, hidden) repetitive structure. Besides

the pure theoretical interest in studying what seem to be a natural generalisation of the notion of repetition, one can identify connections between the aforementioned pseudo-repetitions and biology or music. In this talk we overview a series of recent algorithmic (e.g., [7, 3, 4]) and combinatorial results (e.g., [1, 2, 5, 6]) regarding pseudorepetitions, as well as some of the specific tools that were developed to get these results.

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## The story of the Bucharest University Mathematics

***Solomon Marcus***

This story begins long time before the year 1863, the birth of the Faculty of Sciences in Bucharest and it is in sharp contrast with the Romanian cultural development in the same historical period. To some extent, this story

is still unknown and it is waiting for research that should be accomplished by the new generations.

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## Repetitions in Partial Words

***Robert Mercaş***

The area of Combinatorics on Words took birth at the beginning of the last century when Thue initiated a systematic study of words in a series of papers. Several combinatorial problems that arose in the study of the sequences of symbols were considered, problems which were solved with the usual tools of discrete mathematics. Moreover, two of his papers contained results regarding repetitions (consecutive occurrences of a factor) inside a word.

Having as motivation some practical problems, such as gene comparison, Berstel and Boasson suggested the usage of partial words in this context. Partial words, a canonical extension of the classical words, are sequences that besides regular letters may have a number of unknown symbols.

The problem is not new, and it has been previously studied in different contexts. These "mutated" information represent in fact pieces of data that are unknown or uncertain and are lots of times denoted as "holes" or "don't care" symbols. Thus looking at a specific sequence of characters like $\diamond ame$, where the symbol $\diamond$ represents the "don't care" character, one can find in the English language no less than 10 words that might overlap it, *came*, *dame*, *fame*, *game*, *hame*, *kame*, *lame*, *name*, *same* and *tame*, and this without considering acronyms.

This talk is going to survey the classical problem of repetitions in the new setting of partial words. If we consider the English word *banana*, then we notice that the letter $b$ is followed by a $\frac{5}{2}$ -repetition of the word $an$, that is two full occurrences of $an$ followed by the first letter $a$. It is easy to note that over a binary alphabet all words of length 4 or larger contain a repetition. Since in many applications the length of the words investigated can be arbitrarily long, it was natural to study infinite words. The concept of partial word is extended to that of infinite partial word.

In this framework, we will present the problem of identifying and constructing $k$-free partial words, i.e., words that do not contain $k$ consecutive factors which are pairwise compatible.

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## Cell simulation using a new discrete technique

***Andrei Păun, John Jack***

We provide a refined approach of the discrete modeling of protein interactions within the environment of a single cell. The technique we offer utilizes the Membrane Systems paradigm which, due to its hierarchical structure, lends itself readily to mimic the behavior of cells. Since our approach is nondeterministic and discrete, it provides interesting contrast to the standard deterministic ordinary differential equations techniques. We present examples that show the power of the proposed simulation methodology: for the same rules and initial conditions in the models considered we show that the new method in one case gives results that agree with ODE and in another case/model the results agree with Gillespie. We will look at the well-known Lotka-Voltera (predator-prey model) and a recent circadian rhythm that are known for the difference in results of ODE vs. Gillespie simulations. We argue that our approach may outperform ordinary differential equations when modeling systems with relatively low numbers of molecules - a frequent occurrence in cellular signal cascades.

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## Membrane Computing – After 15 Years

***Gheorghe Păun***

Membrane computing is a branch of natural computing initiated in [1] which abstracts computing models (called P systems) from the structure and the functioning of living cells, as well as from the organization of cells in tissues or other higher order structures (brain included).

In short, a P system consists of a *membrane structure* (described by a tree in the case of cell-like systems, or by an arbitrary graph in the case of tissue-like P systems), which define compartments where *multisets of objects* (evolve according to local *evolution rules*. Starting from an initial configuration and using evolution rules in a specified way (the basic one is the nondeterministic maximally parallel way) one obtains computations, sequences of transitions among configurations; halting computations provide a result – usually, a number, but also strings can be defined. Many variants

were defined, in terms of the architecture, the types of rules and the ways of using them.

Many of the considered classes of P systems proved to be Turing equivalent, while P systems which can construct an exponential working space in a polynomial time (e.g., by means of membrane division), can solve computationally hard problems (typically, **NP**-complete problems) in a feasible time (polynomial, but often even linear), by trading space for time.

Although initially membrane computing was not conceived as a modeling framework, this turned out to be a very fruitful direction of research, and a series of applications were reported in the last years, in biology, bio-medicine, linguistics, computer graphics, economics, approximate optimization, cryptography, etc.

The literature of membrane computing is very large, counting probably more than 2000 papers (already in 2003, Thompson Institute for Scientific Information, ISI, has qualified the initial paper as "fast breaking" and the domain as "emergent research front in computer science" – see `http://esi-topics.com`).

The presentation will only give a quick overview of this research area, pointing the basic notions and only presenting some (types of) results and of applications. Details and references can be found in [2] and at [3].

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## Specify and verify your language using K

***Grigore Roşu***

One of the long-lasting dreams of the programming language community is to have one formal semantic definition of a target programming language and from it to derive all the tools needed to execute and analyze programs

written in that language: parsers, interpreters, compilers, symbolic execution engines, model checkers, deductive program verifiers, and so on. We believe that this dream started to become reality. In this talk we will give an overview of K, a rewrite-based executable semantic framework in which programming languages can be defined using configurations, computations and rules. Configurations organize the state in units called cells, which are labeled and can be nested. Computations carry computational meaning as special nested list structures sequentializing computational tasks, such as fragments of program. Computations extend the original language abstract syntax. K (rewrite) rules make it explicit which parts of the term they read-only, write-only, read-write, or do not care about. This makes K suitable for defining truly concurrent languages even in the presence of sharing. Computations are like any other terms in a rewriting environment: they can be matched, moved from one place to another, modified, or deleted. This makes K suitable for defining control-intensive features such as abrupt termination, exceptions or call/cc. The K framework is designed to allow implementing a variety of generic tools that can be used with any language defined in K. Currently, it includes the following: a parser, interpreters, symbolic execution engines (connected to the Z3 SMT solver), state-space exploration via a configurable semantic debugger, a model checker, and a deductive program verifier. The latter is based on matching logic for expressing static properties, which generalizes separation logic, and on reachability logic for expressing dynamic properties, which generalizes Hoare logic.

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## Hierarchical reasoning in local theory extensions and applications

***Viorica Sofronie-Stokkermans***

Many problems in mathematics and computer science can be reduced to proving the satisfiability of conjunctions of literals in extensions and combinations of theories. It is therefore very important to identify situations where reasoning in complex theories can be done efficiently and accurately. Efficiency can be achieved for instance by: (1) Reducing the search space (preferably without losing completeness); (2) Exploiting modularity - i.e. delegating some proof tasks which refer to a specific theory to provers specialized in handling formulae of that theory. Identifying situations where the search space can be controlled without loss of completeness is of utmost importance. To address this problem, very similar ideas occurred in various

areas:

1. **Proof theory**: Possibilities of restricting the search space in inference systems without loss of completeness were studied by McAllester and Givan who introduced so-called local inference systems (for which validity of ground Horn clauses can be checked in PTIME).

2. **Algebra**: Similar ideas also occurred in algebra; they were used by Skolem (1920) to prove that the uniform word problem for lattices is decidable in PTIME and by Evans (1953) in the study of classes of algebras with a PTIME decidable word problem, then generalized by Burris (1995) who identified a criterion to recognize quasi-varieties for which the uniform word problem is decidable in PTIME.

3. **Automated deduction**: A link between (a certain version of) locality and saturation w.r.t. ordered resolution was established by Basin and Ganzinger in 1996. In 2001, Ganzinger established a link between the proof theoretic notion of locality and embeddability of partial into total algebras.

In 2005, we showed that the notion of locality for Horn clauses can be extended to the more general notion of local extension of a base theory. In addition to allowing to reduce the search space, in local theory extensions hierarchic reasoning is possible (proof tasks can be hierarchically reduced in PTIME to proof tasks in the base theory). This allows to give parameterized complexity results for ground satisfiability w.r.t. such extensions. Since in applications it is often necessary to consider complex extensions, in which various types of functions or data structures need to be taken into account at the same time, we present conditions under which locality is preserved when combining theories. We showed that many theories important for computer science or mathematics fall into this class (typical examples are theories of data structures, but also various theories of functions important in mathematical analysis). We present several examples of applications in mathematics, verification of reactive, real time and hybrid systems, and description logics.

Acknowledgment: Many of these results mentioned here were established in joint work with Werner Damm, Johannes Faber, Matthias Horbach, Carsten Ihlemann and Swen Jacobs.

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## The Role of Hypergraphs in Association Rule Discovery

***Cristina Tîrnăucă***

In data mining, association rule learning is a popular and well researched

method for discovering useful relations between items in a dataset. For example, in a market basket dataset, one might conclude after analyzing the data that $bread, sausages \rightarrow mustard$, that is, "most of the customers that bought bread and sausages also bought mustard". Association rule generation is often divided into two separate steps: minimal support is applied to find all frequent itemsets, which are subsequently used to form rules. In practice, the number of frequent itemsets is often huge, so condensed representations, with sizes that can be several orders of magnitude smaller than the size of frequent set collections, are the norm.

In particular, *minimal generators* are widely used in order to prune non-redundant rules. Unfortunately, finding minimal generators is equivalent to finding minimal transversals in a certain hypergraph (the relation between minimal hypergraph transversals and data mining has already been noted in [1], for example), and whether all minimal transversals can be computed in output-polynomial time is still an open problem.

The aim of this presentation is to offer a brief introduction of the above mentioned concepts and the relevant literature, hopefully leading to fruitful collaborations that may shed some light on the above mentioned problem.

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## Connected graphs of diameter two having minimum and maximum degree distance

***Ioan Tomescu***

Topological indices, like degree distance, introduced by Dobrynin and Kochetova and Gutman were studied in mathematical chemistry. In this paper it is proved that in the class of connected graphs $G$ of order $n \geq 4$ and diameter equal to 2 such that $G \ncong K_{1,n-1}$, the minimum degree distance is reached by $K_{1,n-1}+e$ and the maximum degree distance is attained by the complete graph with one edge deleted $K_n - e$. It is also conjectured that the bistar consisting of vertex disjoint stars $K_{1,n-3}$ and $K_{1,1}$ with central vertices joined by an edge has minimum degree distance in the class of connected graphs $G$ of order $n$ such that $G \ncong K_{1,n-1}$.

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## Computational Soundness in Security Protocols Analysis

***Bogdan Warinschi***

There are two largely distinct methods that have been used in protocol analysis, one based on logic and formal languages and one based on computability and complexity theory. In this talk I will argue that the two approaches have complementary benefits and shortcomings and I will discuss "computational soundness", an approach that combines the two methodologies in a way that obtains the best of both worlds.

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# 5. Mechanics, Differential Equations and Numerical Methods

Organizer:

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## On the convergence of some hybrid multigrid methods for variational inequalities

***Lori Badea***

We introduce four hybrid multigrid algorithms for the constrained minimization of non-quadratic functionals. The first algorithm we introduce is a standard V-cycle multigrid iteration. This algorithm can be also viewed as performing a multiplicative iteration on each level and a multiplicative one over the levels, too. The three other proposed algorithms are combinations of additive or multiplicative iterations on levels with additive or multiplicative ones over the levels. These algorithms are given for the constrained minimization of non-quadratic functionals where the convex set is of two-obstacle type and have an optimal computing complexity of the iteration steps. We give estimations of the global convergence rate in function of the number of levels, and compare our results with the estimations of the asymptotic convergence rate existing in the literature for complementarity problems.

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## Dirichlet problems with the mean curvature operator in Minkowski space

***Cristian Bereanu***

In this talk we present existence and multiplicity of classical positive radial solutions for Dirichlet problems with the mean curvature operator in Minkowski space. We use a combination of degree arguments, critical point theory for lower semicontinuous functionals and the upper and lower solutions method.

This is a joint work with P. Jebelean and P.J. Torres.

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## Asymptotic behavior for the alpha Navier-Stokes equations

***Valentina Busuioc***

In this talk I will study the large time behavior of the solutions of the alpha Navier-Stokes equations in dimension two. It was shown by Bjorland that the large time behavior of the solutions of the alpha Navier-Stokes equations is the same as for the classical Navier-Stokes equations provided that the initial data is small. In this talk, I will explain why the smallness of the initial data is not necessary.

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## Homogenization results for microcontact elasticity problems

***Anca Căpăţână, Claudia Timofte***

A macroscopic model for an $\varepsilon$-periodic elastic body is analyzed. The material consists of an elastic connected matrix and rigid inclusions, which are in frictional contact with the matrix. The contact is modeled by the Signorini conditions and the friction is described by a nonlocal version of Coulomb's law. The body is considered to be clamped along a part of its outer fixed boundary and tractions are supposed to act on the rest of the exterior boundary.

Our approach is based on the periodic unfolding method, which allows us to deal with general materials.

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## The steady compressible flow of an electroconducting fluid past a thin airfoil

***Adrian Carabineanu***

We assume that the uniform velocity and electromagnetic field is perturbed by the presence of a thin airfoil. We linearize the Euler equations

and the magnetic induction equation. The system of linear partial differential equations is hyperbolic for the supersonic flow and has a hyperbolic part and an elliptic part for the subsonic flow. In the case of subsonic flow, a singular integral equation has to be solved in order to calculate the jump of the pressure over the airfoil.

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## On a class of nonlinear differential inclusions

***Aurelian Cernea***

We study nonlinear differential inclusions of the form

$$x' \in Ax + F(t,x), \quad x(0) = x_0,$$

where $A$ is a $m$-dissipative operator on a Banach space $X$, $x_0 \in X$ and $F(.,.) : [0,T] \times X \to \mathcal{P}(X)$ is a set-valued map with nonconvex values that satisfies Fillipov type assumptions.

Using certain selection theorems, some existence results are obtained when $X$ is separable and nonseparable.

We also establish several variational inclusions for solutions of the problem considered in separable Banach spaces.

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## Free energy imbalance principle in finite elasto-plastic damaged materials

***Sanda Cleja-Ţigoiu, Victor Ţigoiu***

The elasto-plastic models coupled with damage have been introduced to be compatible with the free energy imbalance principle. The defect existing in elasto-plastic materials with damaged microstructure are described by certain geometric incompatibilities, motivated by physical evidences. We restrict to crystalline materials and we suppose the existence of an non-holonomic configuration, a so called damaged configuration related with the lattice structure, at which level we identify the tensorial measure of defects. The damage deformation (third rank) tensor, Q, is introduced to characterize the non-metric property of the geometry associated with lattice

structure. A symmetric second order tensor, H, the so-called quasi-strain, has been associated with Q, in order to establish the metric property of the structure, but this time the curvature tensor (Frank vector) becomes zero. Another second order like deformation tensor, the so-called disclination tensor, can be introduced in order to describe the rotational effect in the motion of the defects, experimentally observed at the micro scale. Our description is different from those that based on the existence of the undamaged and stress free (fictitious) configuration, when an invertible second order field has been introduced to locally realize the passage to the damaged and stress free configuration. The dissipative nature of the damage is modeled in term of the free energy imbalance which involve the dissipated power by the micro forces, conjugated with the variation in time of the considered tensorial damage (like deformation) variables.

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## Implicit evolution inequalities, fixed point methods and applications to contact mechanics

***Marius Cocou***

Implicit variational inequalities have been proved to be very useful in dealing with variational problems involving inequality constraints that depend on the solution itself.

Their first applications in mechanics were represented by the quasivariational inequalities corresponding to static contact problems with Coulomb friction or with normal compliance laws, despite the fact that the static formulation is not a realistic model, except in some special cases.

The frictional contact problems, in the quasistatic or the dynamic case, are generally described by implicit evolution inequalities of variational or hemivariational type.

This talk is concerned with the analysis of a class of implicit inequalities which constitute a direct and unified approach to solve several nonsmooth dynamic contact problems in viscoelasticity coupling complex surface interactions as those due to adhesion or friction.

In this general framework, the study of solutions is based on topological methods, consisting in appropriate estimates, compactness results and fixed point arguments.

Some existence, approximation and regularity results, obtained by using these methods, are presented and several applications and examples are considered.

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## Geometry of Sobolev Spaces with Variable Exponents and Duality Mappings

***George Dincă***

Some geometric properties (as smoothness and uniform convexity) for Sobolev spaces with variable exponents are given in connection with the properties of the duality mappings defined on such spaces.

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## A viscoplastic model with negative strain-rate sensitivity for the Portevin-Le Chatelier effect and relaxation oscillations for dynamical systems

***Cristian Făciu***

The Portevin-Le Chatelier (PLC) effect is an unstable, oscillatory plastic flow that may be observed in metallic alloys subjected to load-or displacement-controlled deformation. We consider an elasto-viscoplastic model capable of describing the negative strain-rate sensitivity of metals. This phenomenological model characterizes the kinetics of Dynamic Strain Ageing (DSA), that is the dynamic interaction between mobile dislocations and diffusing solute atoms which is known to be the primary mechanism inducing the PLC effect. The homogeneous solution of the corresponding PDEs satisfies a non-linear autonomous two-dimensional system of differential equations. That gives a nice illustration of what is known as "fast dynamics" and bistability. We determine critical conditions on the mechanical parameters such that the trajectory of the solution in the phase space is isolated, closed and consists of an extremely slow buildup followed by a sudden discharge, followed by another slow buildup, and so on. Oscillations of this type are often called relaxation oscillations, because the stress accumulated during the slow buildup is relaxed during the sudden discharge.

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## Hopf bifurcations in models for blood cells' evolution in leukemia, considering the immune response and treatment

***Andrei Halanay***

A model for the evolution of stem-like short-term cells and of mature leukocytes is considered. A system of two delay differential equations is used on the traditional way initiated by Mackey-Glass in 1977, but now with the notable difference of the consideration of asymmetric division. Stability analysis of equilibria reveals the appearance of a Hopf bifurcation. The stability of limit cycles is investigated using normal forms and the computation of the Lyapunov coefficient. With a constant dose treatment considered in the model, one analyses its influence on the behavior of the solutions. When the action of the immune system is introduced in the model, the complexity of the system raises considerably :the dimension becomes 7 and several regulatory functions are considered. Stability analysis and existence of Hopf bifurcation are investigated in this setting The theoretical study is complemented by numerical simulations. This research is supported by the CNCS Grant PNII-ID-PCE-3-0198, with the cooperation of D. Candea, R. Radulescu, S. Balea, C. Safta, M. Neamtu, D. Jardan.

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## Rotationally symmetric p-harmonic maps from $D^2$ to $S^2$: steady states, local existence and finite time blow-up

***Răzvan Iagăr***

In a first part, we consider rotationally symmetric p-harmonic maps from the unit disk $D^2$ to the unit sphere $S^2$, subject to Dirichlet boundary conditions and for $1 < p < \infty$ . We show that the associated energy functional admits a unique minimizer, and that there exist infinitely many global solutions to the associated Euler-Lagrange equations. In the second part, we study the associated p-harmonic ow, restricting the value of $p$ to $1 < p < 2$. We show that the Dirichlet problem is well-posed for a general class of initial data, and we characterize when there exists a global solution and when

blow-up in finite time occurs.

Joint work with Salvador Moll.

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## Weak vorticity formulation for incompressible ideal flows in domains with boundary

***Dragoş Iftimie***

In this talk I will examine the interaction of incompressible 2D flows with compact material boundaries. I will focus on the dynamic behavior of the circulation of velocity around boundary components and the possible exchange between flow vorticity and boundary circulation in flows with vortex sheet initial data. I will formulate the results for flows outside a finite number of smooth obstacles. The point of departure is the observation that ideal flows with vortex sheet regularity have well-defined circulations around connected components of the boundary. In addition, the velocity can be uniquely reconstructed from the vorticity and boundary component circulations, which allows to recast 2D Euler evolution using vorticity and the circulations as dynamic variables. The weak form of this vortex dynamics formulation of the equations is called the weak vorticity formulation. The first result is existence of a solution for the weak velocity formulation with vortex sheet initial data for flow outside a finite number of smooth obstacles. The proof is a straightforward adaptation of Delort's original existence result and requires the usual sign condition. The main result in this talk is the equivalence between the weak velocity and weak vorticity formulations, without sign assumptions. Next, we focus on weak solutions obtained by mollifying initial data and passing to the limit, with the portion of vorticity singular with respect to the Lebesgue measure assumed to be nonnegative. For these solutions we prove that the circulations around each boundary component cannot be smaller than the initial data circulation, so that nonnegative vorticity may be absorbed by the boundary, but

not produced by the boundary. In addition, we prove that if the weak solution conserves circulation at the boundary components it is a boundary coupled weak solution, a stronger version of the weak vorticity formulation. We prove existence of a weak solution which conserves circulation at the boundary components if the initial vorticity is integrable, i.e. if the singular part vanishes. In addition, we discuss the definition of the mechanical force which the flow exerts on material boundary components and its relation with conservation of circulation. This is joint work with M. Lopes Filho, H. J. Nussenzveig Lopes and F. Sueur.

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## Mathematical modelling of metals absorption by the root system of plants

***Stelian Ion***

In the recent years the decontamination of the polluted soil by using plant cultivation becomes a very attractive remediation technology. The quantity of the contaminant extracted by plants depends of many factors. Among them the metal mobility in the root zone and the root vessel system are determinant. In this paper we focus on the theoretical background of modelisation of the metal circulation in the complex system of soil, plants root and plants. We will show that the integral formulation of the mass balance principle of multifluid continuum mechanics is an appropriate base not only for writing down the macroscopic equations but also for highlighting the empirical relations needed to close the model. Different models are analyzed by numerical simulations.

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## Dynamic visco-plastic crystals: an eulerian modeling

***Ioan R. Ionescu, Oana Cazacu***

A robust numerical algorithm for an Eulerian rigid-visco-plastic crystal model that accounts for high-strain rates, large strains, and large material and lattice rotations, was developed. The viscoplastic law is obtained from Schmid law by using an overstress approach. The numerical instabilities associated to the classical power law are thus eliminated.

To handle the non differentiability of the plastic terms an iterative decomposition-coordination formulation coupled with the augmented Lagrangian method was adopted. A mixed finite element-finite volume strategy was adopted: the equation for the velocity field is discretized using the finite element method while a finite volume method, with an upwind choice of the flux, is adopted for the hyperbolic equation related to the lattice orientation.

Several two-dimensional boundary value problems are selected to analyze the robustness of the numerical algorithm. The grains interaction during channel die compression of a multi-crystal was analyzed using an ALE description.

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## Iterative algorithms with relaxation for the Cauchy problem associated with the modified Helmholtz equation

***B. Tomas Johansson, Liviu Marin***

We propose two algorithms involving the relaxation of either the given Dirichlet data or the prescribed Neumann data on the over-specified boundary in the case of the alternating iterative algorithm of Kozlov, Maz'ya and Fomin (*U.S.S.R. Computational Mathematics and Mathematical Physics* **31**, 45–52, 1991) applied to Cauchy problems associated with the two-dimensional modified Helmholtz equation. A theorem stating the convergence of these relaxation methods, in the standard Sobolev space of functions with weak first-order derivatives, is presented, along with a stopping criterion. The numerical results obtained using these procedures in conjunction with the boundary element method show the numerical stability, convergence, consistency and computational efficiency of the proposed method.

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## Variational principles for nonlinear diffusion equations

***Gabriela Marinoschi***

We provide existence results for time-dependent nonlinear diffusion equations by following a variational principle. The results state that the solution of the nonlinear equation can be retrieved as the null minimizer of an appropriate minimization problem for a convex functional involving the potential of the nonlinearity and its conjugate. Applications are presented for fluid infiltration in porous media.

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## A duality-type method for the obstacle problem

***Diana Merluşcă***

Based on a duality property, we solve the obstacle problem on Sobolev spaces of higher order. We have considered a new type of approximate problem and with the help of the duality we reduce it to a quadratic optimization problem, which can be solved much easier.

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## Critical variational vector-valued problems

***Petru Mironescu***

The basic method for solving variational problems is the direct one, consisting in the minimization of the energy functional. According to the functional space, a problem can be subcritical (minimizing sequences are relatively compact), supercritical (energy is not well defined) or critical (energy is well defined, but minimizing sequences are not relatively compact). I will introduce a critical problem related to superconductivity (involving the Ginzburg-Landau energy with prescribed boundary degrees) and some existence/non existence results related to this problem, as well as some related problems and tools. This will be mainly an occasion to see at work some of the most variational methods developed in the last forty years.

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## Optimal estimates for liftings of unimodular maps

***Petru Mironescu, Ioana Molnar***

We consider the spaces $\mathrm{W}^{s,p}(\mathbb{T}^n;\mathbb{S}^1)$ that have the lifting property. These spaces have been characterized in [1] according to the values of $s$, $p$ and $n$. The *lifting property* here means that for every map $u$ there exists a function $\varphi$ having the same regularity of $u$ such that $u = e^{\imath\varphi}$. We address the problem of the control of $|\varphi|_{\mathrm{W}^{s,p}}$ in terms of $|u|_{\mathrm{W}^{s,p}}$.

More precisely, first we show that for the case $sp \geq 1$ (where there is uniqueness of the phase $\varphi$), two quantitatively different type of estimates occur:

$$|\varphi|_{\mathrm{W}^{s,p}} \leqslant c\,|u|_{\mathrm{W}^{s,p}},\ \text{when } s \geq 1,$$

and

$$|\varphi|_{\mathrm{W}^{s,p}} \leqslant c\,(|u|_{\mathrm{W}^{s,p}} + |u|^{\alpha}_{\mathrm{W}^{s,p}}),\ \text{when } s < 1.$$

In each situation, we study their optimality, the proper meaning of *optimality* depending on the linear or superlinear regime of the estimates. In the more delicate case when $sp < 1$, the optimal estimate is given by

$$|\varphi|_{\mathrm{W}^{s,p}} \leqslant c\,|u|_{\mathrm{W}^{s,p}}/(s(1-sp)^{1/p})$$

for $p > 1$. This was settled for $p = 2$ in [1] and [2] using an averaging method and $\mathrm{L}^2$–Fourier analysis. We extend these results developing non $\mathrm{L}^2$–specific tools and an approach based on symmetrization. We also present a new lifting construction based on geometric methods in the spirit of Federer–Fleming's projection method.

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## Some Problems in Oil Recovery and Hele-Shaw Displacements

***Gelu Paşa***

A simple model for a porous medium is the Hele-Shaw approximation. A Stokes fluid flows between two parallel plates at a small distance The averaged (across the plates) velocities are verifying an equation quite similar with Darcy's law. This model is used to study the Secondary Oil Recovery: the oil from a porous medium is displaced by a second immiscible fluid (water). Saffman and Taylor (1958) proved that the interface between the two fluids is unstable when the displacing fluid is less viscous. An intermediate region I.R. between water and oil can be considered between water and oil. An exponential viscosity in I.R. can reduce the instability. We study here the case of a diffusion phenomenon in I.R.. Daripa and Pasa (2007) proved the stabilizing effect of diffusion. We give here a simpler method for estimate the eigenvalues of the Sturm-Liouville system which governs the interface stability, by using a Poincaré type inequality for the corresponding eigenfunctions.

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## Analysis of a Modified Parareal Algorithm for Second-Order Ordinary Differential Equations

***Mădălina Petcu***

The parareal algorithm is a numerical method to integrate evolution problems on parallel computers. The performance of the algorithm is well understood for diffusive problems, and it can have spectacular performance when applied to certain non-linear problems. Its convergence properties are however less favorable for hyperbolic problems. In this talk, we present and analyze a variant of the parareal algorithm, recently proposed in the PITA framework for systems of second order ordinary differential equations.

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## Homogenization of fluid flows through fractured porous media

***Dan Polişevschi***

We consider a fluid flow traversing a porous medium and obeying the Darcy's law in the case when this medium is fractured in blocks by an

$\varepsilon$-periodic ($\varepsilon > 0$) distribution of fissures filled with a Stokes fluid. The coupling is governed by a Beavers-Joseph type interface condition. The existence and uniqueness of this flow are proved in the $\varepsilon$-periodic framework. As the small period of the distribution tends to zero, we study the asymptotic behavior of the flow when the permeability and the entire contribution of the Beavers-Joseph transfer coefficients on the interface are of unity order. We find the homogenized problem verified by the two-scale limits of the coupled velocities and pressures. It is well-posed and provides the corresponding classical homogenized problem.

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## Guided Waves in Strained/Polarized Media

***Olivian Simionescu-Panait***

The problems related to electro-elastic materials subject to incremental fields superposed on initial mechanical and electric fields have attracted considerable attention over the past few decades. Electro-elastic materials are frequently used to make various electromechanical devices, such as transducers for converting energy, resonators and filters for frequency control, sensors and actuators for the control of smart structures, etc. The behavior of such electromechanical devices may be affected by imposing various biasing fields. The main examples are the initial mechanical and electrical fields.

Last years we studied the coupling conditions for propagation of guided waves in an isotropic and anisotropic solid media subject to electromechanical biasing fields. We obtained four different waves, two polarized in the sagittal plane, and two polarized transverse-horizontal, generalizing the classical guided waves from the case without initial fields. We present here two mechanical problems, namely the propagation of guided waves of Rayleigh and Love type in isotropic, resp. in anisotropic layered media subject to a bias. Our results generalize, for initial mechanical fields, classical results from seismology concerning Love and Rayleigh waves propagation

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## Mixed Variational Problems with Applications to Contact Mechanics

***Mircea Sofonea***

We provide an existence result in the study of a new class of mixed variational problems in a real Hilbert space. The problems are formulated on an unbounded interval of time, involve history-dependent operators and two nondifferentiable functionals which depend on the solution. The proof is based on arguments of generalized saddle point theory and fixed point. Then, we consider a mathematical model which describes the frictionless contact between a viscoplastic body and an obstacle. The process is quasistatic and the contact is modelled with a multivalued normal compliance condition and unilateral constraint. We use our abstract result to prove the weak solvability of this contact problem.

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## The Fisher-KPP equation with nonlinear fractional diffusion

***Diana Stan***

We study the propagation properties of nonnegative and bounded solutions of the class of reaction-diffusion equations with nonlinear fractional diffusion:

$$u_t + (-\Delta)^s(u^m) = f(u).$$

For all $0 < s < 1$ and $m > m_c = (N-2s)_+/N$, we prove that the level sets of the solution of the initial-value problem with suitable initial data propagate exponentially fast in time, in contradiction to the traveling wave behavior of the standard KPP case, which corresponds to putting $s = 1$, $m = 1$ and $f(u) = u(1-u)$. The proof of this fact uses as an essential ingredient the recently established decay properties of the self-similar solutions of the purely diffusive equation, $u_t + (-\Delta)^s u^m = 0$, combined with the construction of suitable sub- and super-solutions. We also need accurate lower estimates for positive solutions of this latter equation, and a further self-similar analysis for the linear diffusion problem.

This problem is part of my PhD thesis and it is a joint work with professor Juan Luis Vázquez (UAM).

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## A two fluids interaction problem with jump conditions

***Ruxandra Stavre***

In many practical problems, different physical characteristics, different parameter regimes or different solution behaviors are coupled across interfaces. Such situations arise in fluid-fluid or fluid-structure interaction problems, where two domains corresponding to different fluids or to a fluid and a deformable solid are separated by an interface.

We present a mathematical model and a distributed control problem associated with the interaction between two non miscible fluids in a porous medium, when on their interface there exists a jump of temperature.

After obtaining the existence of a solution for the considered problem by applying the Schauder's fixed point theorem, we introduce a distributed control problem in order to determine the radiant sources that provide an optimal configuration for the pressure. The control problem is studied by means of a penalization method which permits to obtain the optimality conditions.

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## The implicit function theorem and implicit parametrizations

***Dan Tiba***

We discuss a differential equations treatment of the implicit functions problem. Our approach allows a precise and complete description of the solution, of continuity and differentiability properties. The critical case is also considered. The investigation is devoted to dimension two and three, but extensions to higher dimension are possible.

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## Control problems for some systems modeling fluid-structure interactions

***Marius Tucsnak***

The aim of this presentation consists in presenting some recent advances in the control of fluid-structure interactions, with emphasis on those ob-

tained by our group in Institut Elie Cartan. Two main cases will be considered. In the first one, the solid is supposed to be rigid and the control acts in a zone of the fluid. In the second case, the control is localized on solid. This second situation occurs, for instance, in systems modeling propelling of underwater vehicles or aquatic organisms. The main mathematical difficulty encountered in these problems consists in the fact that the fluid domain is not a priori.

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## Flow through Permeable Membranes

***Bogdan Vernescu***

We review results related to viscous flows through porous membranes, and develop a model for randomly leaky permeable membranes for which we determine the effective boundary conditions. Threshold leak conditions of sub-gradient type are considered on randomly distributed solid parts of the membrane. Using Mosco convergence the effective conditions are obtained and shown to be of sub-gradient type with an effective yield limit, in the case of a densely distributed solid part, or of Navier slip type, in the case of dilute solid part; in the intermediate case the tangential slip cancels, whereas the normal velocity and stress are continuous. The results are extend to the time dependent case. The model introduced does not display infinite stresses in the membrane boundary layer.

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# 6. Probability and Statistics

Organizer:

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## On matrix exponential approximations of densities and applications to ruin and queueing theory

***Florin Avram, B. Dumitrescu, B. Sicleru***

We consider a classic problem of applied probability, the approximation of a theoretical or empirical density of nonnegative input data by a matrix exponential density.The difficulty of the problem is illustrated by the challenging example of the uniform density.

We provide and compare then several low ordermatrix exponential approximations which may be used in applications where inverting the Pollaczek-Khinchine formula is required.

Finally, we present a numerical approach for obtaining higher order approximations, based on reduction to positivity of polynomials and semidefinite programming.

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## A probabilistic interpretation of the parametrix method

***Vlad Bally***

We introduce a parametrix method for the construction of fundamental solutions as a method based on semigroups and difference of generators. This leads to a probabilistic interpretation of the parametrix method that are amenable to Monte Carlo simulation. We consider the explicit examples of continuous diffusion processes and of jump driven stochastic differential equations with Hölder continuous coefficients.

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## Divide and conquer: Some strategies for regional adaptive MCMC

***Radu Craiu***

Adaptive Markov chain Monte Carlo (AMCMC) is a new class of MCMC algorithms in which the transition kernel is continuously modified "on the fly" using the information provided by the very samples produced by the chain. Such strategies are useful in situations in which tuning the simulation parameters by hand can be tedious, even futile. However, such strategy raises interesting theoretical questions since, by allowing the transition kernel to depend on the entire past, the Markovian property is lost.

I will introduce general AMCMC and briefly discuss the theory used to validate this type of sampling algorithms. The discussion will focus on the so-called regional adaptive samplers that are useful in situations in which one would like to use different transition kernels across a partition of the sample space. Our discussion will focus on Random Walk Metropolis algorithms and will introduce a few practical strategies for regional AMCMC.

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## Kusuoka-Stroock gradient bounds for the solutions of stochastic PDEs

***Dan Crişan***

We introduce sharp gradient bounds for the perturbed diffusion semigroup. In contrast with existing results, the perturbation studied here is random and the bounds obtained are pathwise. The approach builds on the classical work of Kusuoka and Stroock. It extends their program developed for the heat semi-group to solutions of stochastic partial differential equations. The work is motivated by and applied to nonlinear filtering. The analysis allows us to derive pathwise gradient bounds for the un-normalized conditional distribution of a partially observed signal. by a random process. It uses a pathwise representation of the perturbed semigroup in the spirit of the one introduced by Ocone. The estimates we derive have sharp short time asymptotics.

This is joint work with C. Litterer (Imperial) and T. Lyons (Oxford).

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## Spectral analysis of the continued fraction expansion

***Marius Iosifescu***

Let $\tau$ be the continued fraction transformation of the interval $[0,1]$ defined as

$$\tau(x) = \{1/x\} \text{ for } x \in (0,1] \text{ and } \tau(0) = 0.$$

We discuss the representation of $\tau^{-n}$ in terms of the eigenvalues of the integral symmetric linear operator $K\phi(s) = \int_0^\infty k(s,t)\,\phi(t)\,m(dt)$, $\phi \in L_m^2$, $s \geq 0$, on $L_m^2$, where $m$ is the measure with density $t/\left(e^t - 1\right)$, $t \geq 0$, and $k(s,t) = \sum_{n \in N} (-1)^n (st)^n / n!\,(n+1)!$, $s, t \geq 0$.

### References

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## Nonlinear Riccati type equations with applications to stochastic control problems

***Toader Morozan, Vasile Drăgăn***

The study of the stochastic systems has a long history, they providing reliable mathematical models of various phenomena and processes subject to unpredictable perturbations. Traditionally, two distinct classes of such systems were separately considered in control literature, namely, stochastic systems subject to multiplicative white noise perturbations and systems with Markovian jumping, respectively.

Our study refers to continuous time and discrete time systems simultaneously affected by multiplicative white noise perturbations and jump Markov perturbations.

First, we state the main important stochastic control problems for such controlled systems: the stochastic linear quadratic control problems, the stochastic $H_2$ and $H_\infty$ control problems, concepts of stochastic stabilizability and stochastic detectability.

In many control problems the first task imposed to the admissible controls is to guarantee a *stable behavior* of the trajectories of the controlled

systems. In stochastic framework there are many types of stability of solutions but, among them, the most popular is *the exponential stability in mean square*. In order to derive criteria for exponential stability in mean square we have studied a class of deterministic differential equations (difference equations) defining positive evolution on some suitable ordered Banach spaces.

Further, we consider a general class of Riccati type equations in continuous-time case and discrete-time case which contains as special cases the Riccati type systems arising in the above mentioned stochastic control problems.

Necessary and sufficient conditions for the existence of global bounded maximal solutions, minimal solutions and stabilizing solutions of such equations are given. Also, iterative procedures for numerical computations of the afore mentioned global solutions of coupled Riccati equations are provided.

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## Statistical Methods for Next-Generation Genomics Technologies

***Dan L. Nicolae***

Large genomics datasets have been an important component of recent progress in statistics and machine learning. Among the important scientific problems targeted by these data is the development of a better understanding of the risk architecture for complex diseases, such as asthma. I will describe some of the challenges in this field, from sparsity of signals to non-standard missing data issues. I will focus the presentation of novel statistical methods to the use of mixed effects models for inference in two settings. The first is on estimating the heritability (proportion of variance attributed to genetic variation) of a functional phenotype using genome-wide SNPs and longitudinal observations for a quantitative trait. The second is a framework for the analysis of rare variants from sequence data where we harness population genetics theory to provide prior information on effect sizes that allows a general and powerful test for association.

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## Stochastic Target Approach to Ricci Flow on Surfaces

***Ionel Popescu***

We first set up a stochastic target approach to the Ricci flow in surfaces. Using this we prove that the normalized Ricci flow converges to a constant curvature metric on all surfaces of non-positive Euler characteristic. This convergence takes place in all $C^k$ topology and happens exponentially fast. The main technique we use is couplings of time changes Brownian motions. This gives the $C^0$ and $C^1$ convergence. However, to get the $C^2$ convergence we introduce a novel technique which is a coupling of three particles.

Our approach gives sort of ergodic like picture of why the normalized Ricci convergence takes place. This ergodicity is probabilistically viewed via coupling alluded above.

This is joint work with Robert W. Neel.

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## 1-dependent stationary sequences snd application to scan statistics

***Cristian Preda***

The scan statistics associated to an i.i.d. model is viewed as the maximum of a particular 1-dependent stationary sequence. Some recent results concerning the distribution function of the partial maximum sequence generated by a 1-dependent stationary sequence are then applied to approximate the scan statistics distribution. We present a review of our results for the one, two and three-dimensional scan statistics and compare our method with other existing methods. Joint work with George Haiman and Alexandru Amarioarei.

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## Precise asymptotics in strong limit theorems

***Aurel Spătaru***

Let $X_1$, $X_2$, ... be i.i.d. random variables, and set $S_n = X_1 + ... + X_n$, $n \geq 1$. Expressions of the form $P(|S_n| \geq xn^{1/p})$, $0 < p < 2$, $P(|S_n| \geq x\sqrt{n \log n})$

and $P(|S_n| \geq x\sqrt{n \log\log n})$ are termed probabilities of large, moderate and small deviations, respectively. We consider series of the type

$$f(x) = \sum_n w_n P(|S_n| \geq x b_n), \quad x > 0,$$

where $w_n \geq 0$ and $\sum_n w_n = \infty$, and $b_n$ is either $n^{1/p}$, $0 < p < 2$, $\sqrt{n \log n}$ or $\sqrt{n \log\log n}$. $w_n$, $n \geq 1$, are called *weights*, and $b_n$, $n \geq 1$, are called *boundaries*. Such functions $f$, and even $\int_\delta^\infty f(x)dx$, $\delta > 0$, are involved in the theory of branching processes. Under appropriate necessary and sufficient moment conditions, several authors (Hsu and Robbins (1947), Erdős (1949,1950), Spitzer (1956), Baum and Katz (1965), Davis (1968a,1968b), Lai (1974), Gut (1980), etc) proved that $f(x) < \infty$ for $x >$ some $a$. For each case we solve the precise asymptotic problem, i.e. we find an elementary function $g$ on $]a, \infty[$ and a finite number $l$ such that $f(x) \sim lg(x)$ as $x \searrow a$. Highlighting an interplay between probability theory and number theory, we outline random field versions of this problem.

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## A Hölder-Young inequality for the norms of generalized Gaussian Wick products

***Aurel Stan***

Da Pelo and Lanconelli have introduced, for every $t$ between 0 and 2, the following $t$–Wick product:

$$f \diamond_t g \quad = \quad \Gamma\left(\frac{1}{\sqrt{t}} I\right) \left[\Gamma(\sqrt{t}I)f \cdot \Gamma(\sqrt{t}I)g\right],$$

for random variables $f$ and $g$ measurable with respect to the sigma–algebra given by a Gaussian probability measure $\mu$, where $\Gamma(cI)$ denotes the second quantization operator of $c$ times the identity operator, for every constant $c$. We present the following inequality:
For all $t$ in [0, 2], if $\alpha$ and $\beta$ are real numbers between 0 and 1, such that:

$$\left(1 - \alpha^2\right)\left(1 - \beta^2\right) \quad = \quad \alpha^2\beta^2(t-1)^2,$$

then for all $p$, $q$, $r$ greater than or equal to 1, such that:

$$r - 1 \quad = \quad \frac{(p-1)(q-1) - \alpha^2\beta^2 t^2}{\alpha^2(q-1) + \beta^2(p-1) + 2\alpha^2\beta^2 t},$$

and for all $f$ in $L^p(\mu)$ and $g$ in $L^q(\mu)$, $\Gamma(\alpha I)f \diamond_t \Gamma(\beta I)g$ belongs to $L^r(\mu)$, and the following inequality holds:

$$\| \Gamma(\alpha I)f \diamond_t \Gamma(\beta I)g \|_r \quad \leq \quad \| f \|_p \cdot \| g \|_q .$$

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## Modeling distribution functions and quantiles for processes with complex temporal and spatial dependencies

***Dana Sylvan***

The study of probability laws or, equivalently, of quantiles of distribution functions, is fundamental in Statistics. When the data are not independent, modeling distribution functions and quantiles become hard mathematical problems, with a wide area of applicability. Many real-life processes have been observed to have complex structures, generated by their temporal and spatial dependencies, that in many cases show significant departures from normality and stationary behavior. Examples include processes in climatology, ecology, education, finance, medicine, and so on.

For example, in practice it is important to be able to model effects of high order quantiles, say, rather than modeling mean effects, on the grounds that people are adversely affected only by very high values of temperature, precipitation, air pollution. For these reasons, policy makers have issued environmental standards that are based on more relevant distributional characteristics, such as quantiles or threshold exceedance probabilities. While there exists a large body of research on modeling and predicting trends (mean functions), comparatively little is known about spatio-temporal behavior of probability distributions for environmental processes.

In this talk I will present statistical methodology for modeling probability distributions and quantiles in a wide class of processes with complex temporal and spatial structures. I will discuss asymptotic properties of various estimators and predictors, and will address uncertainty assessment, computational and implementation issues. For illustration, I will show applications on precipitation and air pollution space-time data.

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## From deterministic to stochastic via the characteristic systems

***Constantin Vârsan***

In this talk some solutions for linear and nonlinear SPDE (stochastic partial differential equations) are presented. These solutions are obtained from deterministic hyperbolic equations involving stochastic perturbations generated by a finite set of vector fields which commute using Lie bracket multiplied by a vectorial Wiener process In the linear case the hyperbolic equation comes from a higher equation determined by an algebraic derivation.On the other part the nonlinear case starts with a nonlinear hyperbolic equation and the stochastic perturbation is generated using a finite set of nonlinear vector fields which commute using Lie bracket. In both cases the solution of the associated SPDE can be represented explicitly using so called Doss-Sussman type of transformation.

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