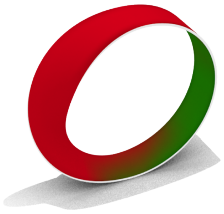

Book of Abstracts

Joint Austrian-Hungarian Mathematical Conference 2015

Széchenyi István University, Győr, 25-27 August 2015

Speaker: **Ambrus, Gergely** (MTA Rényi Institute)
Author(s): Gergely Ambrus
Title: **Small subset sums**
Abstract: Given a d-dimensional normed space, n vectors whose lengths are at most one and their sum is zero, and a k at most n, there exists a subset of the vectors of cardinality k such that the norm of their sum is at most the upper integer part of $d/2$. This bound is sharp.

Speaker: **Balazs, Peter** (Acoustics Research Institute)
Author(s): Peter Balazs, Karlheinz Gröchenig
Title: **Notes on intrinsically localized frames**
Abstract: In this paper the we provide some detailed results for intrinsically localized frames. In particular, we show explicit results for the associated Banach space corresponding to bounded sequences, i.e. the corresponding 'distribution space'. We state duality results of these spaces. We give formulas for the frame-related operators in a strong sense, and show a new classfication result for localized Riesz sequences.

Speaker: **Barany, Imre** (MTA Renyi Institute)
Author(s): Imre Barany
Title: **Universal points**
Abstract: Let K be a convex body in R^3, and z be a point on its boundary where the tangent plane $T(z)$ to K at z is unique. Let $K(z,t)$ denote the intersection of K and the plane parallel with $T(z)$ and at distance t from $T(z)$, so $K(z,t)$ is a 2-dimensional convex set. The point z is called universal if for every 2-dimensional convex body L there is a null-sequence t_n such that the shape of $K(z,t_n)$ tends to the shape of L. We show that a typical boundary point of a typical convex body K in R^3 is universal. Here typical is meant, in both cases, in Baire category sense. Joint work with Rolf Schneider.

Speaker: **Berg, Astrid** (Vienna University of Technology)
Author(s): Astrid Berg
Title: **The Lutwak-Petty projection inequalities for Minkowski valuations**
Abstract: The Petty projection inequality is an affine isoperimetric inequality for the volume of the polar projection body of order $n-1$, which was generalized by Lutwak to projection bodies of order i. It was recently proven by Haberl and Schuster, that the Petty projection inequality can be extended to $(n-1)$-homogeneous Minkowski valuations intertwining rigid motions which are genereated by zonoids of revolution.

In this talk we present a generalization of the Lutwak-Petty projection inequalities to such Minkowski valuations which are i-homogeneous. To this end we present a version of the Busemann-Petty centroid inequality for a generalized centroid body operator. We identify Lutwak's inequalities as the strongest among our family and relate our results to the classical isoperimetric inequalities, comparing volume and intrinsic volumes of a convex body and to a conjecture of Lutwak on affine quermassintegrals.

Speaker: **Biro, Peter** (Hungarian Academy of Sciences)
Author(s): Peter Biro, Iain McBride
Title: **Integer programming methods for special college admissions problems**
Abstract: We develop Integer Programming (IP) solutions for some special college admission problems arising from the Hungarian higher education admission scheme. We focus on four special features, namely the solution concept of stable score-limits, the presence of lower and common quotas, and paired applications. We note that each of the latter three special feature makes the college admissions problem NP-hard to solve. Currently, a heuristic based on the Gale-Shapley algorithm is being used in the application. The IP methods that we propose are not only interesting theoretically, but may also serve as an alternative solution concept for this practical application, and other similar applications.

Speaker: **Bolla, Marianna** (Budapest University of Technology and Economics)
Author(s): Marianna Bolla
Title: **Discrepancy and spectra**
Abstract: The k-way discrepancy $md_k(A)$ of a rectangular array A of nonnegative entries is the minimum of the maxima of the within- and between-cluster discrepancies that can be obtained by simultaneous k-clusterings (proper partitions) of its rows and columns. In Theorem 1, irrespective of the size of A, I will give the following estimate for the kth largest non-trivial singular value of the normalized table: $s_k \leq 9md_k(A)(k+2-9k\ln md_k(A))$, provided $0 < md_k(A) < 1$ and $k \leq rank(A)$. This statement is the converse of a former theorem, where I estimated the constant of the pairwise volume-regularities of the above clusters by s_k, and the proof uses some lemmas and ideas of S. Butler, who treated the $k = 1$ case as the converse of the generalized form $md_1(A) \leq s_1$ of the expander mixing lemma. The result naturally extends to the singular values of the normalized adjacency matrix of a weighted undirected or directed graph (Propositions 1,2), and gives useful tools for the practitioners to find homogeneous patterns in their data via SVD.

Speaker: **Bollobás, Béla** (University of Cambridge and The University of Memphis)
Author(s): Béla Bollobás
Title: **Extremal and Random Cellular Automata**
Abstract: A cellular automaton, introduced in the 1940s by von Neumann after a suggestion of Ulam, is an interacting particle system. In its simplest form it is a collection of sites of a grid, with each site in one of finitely many states'. Starting with a certain configuration, at each time-step the system updates itself according to some fixed rule: each site goes into a state that depends only on the states of a few nearby sites. Examples include the Ising model of ferromagnetism, many simple models of the brain, and Conway's Game of Life'. Despite much effort, a general theory of cellular automata is still far out of reach.

One of the simplest cellular automata is *bootstrap percolation with infection parameter* r, introduced in 1979. This process is an oversimplified model of the spread of an infection on a graph: each site may be *healthy* or *infected*, with an infected site remaining infected for ever, and a healthy site getting infected if it has at least r infected neighbours. I shall present some basic facts about bootstrap percolation, and will describe some important theorems proved by Aizenman, Lebowitz, Cerf, Manzo, Cirillo and Holroyd, culminating in some substantial results I have proved with Balogh, Duminil-Copin and Morris.

Recently, with Smith and Uzzell, I introduced a far-reaching generalization of bootstrap percolation on lattices and lattice-like finite graphs. The only assumptions we made about such a process is that it is local, homogeneous and monotone. Surprisingly, much can be proved about these very general processes; in particular, they can be classified into three classes, telling us much about the critical probability. In two dimensions such a classification was given by Smith, Uzzell, Balister, Przykucki and me. Very recently, Duminil-Copin, Morris, Smith and I have gone much further: we have proved fairly precise results about the process in all dimensions, indicating that a rich theory of 'universality theory' is waiting to be discovered.

In my lecture, *aimed at a general audience*, I shall give a brief introduction to some aspects of cellular automata, ending with a number of recent results. There are no prerequisites: I shall assume *very little* and will keep the lectures *very simple*.

Speaker: **Chazottes, Jean-René** (CPHT, École Polytechnique)
Author(s): Jean-René Chazottes
Title: **Concentration inequalities: from the law of large numbers to dynamical systems**
Abstract: Starting from an elementary but fundamental example, namely partial sums of independent random variables, I will introduce concentration inequalities. Such inequalities allow to control the fluctuations of a nonlinear function of many random variables, provided it is separately Lipschitz. I will then show the measure concentration phenomenon in action in the case of discrete-time dynamical systems. This is natural situation where nonlinear functions of dependent random variables occur.

Speaker: **Cristea, Ligia Loretta** (Karl Franzens Universität Graz)
Author(s): Ligia L. Cristea, Bertran Steinsky
Title: **On the topology of labyrinth fractals**
Abstract: Labyrinth fractals are a special case of Sierpinski carpets. They were introduced and studied in two papers by Cristea and Steinsky published a few years ago (1,2) and were shown to be self-similar dendrites in the unit square. These fractals are constructed iteratively by using a pattern (or labyrinth set) that is the generator of the fractal. Under certain conditions on the labyrinth pattern that generates the self-similar fractal, the length of the path (in the fractal) between any two points of the fractal is infinite. Mixed labyrinth fractals (3) are one possible generalisation of labyrinth fractals. They are in general not self-similar. Among other, we have shown that they are dendrites, and we study properties of the paths.

Ackonwledgement
Ligia L. Cristea founds her research by means of the stand-alone FWF-project P27050-N26.

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Speaker: **Csendes, Tibor** (University of Szeged)
Author(s): Tibor Csendes
Title: **Optimization in Surgical Operation Design**
Abstract: A new treatment of oncological diseases is brachytherapy that means the insertion of low level radiation isotopes into the organ to be healed. This cure has much less side effects than traditional radiation therapy, while being as much effective. The problem is to determine how to position the 40-90 capsules in such a way that the tissue to be healed should obtain at least a given level of dose, while the surrounding other organs should absorb a dose less than a prescribed level. The related nonlinear optimization problem is of medium dimensionality (120-270). The global optimization problem is very redundant, and it has several forms of symmetries as well. The present work aims to speed up the optimization, to allow different intensity radiation capsules, and to decrease the cost of the treatment. The first test results obtained for artificial models are reported.

Speaker: **Erdős, László** (Institute of Science and Technology Austria)
Author(s): László Erdős
Title: **Universality of random matrices and log gases**
Abstract: Eugene Wigner's revolutionary vision predicted that the energy levels of large complex quantum systems exhibit a universal behavior: the statistics of energy gaps depend only on the basic symmetry type of the model. These universal statistics show strong correlations in the form of level repulsion and they seem to represent a new paradigm of point processes that are characteristically different from the Poisson statistics of independent points. Simplified models of Wigner's thesis have recently become mathematically accessible. For mean field models represented by large random matrices with independent entries, the celebrated Wigner-Dyson-Gaudin-Mehta (WDGM) conjecture asserts that the local eigenvalue statistics are universal. For invariant matrix models, the eigenvalue distributions are given by a log-gas with potential V and the analogue of the WDGM conjecture asserts that the local statistics are independent of V. In this lecture I explain the main ideas leading to the recent solution of these conjectures.

Speaker: **Fazekas, István** (University of Debrecen)
Author(s): István Fazekas, Csaba Noszály, Attila Perecsényi, Bettina Porvázsnyik
Title: **Asymptotic results for a random graph model**
Abstract: To describe complex real-life networks several random graph models have been proposed (see [1], [2], [3], [4]). It is known that many real-world networks are scale-free ([1]). A random graph is called scale-free if its asymptotic degree distribution has a power-law tail.

In this paper, we introduce a random graph evolution method. During the evolution both the preferential attachment rule and the uniform choice of vertices are allowed. A vertex in our model is characterized by three parameters: by its degree and two weights. The weights of a given vertex describe the number of its interactions. The first weight is the number of those interactions when the given vertex is the center while the second weight means the number of interactions when the vertex is on the periphery. The asymptotic behaviour of the graph is studied. Besides mathematical results, numerical evidence is also given for the power-law distribution.

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Speaker: **Fetz, Thomas** (University of Innsbruck)
Author(s): Christian Pfeifer, Thomas Fetz
Title: **Decision strategies for backcountry skiers in avalanche terrain using fuzzy logic and imprecise probability theory.**
Abstract: In the Alps, most fatal snow avalanche accidents are caused by skiers or snowboarders. As a consequence several decision strategies for backcountry skiers have been established in the last two decades in order to prevent avalanche accidents or avalanche fatalities. The most important among them are: Munter's method of reduction, Snowcard method (DAV), Stop or Go (OeAV) and an empirically driven decision strategy [1].

In these strategies the fundamental input variables are $x =$ ""danger level of avalanche"", $y =$ ""incline of the slope"".

In our presentation we use limit state functions $g(x, y)$ which are less or equal to zero in cases where backcountry skiers trigger an avalanche and positive otherwise. Such functions g are obtained by a fuzzy logic approach translating the rules formulated in the above decision strategies. Limit state functions g may also depend on additional parameters (e.g. aspect of the slope, behaviour of skiers,...) and on further uncertainties which are modelled by random sets or by sets of probability measures in the framework of imprecise probability theory [2]. The goal is to develope a new encompassing mathematical basis for a rational decision strategy.

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Speaker: **Figula, Agota** (University of Debrecen)
Author(s): Agota Figula
Title: **Extensions of groups by weighted Steiner loops**
Abstract: The extension theory in the category of groups is a classical part of group theory (cf. [2], Kap. I, § 14 and § 16, [3], Chap. XII). In [4] the authors investigate thoroughly a variation of extensions which yields loops as extensions of groups by loops such that these extensions are the most natural generalization of Schreier's extension theory for groups. These extensions of groups A by loops S are given by two equations describing the action of S on A. Special types of extensions of groups of order 2 by Steiner loops play an important role in code theory. In [5] and [6] the authors study extensions of groups of order 2 by Steiner loops such that the corresponding Steiner triple system has an orientation.

A Steiner loop S equipped with a function $h : S \setminus \{e\} \to A$, where e is the identity element of S and A is a group, is called a weighted Steiner loop. We study in this talk Schreier's extensions L of groups A by weighted Steiner loops (S, h) such that for the factor system $f : S \times S \to A$ one has $f(x, y) = h(x)h(y)$ for all $x, y \in S \setminus \{e\}$ and S induces only the trivial automorphism on A. We call such extensions L Steiner-like loops. To obtain Steiner-like loops we have to decide in which groups the functional equations described in [4] have solutions and determine them explicitly. In this way we can describe all Steiner-like loops with interesting weak associative properties. We show that the restricted Fischer groups and their geometry play an important role for loop extension with right alternative property.

This talk is based on the publication [1].

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Speaker: **Fohler, Armin** (RICAM JKU)
Author(s): Armin Fohler, Walter Zulehner
Title: **A continuation method with Euler-predictor for parametrized problems in the framework of rotating electrical machines**
Abstract: For simulation and optimization of electrical machines the time-performance of finite element programs is very crucial, since many possible motor-geometries have to be evaluated to decide on an optimal geometry. Each simulation consists of many different rotor-to-stator positions to describe the behaviour of the machine during a whole rotation. The approach pursued in this work to reduce the time-consumption is the construction of a new predictor for each consecutive rotation step to get a better initial guess for the solution of the nonlinear problem we have to solve in each step.

Speaker: **Fridli, Sándor** (Eötvös Loránd University, Budapest)
Author(s): Sándor Fridli, Ferenc Schipp, Péter Kovács, Gergő Bognár
Title: **Rational functions, Malmquist-Takenaka system, ECG, EEG processing, CT, PET images**
Abstract: In this talk we present results and problems related to research projects in biomedical signal and image processing carried out by the research group of the Department of Numerical Analysis, Faculty of Informatics, Eötvös Loránd University (Budapest, Hungary). We are concerned with approximation,

compression, classification of Electrocardiogram (ECG) signals, epileptic seizure detection in Electroencephalograph (EEG) signals, objective image quality measurement of low dose human lunge Computer Tomograph (CT) scans, and mathematical modeling of dynamic human breast Positron Emission Tomograph (PET) scans. The attention is focused on the novel mathematical machinery developed for and inspired by these biomedical applications. In particular an adaptive transformation technique based on rational function systems has been developed. Problems like optimization, discretization etc. will be addressed in the talk. The so called transformation method is known to be one of the most effective methods used in signal processing. Especially, the wavelet method has gained high popularity over the recent years. We will show that our approach is more natural, flexible and as a result it outperforms the other methods in several respects. Examples will be given in ECG analysis and in epileptic seizure detection in EEG signals, where an adaptive and localized time-frequency representation of the signals is constructed. It is another transform, namely the Radon transform which is fundamental in the construction of CT images. Although CT scans are very efficient tools in tumor, in particular in lung tumor diagnosis they come with a high radiation exposure risk. Dose reduction on the other hand decrease image quality. That is why the objective quality measurement method developed and presented is relevant and useful. It can among others be used in quality enhancement processes. Our last topic will be the analysis of dynamic PET scans of human breast. The mathematical model containing medical parameters and the glucose level of both the blood and the tumor is investigated. The motivation behind it is to determine the best therapy by means of the parameters generated.

Speaker: **Fuchs, Clemens and Hajdu, Lajos** (Paris Lodron University of Salzburg and University of Debrecen)
Author(s): Clemens Fuchs, Lajos Hajdu
Title: **30 years of collaboration**
Abstract: We highlight some of the most important points of the long standing and very fruitful collaboration of the Austrian (Diophantine) Number Theory research group and the Number Theory and Cryptography research group of Debrecen. However, we do not plan to be complete in any sense but give some interesting data and selected results that we find particularly nice. At the end of the talk we will focus on two topics in more details, namely a problem that origins from a conjecture of Rényi and Erdős and another one that origins from a question of Zelinski (on the unit sum number), which we present in turn.

Speaker: **Gerhold, Stefan** (Vienna University of Technology)
Author(s): Stefan Gerhold
Title: **Small-maturity options in the moderate regime**
Abstract: Asymptotic approximations of option prices are very useful for fast model calibration and to understand the influence of model parameters on prices. In this talk we focus on small-maturity expansions in stochastic volatility models. The at-the-money and out-of-the-money regimes are well understood, related respectively to central limit theorems and large deviations theory. We discuss an intermediate regime, where strike converges to spot for small maturity at "moderate" speed. Numerical evaluation of the resulting expansions is easier than for the OTM regime. Furthermore, a novel relation between call prices and implied volatility skew is uncovered. We illustrate our results numerically in the Heston model.

Speaker: **Gáspár, Csaba** (Széchenyi István University)
Author(s): Csaba Gáspár
Title: **A Variant of the Method of Fundamental Solutions Without Using Fundamental Solutions**
Abstract: The original form of the Method of Fundamental Solutions provides an approximate solution of a partial differential equation as a linear combination of the fundamental solution shifted to some external source points. The unknown coefficients of the linear combination can be computed by enforcing

the boundary conditions which are prescribed at some boundary collocation points. The method is simple, quite accurate, easily programmable and can be generalized to multi-dimensional problems in a natural way. The price to be paid is that it results in extremely ill-conditioned linear systems of equations, which leads to severe computational difficulties. Another limitation of the method is that a fundamental solution has to be explicitly known. To avoid the ill-conditioned character of the approach, the source points are sometimes allowed to coincide with the boundary collocation points. In this case, however, special tricks have to be applied to treat the appearing singularities.

In this talk, a different approach is presented. Instead of using the fundamental solution explicitly, the original problem is extended to a larger domain. This external problem is solved by simple finite volume schemes on a non-uniform cell system which is generated by the boundary collocation points on the basis of the quadtree/octree algorithm, therefore the method is essentially meshfree. The a priori unknown external boundary conditions are defined in such a way that the original boundary conditions are satisfied at the boundary collocation points. This can be performed by simple Richardson type iterative techniques. The approach can be considered a special version of the Method of Fundamental Solutions; however, it leads to a much better conditioned problem. In addition to this, the explicit use of the fundamental solution is not needed. Embedding the method in a natural multi-level context, the computational cost can be significantly reduced; moreover, the problem of severely ill-conditioned systems of equations is completely avoided.

Speaker: **Gerencsér, László** (Institute for Computer Science and Control (MTA SZTAKI))
Author(s): László Gerencsér, Máté Mánfay, Balázs Gerencsér
Title: **The Empirical Characteristic Function (ECF) method in system identification**
Abstract: The objective of this talk is to extend the ECF method to identify finite dimensional linear stochastic systems driven by an i.i.d. noise process, the characteristic function of which is known to belong to a parametric class of characteristic functions given in closed form.

The ECF method was originally developed for the estimation of the unknown parameters of a characteristic function using i.i.d. samples. It is known to be essentially as efficient as the maximum likelihood method. Extesnions for the case of dependent data have been only partially succesul in the literature.

The proposed method is the first known example of an extension of the ECF method for dependent data that is essentially efficient. Our results will be supported by extensive numerical experiments.

Speaker: **Gruber, Peter** (TU Wien)
Author(s): Peter Gruber
Title: **Structure preserving mappings of spaces of convex bodies**
Abstract: TBA

Speaker: **Hackmann, Daniel** (Johannes Kepler University)
Author(s): Daniel Hackmann, Alexey Kuznetsov
Title: **The density of the supremum of an alpha-stable process**
Abstract: Levy processes are popular and well-studied stochastic processes in part because they strike a good balance between fit – they represent real-world phenoma reasonably well – and tractability – there is a well established theory which allows for calculation of results. A particular Levy process known as an alpha-stable Levy process is more tractable still because it satisfies the so-called "self-similarity" property: Essentially, a scaling of the process in space is equivalent to a scaling in time, and the nature of this scaling is controlled by a parameter alpha. We find many applications of alpha-stable, or just stable, processes in the natural sciences where they also go by the name Levy flights. An important area of research is the running supremum of a stable process, in particular its density. Finding an expression for this density is a problem that has been considered since the 1950s, and has been solved in certain special cases by researchers such as Darling, Heyde, Bingham, Doney and others. In this talk I will speak about the connection between this problem and the problem of finding an expression for the Wiener-Hopf

factors of a stable process. I will discuss the recent work of Kuznetsov who has found a general expression for the Wiener-Hopf factorization, and then the work of Hubalek and Kuznetsov who exploit this result to obtain an absolutely convergent double series representation for the density of the supremum for almost all stable processes with irrational parameters. Their work leaves a gap, in that it fails to provide an expression for processes where alpha is in some sense too close to a rational number. I will present a way to close this gap and show that the original absolutely convergent double series can be rearranged so that it converges conditionally for all irrational alpha.

Speaker: **Hajba, Tamás** (Széchenyi István University)
Author(s): Tamás Hajba, Zoltán Horváth, Christian Kiss-Tóth
Title: **Mathematical methods of production line optimization**
Abstract: Permutation flow shop problems (PFSPs) with makespan minimization that model production lines working in the industry often have some special features: they are typically large-scale and the jobs can be sorted into types so that jobs of the same type have equal processing time values at each machine. We define the related R-PFSP, the Permutation with Repetition Flow Shop Problem, which is of less complexity if the number of types is bounded. We construct MILP models for R-PFSPs. The MILP models and the NEH, iterated greedy and Paco heuristics are applied to solve industrial like problems. The experiments show that large scale PFSPs with few types can be effectively solved optimally by using MILP models. Furthermore it turns out that on industrial like problems the 3 heuristics give nearly optimal solutions.

Speaker: **Hannusch, Carolin** (University of Debrecen, Institute of Mathematics)
Author(s): Carolin Hannusch, Piroska Lakatos
Title: **Self-dual binary codes**
Abstract: Let $K = GF(2)$ and G be an elementary abelian 2-group of order 2^m. Then the 2^l-dimensional subspaces of the modular group algebra $K[G]$ can be considered as linear codes. If the minimum (Hamming) weight of the 2^l-dimensional subspace C is 2^d then C is called a linear code (with parameters $(2^m, 2^l, 2^d)$).

For abelian G Berman [1] initiated the study of the Jacobson radical of the group algebra $K[G]$. He proved that the well known Reed-Muller (RM)-codes are the powers of the radical of the group algebra. The Generalized Reed-Muller (GRM) codes were introduced by Kasami, Lin, and Peterson [5] over an arbitrary finite field as the powers of the radical of the underlying group algebra.

The group algebra approach enables us to construct binary self-dual codes with good properties. Since $K[G]$ is isomorphic to $K[X_1, \ldots, X_m]/(X_1^2, \ldots X_m^2)$, the ambient space of the codes can be described by polynomials of m-variables.

The code C in $K[G]$ is called a *monomial code* [2] if it is generated by some monomials of the form $X_1^{b_1} X_2^{b_2} \ldots X_m^{b_m}$, where $0 \leq b_i \leq 1$.

The main objectives of this talk are to provide a construction of self-dual binary codes of given distance [3] and to provide a new method for the construction of self-dual binary codes with parameters $(2^{2k}, 2^{2k-1}, 2^k)$ for all positive integers k [4].

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Speaker: **Horváth, Zoltán** (Széchenyi István University)
Author(s): Zoltán Horváth
Title: **Numerical analysis of positively invariant convex sets and entropies**
Abstract: The state space of dynamical systems arising in mathematical modelling of many real time problems – in particular transport processes, diffusion-reaction-advection problems – often posseses positively invariant convex subsets (which are subsets of the state space from which trajectories do not escape forward in time) or have convex functionals (e.g. entropy-like or Lyapunov functions) that are decreasing along the solutions.

When approximating these dynamical systems numerically, e.g. in the core of a computational simulation of the real life process, it is not trivial at all what numerical processes and under which numerical time discretization steps preserve the positive invariance of these sets or the functional of the numerical solutions decrease which do so for the continuous time dynamical system. This is an important problem in many simulations since, for example, it makes no sense physically and even causes the break down of the computational code when a concentration becomes negative or state variables become infeasible for fluid flow problems. Simply high order accuracy and stability of the numerical methods do not guarantee the fulfilment of the discrete properties under examination.

In this lecture we present the state-of-the-art analysis developed in the past decades and a novel analysis for the problem. We show that the novel analysis is more general for implicit methods than the state-of-the-art and actual important examples of applied mathematics where only the novel approach works.

Speaker: **Hubalek, Friedrich** (TU Wien)
Author(s): Friedrich Hubalek, Paul Krühner, Thorsten Rheinländer, Sabine Sporer
Title: **Brownian excursion limits for the avalanche length in a binomial limit order book model**
Abstract: We briefly describe the mechanics of a stylized limit order book model for an electronic exchange, which is based on the simple symmetric random walk. While the order volume is a special process, we take up the study of the avalanche length of trades, that was begun by Thorsten Rheinländer and his students in a Brownian motion model.

By more or less elementary limit calculations we connect to Ito?s theory of Brownian excursions. In doing so we briefly, but inevitably meet the error, gamma, zeta, xi, theta, Bessel, and the Gauss hypergeometric function.

We derive the generating function for the simplified and full avalanche length, their Brownian limits, and study the distribution of the simplified avalanche length in some detail.

Speaker: **Janecek, Stefan** (RICAM / Mathconsult)
Author(s): Stefan Janecek
Title: **Mathematical simulation of iron ore sintering**
Abstract: For the efficient operation of a blast furnace in steel making, the burden material is often prepared through sintering. In this process, iron-bearing materials of fine particle size are converted into coarse agglomerates through partial fusion. Sinter plants are built to order, taking into account local factors such as legal regulations regarding emissions. Their operation conditions cannot be changed easily without the danger of causing expensive outages in the whole steel production chain. As a result, there is strong industry demand for realistic simulations of sinter plants. In this talk, we present the mathematical modeling and numerical simulation of the physical and chemical processes occuring in a sinter plant, as well as a small case study on how our simulation is employed in practice.

Speaker: **Kallós, Gábor** (Széchenyi István University)
Author(s): Gábor Kallós
Title: **Expansions in Noninteger Bases**
Abstract: The properties of the expansions of real numbers in noninteger bases have been systematically investigated since the late 50s, when the seminal works by Alfréd Rényi and William Parry were published. The original idea was to choose the digits in ""greedy"" way, but the analysis was extended soon to general β- or q-expansions. In this talk we give a brief review about the results in this field.

The central questions in the presentation are as follows: What kind of expansions can be defined? How many possible expansions can exist? Which parts can occur in general and special expansions? What type of regularities can be found in expansions? Especially, what are the 1-expansions like?

Especially, we emphasize the activities and results of Professors Paul Erdős, Zoltán Daróczy, Imre Kátai and Vilmos Komornik, which mostly induced the author's present work and investigation.

Speaker: **Keszegh, Balázs** (MTA Rényi Institute)
Author(s): Balázs Keszegh, Xuding Zhu
Title: **Paintability of the lexicographic product of graphs**
Abstract: We study the paint number of the lexicographic product of graphs. We prove that if G has maximum degree Δ, then for any graph H on n vertices, $\chi_P(G[H]) \leq (4\Delta + 2)(\chi_P(H) + \log_2 n)$.

Speaker: **Kis, Tamás** (MTA SZTAKI)
Author(s): Tamás Kis
Title: **Planning and scheduling problems in the digital factory**
Abstract: In the talk I will overview some mathermatical optimization problerms that emerge in the course of solving complex production planning and scheduling problems. I will highlight the difficulty of the problems, and some results achieved.

Speaker: **Kovács, Zoltán** (Johannes Kepler Univesity Linz)
Author(s): Zoltán Kovács
Title: **Obtaining conjectures by using the Relation Tool in GeoGebra**
Abstract: Teaching elementary geometry has a minor focus in most secondary schools in Europe. It has, however, deep traditions in Hungary, and (mostly in advanced classes) also in Austria. On the other hand, elementary geometry has been more popular in secondary schools in the last decade because of the convenient graphical ways of demonstrating relationships between points, lines and circles, by utilizing computers. In this contribution usual relationships between objects of Euclidean geometry constructions will be collected by using GeoGebra's Relation Tool which was recently extended by an automated prover subsystem. The Relation Tool can compute proofs of Euclidean geometry statements and obtain sufficient conditions which are typical in planar geometry (but usually not discussed in most classrooms), such that non-degeneracy of a triangle.

Speaker: **Kulcsár, Nárcisz** (Széchenyi István University)
Author(s): Nárcisz Kulcsár
Title: **Bridges between mathematics and real life in mass higher education**
Abstract: Nowadays all over Europe higher education faces the problems of mass education. The growth of participation has a strong impact on tertiary education from the nano (individual) level to the supra (international) level. Higher education tried to react to these changes with new organizational methods, curriculums, pedagogical and andragogical methods. In contrast with elite higher education the relationship between professor and student became subordinated in mass higher education. New mediators appeared which can be technical devices, computers and internet.

Teaching natural sciences especially physics, chemistry and mathematics faces problems, interest of students turns away from these sciences. In engineering education in higher education mathematics is a

basic course in which students do not like immerse deeply. Teachers struggle with this problem day by day and they think they do not have enough impact on students because of mass education (300-400 students in a course). Is there any way to recapture their interest in mathematics?

In my presentation I would like to present what kind of elements of experiences can be utilized in mathematics, what kind of technical mediators can help teachers to illustrate mathematical problems, what is the role of visualization, how can we make relations between an abstract science and real world. Through experiential learning not only algorithmic thinking but heuristic thinking can be improved as well which is more useful to solve technical problems.

Speaker: **Lapkova, Kostadinka** (MTA Renyi Institute of Mathematics)
Author(s): Kostadinka Lapkova
Title: **On the k-free values of the polynomial $xy^k + C$**
Abstract: Consider the polynomials $f(x, y) = xy^k + C$ for $k \geq 2$ and any nonzero integer constant C. We are interested in deriving an asymptotic formula for the k-free values of $f(x, y)$ when $x, y \leq H$. The strongest tool we would use is a recent generalization of the determinant method due to Reuss.

Speaker: **Markót, Mihály Csaba** (University of Vienna)
Author(s): Mihály Csaba Markót, Hermann Schichl
Title: **The COCONUT framework for interval global optimization**
Abstract: The COCONUT Environment, developed in the Computational Mathematics Group of the University of Vienna under the leadership of Arnold Neumaier and Hermann Schichl, is a modular open-source environment for global optimization and constraint satisfaction problems. Its primary goal is to provide numerical algorithms and solver components that are based on interval arithmetic, in order to obtain numerically rigorous results (e.g., mathematically correct enclosures of the respective exact solutions). The original COCONUT project was funded by an IST programme of the European Community (2000-2004). Since then, COCONUT has been developed further by the authors in smaller scale projects supported by the Austrian Science Fund (FWF).

The modularity of the COCONUT system means that it can be expanded by commercial and open-source solver components. Thus, it integrates existing tools and methods, and promotes the development of new, state-of-the-art solvers.

In the talk we give an overview of the concepts used in COCONUT and briefly introduce its main components. COCONUT represents the optimization problems in the form of directed acyclic graphs. The leaves of the graphs are the variables, with initial interval bounds representing the bound constraints. The order of evaluations is represented by directed edges in a natural way. The model functions (objective function(s), constraints, auto-generated optimality conditions) are located on the top level of the DAG.

Furthermore, a branch-and-bound procedure is also represented as a DAG in COCONUT, in the so-called search graph. Here each node of the search graph corresponds to a node of the branch-and-bound search tree. The advantage of this approach is that in each node it is enough to store the difference of the actual node from its parent(s), in the form of special data structures called deltas.

The currently analyzed node of the search graph is extracted into a work node, on which various evaluations can be made and inference engines (solver components) can work. In the presentation we briefly show the methodology behind the available evaluators, including real and interval type function evaluations, first and second order derivatives with backward automatic differentiation, slopes, slopes of derivatives, bicentered forms, etc. Then we introduce some of the most important inference engines, including the ones for calculating inclusion/exclusion boxes, performing local search, and doing constraint propagation.

We conclude the talk by giving an insight into some of the ongoing developments and show a few applications from our collaborative partners where COCONUT solvers have been employed.

Speaker: **Molnár, Emil** (Budapest Univ. Techn. Econ., Inst. Math.)
Author(s): Emil Molnár
Title: **Regular tilings coded by D-symbols and their realizations in homogeneous geometries**
Abstract: There is a coding method for any regular d-dimensional polyhedral tiling based on its barycentric subdivision and $d+1$ adjacency operations. This code is a D-symbol (in honour to B.N. Delone (Delaunay), M. S. Dalaney and A. W. M. Dress), represented also by a $d+1$-coloured graph and a $N/(d+1)\times(d+1)$ matrix funktion on its finite vertex set with some natural requirements. These can be implemented to computer, and so classification problems can be solved (sometimes of super-exponential complexity). Well-formed problems can also be realized in homogeneous 2- and 3-geometries as the author will report about, partly on joint works with his doctor students Rita Koós and Lajos Boróczki.

Speaker: **Nagy, Benedek** (University of Debrecen/Eastern Mediterranean University)
Author(s): Benedek Nagy
Title: **On the number of shortest paths by neighborhood sequences on the square grid**
Abstract: When we are using a computer/digital camera/tablet we are using a digital space, i.e., the square grid with points/pixels addressed by integer coordinate pairs. The digital geometry is essentially different from the Euclidean geometry. Working on digital spaces, e.g., on a computer screen or on digital images the digital, path-based distances have several advantages. Path-based distances are based on the concept of neighborhood relation among the points of the grid. On the square grid there are two basic neighborhood relations: two points are considered as 1-neighbors if one of their coordinates coincides and the difference on the other is at most 1. A step from a point to one of its 1-neighbor points, a 1-step, may change one coordinate by at most 1. One may also allow diagonal movements: two points are 2-neighbors if their coordinate differences are at most 1, consequently in a 2-step both or any of the coordinates can be changed by at most 1. The first two digital distance functions, the cityblock (or Manhattan) and the chessboard distances, using these neighborhood relations in the paths, are very rough approximations of the Euclidean distance, and therefore there are various other digital distances considered to lower the rotational dependency. One of these approaches is the usage of neighborhood sequences giving the flexibility to change only 1 or at most 2 coordinates in a step of a path depending on a predefined sequence. Formally, a neighborhood sequence B = (b(i)) is an infinite sequence containing only the elements of the set 1,2. A path defined by B from a point p to a point q of the grid is a sequence of points $p_0, p_1, ?, p_n$ such that $p_0 = p$ and $p_n = q$, moreover p_{i-1} and p_i are b(i)-neighbors for every $1 \leq i \leq n$. The length of such a path is n. Obviously, there are several B-paths between any two points and some of them (at least one) has a minimal length; this minimal length gives the B-distance of the points. A greedy algorithm that provides a shortest path can be found in [2], while a general formula to compute B-distances can be found in [3]. In digital geometry there are usually more than 1 minimal/shortest paths between 2 points, and it is an interesting combinatorial problem to find their numbers.

In this talk we are addressing a counting problem of discrete mathematics (discrete geometry): in [1], Das gave formula for the number of shortest paths between any two points of the square grid using special distance functions, e.g., the cityblock and the chessboard distances. Actually, by cityblock distance, i.e., using the neighborhood sequence B containing only 1?s, the distance is the sum of the coordinate differences, say i+j, and the number of shortest paths is $\binom{i+j}{i} = \binom{i+j}{j}$. In this talk we address a more general problem: we are counting the number of minimal B-distances from the point p to the point q of the square grid, where apart from the coordinates of the points, the neighborhood sequence B is also a parameter. The formula for the number of shortest paths can be computed in 3 different ways depending on the coordinate differences of the points and the number of 2?s in the beginning of the sequence B, i.e., in the part that is used to provide the shortest path(s). In a nutshell the cases can be considered as follows. Let the maximal coordinate difference of the two points (p and q) be j, and the other coordinate difference be i. Moreover, let d denote the B-distance of the points.
Case 1: If the number of 2?s among the first j elements of B is exactly i, then there is exactly 1 shortest path from p to q (or from q to p). In this case d = j.

Case 2: If there are less 2?s among the first d elements of B than i, then some of the ?diagonal moves? (of the previous case) must be substituted by a sequence of (two consecutive) 1-steps (changing both of the coordinates, one after the other). Therefore, d ¿ j, in this case. The number of minimal paths, in this case, can be considered as the combination based on the 1-steps: among the 1-steps some of them change the first coordinate, the others change the second coordinate, but the order of these steps can be arbitrary (among the 1-steps). Consequently, the formula that gives the result can easily be written by a binomial coefficient (in a very similar way to the case of cityblock distances).
Case 3: In this case there are more 2?s in the initial part of B than the number of 2?s that is needed in a shortest path. This is the most complex case, even the distance d = j. There are various shortest paths: in some of them instead of the possible 2-steps only 1-steps are done (that is allowed in any B-paths). However, instead of having two (consecutive) one steps in one direction instead of 2-steps (e.g., having steps with vector (0,1) twice), one may also have a shortest path having here two 2-steps defined by vectors (1,1) and (-1,1) in any order. Consequently, the formula here uses summations on the possible numbers of these sequences of 1?s or 2?s. In this case the result is more closely related to the case of chessboard distance by Das.

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3. Benedek Nagy: Distance with generalized neighbourhood sequences in nD and ∞D. Discrete Applied Mathematics 156(12): 2344-2351 (2008)

Speaker: **Nagy, Dániel** (Eötvös Loránd University)
Author(s): Dániel T. Nagy
Title: **Incomparable copies of a poset in the Boolean lattice**
Abstract: Let B_n be the poset generated by the subsets of $[n]$ with the inclusion as relation and let P be a finite poset. We want to embed P into B_n as many times as possible such that the subsets in different copies are incomparable. The maximum number of such embeddings is asymptotically determined for all finite posets P as $\frac{\binom{n}{\lfloor n/2 \rfloor}}{M(P)}$, where $M(P)$ denotes the minimal size of the convex hull of a copy of P. We discuss both weak and strong (induced) embeddings.

The talk is based on joint work with Gyula O.H. Katona.

Speaker: **Nehaniv, Chrystopher Lev** (University of Hertfordshire)
Author(s): Chrystopher L. Nehaniv, John Rhodes, Gabor Horvath, Attila Egri-Nagy, Karoly Podoski, Paolo Dini, Piet Van Mieghem
Title: **The Flow Semigroup: An Algebraic Invariant for Graphs and Digraphs, and Some Results on Its Structure**
Abstract: J. Rhodes and C. L. Nehaniv showed that the transformation semigroup generated by associating to each edge of a digraph an idempotent mapping (on the vertices of the digraph collapsing just the source node to its target) is an algebraic invariant for digraphs and is a complete invariant for graphs (regarding them as digraphs with edges always going in both directions). This provides very different information to the spectrum of the graph. The so-called defect k groups arising within these flow semigroups are also invariants, and are natural subsystems in the wreath product decomposition of the flow semigroup invariant. Here we study the structure of the flow semigroup for certain examples and strongly connected digraphs in order to describe its structure, including the structure of its defect k subgroups.

Speaker: **Neuper, Walther** (Graz University of Technology)
Author(s): Walther Neuper
Title: **Brigding Highschool — University in Mathematics**
Abstract: The first two contributions shall be related such that they give motivations for discussion throughout the minisymposium.

The first contribution presents empirical evidence of unsufficient mathematical knowledge learned during secondary school. There are other studies which confirm such lack of knowledge. And there are EU-wide efforts to fight this lack, where the Rocard-Report triggered several projects like Sinus, for "inquiry based learning" of the same like before. Now, are these efforts sufficient to increase the number of students successful in science?

The second contribution presents a joyful approach to mathematics, permutation games. Their graphical representation addresses intuitive understanding and attracts students' interest. In addition, the contribution exposes relations to abstract mathematical concepts and finally rigorous formal proof in the theorem prover *Theorema* — apparently a perfect approach to close the gap between intutive highschool math and formal mathematics at university.

From the tension between the two contributions questions shall be tackled, like

- Is motivating interest by "inquiry-based learning" sufficient to increase the number of students succesfull in science?
- Shall we approach mathematics via games in high-school?
- How appropriately are engineers and natural scientists are prepared by high-school mathematics?
- At what level of insights proof can be tackled at school?
- Do we teach too much (of what) – do we teach too little (of what)?

Speaker: **Neuper, Walther** (Graz University of Technology)
Author(s): Walther Neuper
Title: **Educational Software based on Theorem Prover Technology**
Abstract: After development not noticed by the public for decades, computer theorem provers only recently attracted attention by the proof of the Kepler Conjecture, the second distinctive success after the proof of the Four Colour Theorem in 2005.

Education sooner or later re-used software successful in science and industry (Computer Algebra Systems, Spread Sheets, etc; only Dynamic Geometry Systems were triggered by education itself). This talk presents a prototype for a new generation of educational software based on Theorem Prover (TP) technology.

This new generation of educational software in mathematics comes with these promises:

- TP-based systems model all of mathematics: axioms, definitions, proofs, problems captured by formal specifications, algorithms and their properties including respective proofs.
- TP-based systems are interactive models of mathematics: they can support interactive learning as is possible with chess programs — learning happens by watching and investigating moves|steps (in calculations similiar to pen&paper) of the system, by trying own moves|steps and getting rigorous reliable feedback on erroneous moves|steps; and if the student gets stuck, the system can give hints for the next move|step.
- TP-based systems are transparent models of mathematics: The knowledge, TPs operate on, are represented in a human readable format. So, in principle, all knowledge can be made transparent to the user at any step of a proof or of a symbolic computation.

The prototype will be presented and discussed with respect to these promises.

Speaker: **Of, Günther** (TU Graz)
Author(s): Günther Of
Title: **Analysis and Applications of Finite and Boundary Element Coupling**
Abstract: In this talk, we present recent results of the analysis of the coupling of the weak formulation and boundary integral equations for transmission problems of the stationary diffusion equation.

The coupling of finite and boundary element methods has been attractive for the numerical solution of boundary value problems of second order partial differential equations for decades. In particular, the so-called non-symmetric formulation has been very popular in applications for a long time. The non-symmetric formulation is the coupling of the weak formulation of the differential equation for the interior and the weakly singular boundary integral equation for the exterior problem. The results on the stability of related discrete systems were quite unsatisfying for decades due to high assumptions on the regularity of boundary or the discretization spaces. Major progress has been made in the analysis of non-symmetric formulations in the last few years.

We present these recent results on the analysis of the stability of the non-symmetric formulation on the continuous level and validate these results by numerical examples. The presented analysis can be extended to other discretization methods like discontinuous Galerkin methods and finite volume methods. The use of fast boundary element methods for the coupling is demonstrated for fluid-structure interaction problems within the design of ships.

Speaker: **Parapatits, Lukas** (ETH Zürich)
Author(s): Christoph Haberl, Lukas Parapatits
Title: **Centro-Affine Tensor Valuations**
Abstract: The tensor valued map

$$K \mapsto \int_K x^{\odot p} dx$$

is a natural generalization of volume and moment vector. It is a continuous $\mathrm{SL}(n)$-covariant valuation for each non-negative integer p. A new example with the same properties is

$$K \mapsto \int_{S^{n-1}} u^{\odot p} dS_p(K, u),$$

where $S_p(K, \cdot)$ denotes the L_p surface area measure of K. We show that these operators are essentially the only measurable $\mathrm{SL}(n)$-covariant tensor valued valuations on polytopes with the origin as interior point.

Speaker: **Paulin, Roland** (University of Salzburg)
Author(s): Roland Paulin
Title: **Injectivity of specialization for abelian varieties.**
Abstract: We study the following problem: For a base curve C/k and a family A_t of abelian varieties over C, give some condition for the point $t \in C$, which assures that the specialization homomorphism $A(k(C)) \to A_t(k(t))$ is injective. We give such a condition in some cases, using the points of bad reduction. This generalizes the results of Gusić and Tadić on the injectivity of the specialization homomorphism of elliptic curves. Their method uses the equations defining the elliptic curves, while ours is more conceptual. The proof rests on the use of the Galois action on the points of A and A_t.

Speaker: **Prank, Rein** (University of Tartu)
Author(s): Rein Prank, Evari Koppel, Joosep Kibal, Katrin Valdson, Joosep Norma
Title: **Elementary School Word Problem Solution Environment TEKSTER**
Abstract: TEKSTER is an environment for solution of word problems of elementary level, by asking at each solution step a question and finding the value of some sensible quantity. The program uses computer algebra system Maxima for checking equality of algebraic expressions and a prover-like Solver

for checking the solvability of tasks, for demo solutions and generation of hints. The student program records in solution file the choices and mistakes made by the student.

Tasks are composed in the teacher program. First the teacher types the text of the task. While doing this he/she marks the quantities that can be used in the solution and the program assigns them variables.

For example: There are $a = 15$ boys and $b = 13$ girls in Grade 3A and $c = 16$ boys and $d = 15$ girls in Grade 3B. Every boy bought $e = 3$ pies and every girl bought $f = 2$ pies. How many more pies did the pupils of 3B buy than the pupils of 3A? At next stage the teacher builds question composition matrices that enable the student to compose necessary questions. For example, the teacher can build two set of problems for above task:

1) How many { boys/girls/pupils } are in { 3A/3B/3B more than in 3A } ?

2) How many pies did { the boys/the girls/the pupils } of { 3A/3B/3A and 3B } { buy/buy more } ?

In solution process the student uses for every question an appropriate matrix and selects one phrase in each column. Finally the teacher enters for the questions the expressions that express the asked quantities. In our example the program constructs $3 * 3 + 3 * 3 * 2$ questions. After entering the expressions two of them could look like so: How many pies did the pupils of 3A buy? $c * e + d * f$ How many pies did the pupils of 3B buy more? $c * e + d * f - c * e + d * f$ (Answer) If the expression box of a question remains empty then selection of this question by the student ends with the message that this question is not reasonable.

The student solves the word problem step by step, finding at each step a quantity. At each step he/she performs the following substeps:

1) Builds a question/sentence that tells what quantity will be calculated at this step;
2) Forms a one-operation arithmetic expression that finds the desired quantity;
3) Calculates the result of the operation.

The program checks each substep and requires correction in case of mistakes/misplanning.

Speaker: **Petz, Tiborné** (University of West Hungary, Apaczai Faculty)
Author(s): Tiborné Petz
Title: **Problem of the mathematics thinking - Mathematics knowledge of teacher training students**
Abstract: The Hungarian education has not changed completely so much, as the establishment of the new school-leaving examination would expect. The main front of class working, the little opportunity of introduction, the uninteresting material takes the joy of students from the mathematics. So long at primary school for 6-10-year-olds mathematics is in the three most favorite subjects, and then by passing of time it goes down "on the hierarchy". The mechanical learnt knowledge discourages students from mathematics, but there is a danger, they cram a lot of things that they do not understand. The Hungarian mathematics school-leaving examination finished with a saddening result. This result shows that the subject mathematics still makes one of the biggest difficulties for the school leaving students. Another consequence of the school-leaving examination's results show that the students from the vocational secondary school can mostly solve only such exercises, for which the knowledge brought from the primary school is enough. They do nott develop a lot during the period of secondary school. Some of the students at university have not got the basic knowledge which they learned at primary school. Yearly I survey the mathematics knowledge of teacher training students with a test. I intend to find out how successful the students are in exercise solution in percentages.

Speaker: **Rácz, Gabriella** (University of Debrecen)
Author(s): Gabriella Rácz, Gábor Nyul
Title: **The r-Lah numbers and their summations**
Abstract: Stirling numbers of the first and the second kind are of basic importance in enumerative combinatorics. They count the decomposition of a fixed number of elements into a given number of disjoint cycles or blocks, respectively. If we modify the latter problem such that the blocks are ordered,

we arrive at the Lah numbers, which were introduced by I. Lah in the middle of 1950s. Stirling numbers have various generalizations and variants. Among them, r-Stirling numbers were defined by A. Z. Broder and by R. Merris independently, when r distinguished elements have to be in distinct cycles or blocks.

The r-Lah numbers can be defined similarly to the r-Stirling numbers. In the first part of our talk, after introducing these numbers, we study their properties. For example, we prove their recurrence, their connection with rising and falling factorials, their vertical recurrence, their expression with (r-s)-Lah numbers, a binomial convolutional type identity, their explicit formula, their exponential generating function, their self-orthogonality and connections between the r-Lah numbers and the r-Stirling numbers, and an inversion formula for r-Lah transformation of sequences. We also show that with fixed upper parameter the sequence of the r-Lah numbers is strictly log-concave and therefore unimodal, and we describe their maximum points.

Another fundamental objects in enumerative combinatorics are Bell numbers which count the partitions of a finite set of given size, in other words, they are the sums of Stirling numbers of the second kind with a fixed upper parameter. Ordered variants of Bell numbers are called Fubini numbers, where the partition itself is ordered. It is a natural idea to define and study the r-generalized variants of these numbers, which was done for r-Bell numbers by I. Mező, and for r-Fubini numbers by I. Mező and G. Nyul.

As the sum of the Lah numbers or the r-Lah numbers, the summed Lah numbers or r-Lah numbers can be introduced similarly. Here we should mention that there are only sporadic results even on ordinary summed Lah numbers. We do it in detail in the second part of our talk through summed r-Lah numbers. We give the relationship between the summed r-Lah numbers and the summed (r-s)-Lah numbers, we prove a linear recurrence with non-constant coefficients, we show Spivey and Dobinski type formulas, and we derive the exponential generating function of the sequence of the summed r-Lah numbers. Beside the summed r-Lah numbers we define the r-Lah polynomials, we give their combinatorial interpretation, and we show the above properties for the r-Lah polynomials, as well. We also prove that every root of the r-Lah polynomials is real, non-negative and simple, and as a corollary, we give a new proof to the strictly log-concavity and unimodality of the sequence of r-Lah numbers when the upper parameter is fixed.

We try to prove all the above mentioned properties in a purely combinatorial way when it is possible. Moreover, we use a variety of proof methods including probability theory, differential equations, and we study the roots of the polynomials by Rolle?s mean value theorem. During our investigations, we find some new results for r-Stirling and r-Bell numbers, too.

Speaker: **Rásonyi, Miklós** (MTA Alfréd Rényi Institute of Mathematics)
Author(s): Miklós Rásonyi
Title: **Optimal investment beyond expected utility theory**
Abstract: I will discuss some recent results on optimal investment in incomplete markets where investors' preferences involve probability distortions. Such preferences were advocated in the cumulative prospect theory of Kahneman and Tversky. Part of the mathematical difficulties is related to the closedness of the set of attainable portfolio values for convergence in law. I will present a counterexample and then positive results.

Speaker: **Reheinländer, Thorsten** (TU Vienna)
Author(s): Thorsten Reheinländer
Title: **Brownian trading excursions**
Abstract: In a model of the limit order book with order arrivals and cancellations, we derive an SPDE for the order book distribution which corresponds to a stochastic heat equation with one heat source and two cooling elements on a finite rod which we can actually solve in terms of local time. Moreover, we derive a hyperbolic function table for the Laplace transforms of the time to various types of trades. We introduce and calculate a bivariate Laplace-Mellin transform for the joint excursion height and length in a Brownian framework, involving the Riemann Xi-function. Finally, we show that a certain disintegration of the Ito measure is equivalent to Jacobi?s Theta transformation formula. Joint work with Friedrich Hubalek, Paul Krühner and Sabine Sporer.

Speaker: **Sabanis, Sotirios** (University of Edinburgh)
Author(s): Sotirios Sabanis, István Gyöngy, David Siska, Chaman Kumar and Konstantinos Dareiotis
Title: **New generation explicit numerical methods for nonlinear SDEs and their applications in Finance**
Abstract: The idea of 'tamed' Euler schemes, which was pioneered by Hutzenthaler, Jentzen and Kloeden [1] and Sabanis [2], led to the development of a new generation of explicit numerical schemes

- for SDEs driven by Levy noise with superlinear coefficients and,
- for stochastic evolutions equations with super-linearly growing operators appearing in the drift.

Moreover, high order schemes (such as Milstein) are established (with optimal rates of convergence) by the natural extension of the aforementioned ideas. Theoretical results on this topic along with relevant simulation outputs for financial models, e.g. 3/2 stochastic volatility model, will be presented during this talk.

References

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[2] S. Sabanis, A note on tamed Euler approximations, Electron. Commun. Probab. 18 (2013), no. 47, 1-10.

Speaker: **Schleischitz, Johannes** (BOKU)
Author(s): Johannes Schleischitz
Title: **Diophantine approximation on manifolds**
Abstract: The talk deals with the rational approximation properties of smooth manifolds M in Euclidean space $\mathbb{R}^k$. More precisely, for a parameter $\nu > 0$ we investigate the set of points $a = (a_1, \ldots, a_k)$ on M that are approximable to degree ν, which means that the system $\max_{1 \le j \le k} |p_j/q - a_j| \le q^{-\nu-1}$ has an integral solution vector $(q, p_1, \ldots, p_k) \in \mathbb{Z}^{k+1}$ for arbitrarily large q. By Dirichlet's Theorem any point in $\mathbb{R}^k$ is approximable to degree $1/k$, and almost all to no higher degree. Restricting to $a \in M$ for a sufficiently smooth manifold $M \subset \mathbb{R}^k$ that satisfies some natural regularity conditions, again only a small subset of M is approximable to a degree higher than $1/k$. The question of the Hausdorff dimensions of sets of points on M approximable to a given degree $\nu > 1/k$ arises. The talk aims to sketch selected results for special choices of M, without proofs.

Speaker: **Schuster, Franz** (Vienna University of Technology)
Author(s): Florian Besau, Richard Gardner, Lukas Parapatits, Franz Schuster
Title: **Characterizations of Geometric Additions**
Abstract: A few years ago, R. Gardner, D. Hug, and W. Weil launched an investigation into the characteristics of basic binary operations between compact convex sets in Euclidean spaces. Among several results they established a fundamental characterization of Minkowski addition as the only GL(n) covariant, continuous operation between pairs of compact convex sets having the identity property.

In this talk, we present a characterization of Blaschke addition between convex bodies with non-empty interior (joint work with R. Gardner and L. Parapatits) and discuss a counterpart of the Gardner-Hug-Weil result for spherical convex bodies (joint work with F. Besau).

Speaker: **Schwarz, Martin Peter** (University of Innsbruck)
Author(s): Martin Peter Schwarz
Title: **Hyperbolic PDEs with random spatial coefficients modeled by the Goupillaud medium**
Abstract: In this talk, we consider first order hyperbolic partial differential equations with random spatial coefficients. The randomness is obtained by a discrete Goupillaud medium. The Goupillaud medium is a piecewise constant medium such that the „transport time" through each layer is constant. We will

elaborate details of this method for the transport equation where the transport speed is modeled by the Goupillaud medium. In this setup solving the characteristic equation becomes a geometrical problem. The thickness of the layers will be described by non-negative, independent, identically distributed random variables, depending on a parameter n, such that the variance and the mean is of order $\mathcal{O}(n^{-1})$. We will talk about what to expect when taking the limit $n \to \infty$.

This is a joint work with Michael Oberguggenberger from the University of Innsbruck/Austria and Maarten de Hoop from Rice University/USA.

Speaker: **Speckbacher, Michael** (Austrian Academy of Sciences)
Author(s): Michael Speckbacher
Title: **Reproducing pairs of measurable functions**
Abstract: Discrete frames have been a central topic in signal processing during the last decades. However, continuous frames have found to be useful in many areas such as theoretical physics and constitute the theoretical background for a wide range of time-frequency/time-scale transforms such as the short-time Fourier transform or the continuous wavelet transform. A continuous frame is a mapping $\Psi : X \to \mathcal{H}$, with (X, μ) some measure space and $\mathcal{H}$ a separable Hilbert space, that satisfies

$$A\|f\|^2 \leq \int_X |\langle f, \Psi(x)\rangle|^2 d\mu(x) \leq B\|f\|^2, \quad \forall f \in \mathcal{H}$$

There are, however, situations where it is impossible to meet both frame bounds. Hence, it is necessary to find generalizations of continuous frames. In a first approach, semi-frames have been considered, i.e. complete systems that only satisfy one frame bound. The aim of this talk is to present reproducing pairs as a new approach to deal with the above mentioned problem. A pair of mappings (Ψ, Φ) is called a reproducing pair if it generates a bounded and invertible analysis/synthesis process under the omission of frame bounds. We will show how each reproducing pair intrinsically generates two reflexive Banach spaces, conjugate dual to each other and discuss the properties of these spaces in detail. Moreover, starting from a single mapping Ψ we will introduce conditions which ensure the existence of a partner Φ making (Ψ, Φ) a reproducing pair.

Speaker: **Szölgyényi, Michaela** (Vienna University of Economics and Business)
Author(s): Gunther Leobacher, Michaela Szölgyényi, Stefan Thonhauser
Title: **Solving SDEs appearing in mathematical finance**
Abstract: When solving certain stochastic optimization problems, e.g., in mathematical finance, the optimal control policy sometimes turns out to be of threshold type, meaning that the qualitative behaviour of the control is different depending on the position of the controlled process. We present an example from actuarial mathematics, namely the problem of maximizing the expected accumulated discounted dividend payments over the lifetime of an insurance company. There, SDEs appear that have a discontinuous drift and a degenerate diffusion parameter. We prove an existence and uniqueness theorem for a general class of such SDEs. Additionally, we present a numerical method for solving the solution to SDEs with discontinuous drift that convergences with strong order 1/2.

Speaker: **Vago, Zsuzsanna** (Pazmany Peter Catholic University)
Author(s): László Gerencsér, Zsuzsanna Vágó
Title: **Real-time Change Detection of Stochastic Processes**
Abstract: The objective of this talk is to present a less known methodology for the detection of the change in the dynamics of a stochastic process or time series. This approach is based on the works of J.Rissanen on the interaction of information theory and statistics, and is widely applicable. In the simplest case of detecting switching between two known models the method is the extension of the so-called Page-Hinkley test or CUSUM test. An alarm is given when the detector exceeds a given threshold.

The main advance of the present work is the proof of the fact that the detector process exhibits certain mixing properties, namely it is a so-called L-mixing process under certain technical conditions, which

are stringent, but not unrealistic. Based on this result a nice exponentially decaying upper bound can be derived for the almost sure rate of false alarms. The possibility of extending this result is intimately related to the validity of a novel exponential moment inequality, raising interesting open problems.

The practical applicability of the method will be demonstrated on problems of neurobiology, a research being carried out in the National Institute of Clinical Neurosciences.

Speaker: **Vajda, Robert** (University of Szeged)
Author(s): Róbert Vajda
Title: **Playing Games and Proving Theorems**
Abstract: Permutation games are well known and relatively popular among students. The description and analysis of these games naturally leads to beautiful mathematical concepts and theorems. In this talk the mathematical representations of sliding puzzles and Rubik cubes are investigated. Starting from the descriptions and graphical representations of the games, we come to lists, permutations, graphs, rewrite rules and logical formulae. Once the latter objects are at our disposal, we turn into proving systems to connect the steps of backward and forward reasoning with valid movements of the games and prove reachability propositions. Case studies in the Wolfram Mathematica computer algebra system and the Theorema 2 automated theorem proving system are shown.

Speaker: **Wagner, Roland** (RICAM Linz)
Author(s): Roland Wagner, Ronny Ramlau
Title: **An efficient Reconstruction Method for Ground Layer Adaptive Optics with mixed Natural and Laser Guide Stars**
Abstract: Inverse Problems arise in astronomy as for ground based telescopes like the planned European Extremely Large Telescope (E-ELT) the image quality is degraded by effects of atmospheric turbulence, which need to be corrected on the fly. Therefore, modern ground based telescopes depend heavily on Adaptive Optics (AO) systems, which use measurements of incoming wavefronts from guide stars to reconstruct the turbulence above the telescope and derive the shape of deformable mirror(s) (DM). The main challenge is to have a fast enough algorithm for the reconstruction process as the atmospheric turbulence is constant for approximately only 2 ms. Most types of AO systems rely on measurements from laser guide stars (LGS), which are created artificially by shooting a laser into the sky and observing its reflection at a Sodium layer in the sky, as the sky coverage with bright stars is low. Unfortunately, measurements from LGS suffer from additional effects, e.g., spot elongation, due to the thickness of the Sodium layer, which affect the reconstruction of the atmosphere or the shape of the DM.

We present a new reconstruction method for Ground Layer Adaptive Optics (GLAO), based on the Bayes approach. In GLAO, several guide stars, each associated to a wavefront sensor, and a single mirror are used for the correction of the turbulence in the layer closest to the ground, where usually most of the atmospheric turbulence is located. GLAO systems use a combination of natural and laser guide stars. As mentioned above, spot elongation is a well-documented effect complicating the use of laser guide stars on Extremely Large Telescopes. When an LGS is observed with a Shack–Hartmann wavefront sensor, the spot registered on each subaperture is elongated due to the parallax effect. The elongation degrades the measurement accuracy and the error increases linearly with the elongation of the spot in the direction of the centroid. Furthermore, spot elongation introduces correlation between the measurements in the subaperture. Correction for spot elongation is in particular needed for the planned generation of Extremely Large Telescopes.

In the Bayes approach it is natural to model the spot elongation as a specific noise distribution, which in this case is known from the telescope setting. Contrary to the standard approach, including the noise distribution of the spot elongation directly into the reconstruction of the atmosphere, e.g., by the minimization of an appropriate Tikhonov functional, and thus solving a large coupled system of linear equations, we aim for a compensation of spot elongation in a separate preprocessing step, where the equations decouple and even the derivation of analytic formulae is possible. Thus, the complexity stays linear and fast computations are possible benefiting further from parallelization and piplineability.

Together with a cumulative wavefront reconstructor (CuReD), this results in a new linear and fast GLAO wavefront reconstructor. Simulation results show that the new method is not only fast enough, but also gives the desired quality to be compatible to existing, slower algorithms.

Speaker: **Wagner, Stephan** (Stellenbosch University)
Author(s): Agelos Georgakopoulos, Joubert Oosthuizen, Stephan Wagner
Title: **From hitting times to the Wiener index of trees**
Abstract: We consider the simple random walk on a graph, which at each step moves to one of the neighbours chosen uniformly at random. The hitting time H_{xy} from a vertex x to a vertex y is the average time it takes a simple random walk starting at x to reach y. We present a surprising connection between the hitting time and the Wiener index (sum of all distances between pairs of vertices) of a tree, its ramifications and generalisations.

In particular, we consider the cover cost $CC(x)$ from a vertex x, defined as the sum of the hitting times H_{xy} over all vertices y, and its dual, the reverse cover cost $RC(x)$, which is the sum of the hitting times H_{yx} over all vertices y. The cover cost was recently introduced by Georgakopoulos as a computationally more tractable variant of the cover time (the average time it takes a simple random walk to visit all vertices). It turns out that for trees, the inequalities $H_{xy} \leq H_{yx}$, $CC(x) \leq CC(y)$ and $RC(x) \geq RC(y)$ are all equivalent (which is not generally true for arbitrary graphs), and that both the cover cost and its reverse version can be expressed in terms of the Wiener index and the sum of all distances from x to other vertices. This connection can also be exploited to determine the extremal values of the two quantities CC and RC in trees of given order and the corresponding extremal trees.

We further discuss to what extent the results on trees generalise to arbitrary graphs, as well as the connection to spectra of different matrices associated with a graph (specifically, the combinatorial Laplacian and its random walk counterpart).

Finally, the distribution of hitting times in random trees is studied. The distribution of the cover cost and reverse cover cost in random Galton-Watson trees (which include several important special cases) can be inferred from the connection to the Wiener index, making use of the work of Janson on the Wiener index of random trees. We show further that the hitting time between two randomly selected vertices (or a random vertex and the root) of a random Galton-Watson tree of order n is on average of asymptotic order $n^{3/2}$, and prove asymptotic formulas for all higher moments as well as a limit law.

Speaker: **Wang, Hua** (Georgia Southern University)
Author(s): Hua Wang
Title: **Maximizing distance in trees**
Abstract: We present a question, motivated from chemical graph theory, of maximizing the sum of pairwise distances. When restricted to trees with given degree sequence (a constraint of particular importance in applications), this question turned out to be very difficult. We will explore interesting observations and approaches from graph theory, number theory, and discrete optimization generated from this topic.

Speaker: **Yang, Huidong** (Johann Radon Institute for Computational and Applied Mathematics)
Author(s): Ulrich Langer, Huidong Yang
Title: **Robust monolithic solvers for fluid-structure interaction simulation**
Abstract: In this talk, we construct robust and efficient preconditioned Krylov subspace solvers for the monolithic linear system of algebraic equations arising from the finite element discretization and Newton's linearization of the fully coupled fluid-structure interaction system of Partial Differential Equations in the Arbitrary Lagrangian–Eulerian formulation. We admit nonlinear hyperelastic material in the solid model and cover a large range of flows, e.g,, water, blood, and air with highly varying density. The robust preconditioners are constructed in form of $\hat{L}\hat{D}\hat{U}$, where $\hat{L}$, $\hat{D}$ and $\hat{U}$ are proper approximations to the matrices L, D and U in the LDU factorization of the fully coupled system matrix, respectively.

The inverse of the corresponding Schur complement is approximated by applying one cycle of a special class of algebraic multigrid methods to the perturbed fluid sub-problem, that is obtained by modifying corresponding entries in the original fluid matrix with an explicitly constructed approximation of the exact perturbation coming from the sparse matrix-matrix multiplications. The numerical studies presented impressively demonstrate the robustness and the efficiency of the preconditioners proposed in the talk.

Speaker: **Zarnócz, Tamás** (University of Szeged)
Author(s): Ferenc Fodor, Viktor Vígh, Tamás Zarnócz
Title: **On László Fejes Tóth's spherical plank problem**
Abstract: We consider the following problem, raised by László Fejes Tóth in 1972, which can be regarded as a spherical relative of the well-known plank problem of Tarski. A zone on the 2-sphere S^2 is the parallel domain of a great circle. The half-width of the zone (in the spherical metric) is the radius of the parallel domain. László Fejes Tóth conjectured that the minimum width of n equal zones that can cover S^2 is π/n. The only results about this version of the problem are due to Rosta (1972) who proved Fejes Tóth's conjecture for $n = 3$ and Linhart (1974) who proved it for $n = 4$. The original conjecture is still open. We give a lower bound for the minimum width of $n \geq 2$ equal zones that cover S^2. We also explore possible generalizations of the problem to higher dimensions. In addition, we consider the following related question: what is the maximum of the sum of the angles of n great circles on S^2?

Speaker: **Zeiner, Martin** (TU Wien)
Author(s): Függer Matthias, Nowak Thomas, Schmid Ulrich, Zeiner Martin
Title: **Optimal Strategies for Repeated Leader Election**
Abstract: There are many instances (in particular in computer science, biology, social sciences) that verify the utility of using a leader for solving certain problems. A well-known example is the rotating coordinator approach, which is e.g. used for enforcing a univalent system state in the Byzantine fault-tolerant Phase Queen and Phase King consensus algorithms. An interesting example from biology is long-haul V-formation flying of social birds like geese and pelicans, where all birds except the leader benefit energetically from the uplift of their neighbor ahead. Our goal is to give suitable formal models and to determine 'optimal' strategies for repeated leader election.

The basic formal model is the following: We have n players labelled with 1 up to n. In every discrete time step (round) each player votes for exactly one player. For every player i, the round r-payoff is defined as $u_i^{(r)} = |\mathcal{G}_i^{(r)}| + c \cdot |\mathcal{F}_i^{(r)}|$ (c real) that also depends on the leader choices of all other processes: $\mathcal{F}_i^{(r)}$ is the set of players that voted for i, $\mathcal{G}_i^{(r)}$ is the set of players that voted for the same player as process i. The *payoff* of player i is then defined as $u_i = \liminf_{r\to\infty} \frac{1}{r}\sum_{k=1}^{r} u_i^{(k)}$, and the overall *social payoff* is either $\text{avg}\{u_1, \ldots, u_n\}$, $\min\{u_1, \ldots, u_n\}$ or $\max\{u_1, \ldots, u_n\}$. For this model we characterise the optimal strategies i.e., those sequences of votes for all players which maximise the social payoff.

We will also address the important question of whether and when an optimal strategy is a k-resilient equilibrium (1-resilience = Nash equilibrium), i.e., whether a group of k players that deviate from the optimal strategy can earn a larger social group payoff (according to the same social payoff $\min, \max$ or avg as used for the global social payoff).

Moreover, we generalise the basic model by introducing additional terms in the round r-payoff to reward/penalise if a player votes for the same player in two consecutive rounds or to penalise player i if he is voted for by many other players (this will model exhaustion of the leader, e.g., if the leader has to perform additional computations).