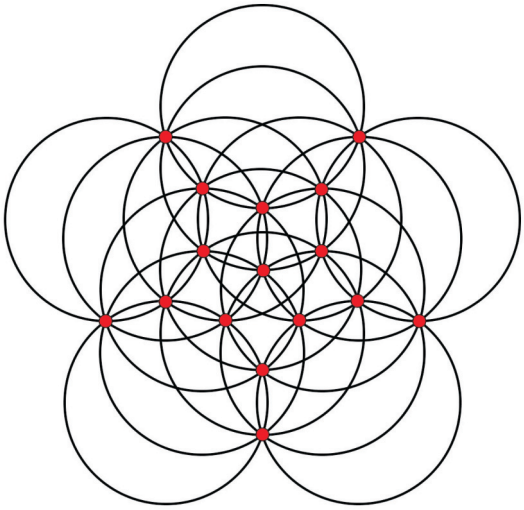
Abstracts of the

CSASC 2013

Joint Mathematical Conference

of the **C**atalan Mathematical Society, **S**lovenian Mathematical Society, **A**ustrian Mathematical Society, **S**lovak Mathematical Society, and **C**zech Mathematical Society

Koper, Slovenia, 9 – 13 June 2013



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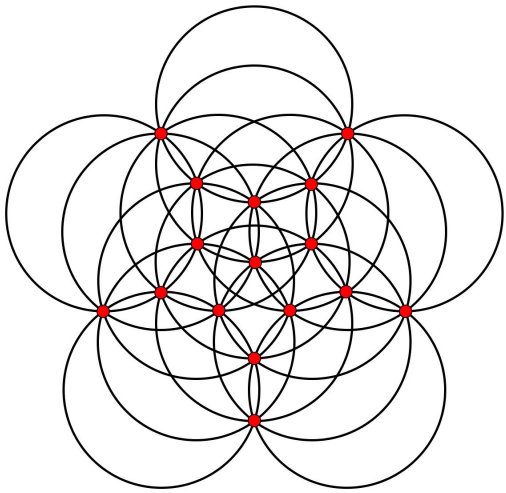

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Edited by
Ademir Hujdurovič, Boštjan Frelih,
Klavdija Kutnar, Jasna Prezelj,
Tomaž Pisanski, and Alen Orbanić

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WELCOME TO CSASC 2013

CSASC is a traditional biannual meeting of Czech, Slovak, Austrian, Slovenian and Catalan Mathematical Societies. Of the main aims of these meetings is to build up European mathematics using a bottom-up approach. In our view this is the way European mathematics should be forged: by successful collaborations of individual mathematicians, of various research groups, and through bilateral and multilateral events organized by national mathematical societies where free dissemination of knowledge and high-quality research is the goal, and where everyone who is fond of mathematics is most welcome.

This year it is the Society of Mathematicians, Physicists and Astronomers of Slovenia that is responsible for organizing CSASC. The conference takes place at the one of the Slovenian jewels, the Coast. As usual the scientific program has been prepared by the Scientific Committee that comprises 10 members, two from each participating society:

- CZECH REPUBLIC:
  Jan Kratochvil, Charles University, Prague
  Bohdan Maslowski, the President of Czech Math Society
- SLOVAK REPUBLIC:
  Roman Nedela, Matej Bel University, Banská Bystrica
  Karol Mikula, Technical University Bratislava
- AUSTRIA:
  Michael Drmota, Technical University, Vienna
  Bernhard Lamel, University of Vienna
- CATALONIA:
  Oriol Serra, Polytechnic University of Catalonia, Barcelona
  Joaquim Ortega, Universitat de Barcelona
- SLOVENIA:
  Tomaž Pisanski, University of Primorska and University of Ljubljana (Chair)
  Jasna Prezelj, University of Ljubljana

The members of the Organizing Committee are Klavdija Kutnar, University of Primorska, Slovenia (Chair), Alen Orbanić, University of Ljubljana, Slovenia, Tomaž Pisanski, University of Primorska and University of Ljubljana, Slovenia, Jasna Prezelj, University of Ljubljana, Slovenia.

We would like to thank everyone who contributed financially to make this conference possible. The list of sponsors include:

- IMFM - Institute of Mathematics, Physics and Mechanics, Ljubljana,
- UL FMF - Faculty of Mathematics and Physics, University of Ljubljana,
- UP FAMNIT - University of Primorska, Faculty of Mathematics, Natural Sciences and Information Technologies,
- UP IAM - University of Primorska, Andrej Marušič Institute,
- ARRS - Slovenian Research Agency,
- EMS - European Mathematical Society,
- ESF - European Science Foundation.

The CSASC conference has evolved from several mathematical meetings in the past, starting with Nachbarschaftstagungen of the Austrian Mathematical Society in Bolzano, Italy in 2003 and followed by Czech-Catalan meeting in Prague, Czech Republic, in 2005 and Barcelona, Spain, in 2006, and a meeting in Podbanske, Slovakia in 2007.

The first CSASC conference took place in Prague, Czech republic, in 2010 while the second one was organized in Krems, Austria in 2011.

This year we have seven plenary speakers. Among them is the distinguished EMS speaker John Eric Fornaess from University of Trondheim, Norway, who was kindly provided by the European Mathematical Society.

We have ten thematic minisymposia, each organized by mathematicians of at least two participating societies. In addition, there is a EuroGIGA session, partially sponsored by the European Science Foundation through EuroCORES/EuroGIGA project. The EuroGIGA session will be distributed through several Minisymposia. During the conference there will be a meeting of the Steering Committee of EuroGIGA. There is also a general session and a poster session.

There are 150 registered participants. The list of co-authors of talks consists of 165 names.

We would like to thank all of you who came to the conference. In particular, we would like to thank the speakers, the minisymposia organizers and all plenary speakers.

Last but not least, the Scientific Committee would like to thank the Organizing Committee, and in particular Dean Klavdija Kutnar who chaired the Organizing Committee, for a job well-done. Our thanks also to the University of Primorska for providing us with a nice place to work and for the wonderful hospitality.

Tomaž Pisanski,
(in the name of the Scientific Committee
and the DMFA Slovenije)

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General Information

CSASC 2013 – Joint Mathematical Conference of the Catalan Mathematical Society, Slovenian Mathematical Society, Austrian Mathematical Society, Slovak Mathematical Society, and Czech Mathematical Society

Koper, Slovenia, June 9 – June 13, 2013.

Organized by:
DMFA - *Society of Mathematicians, Physicists and Astronomers of Slovenia*,
IMFM - *Institute of Mathematics, Physics and Mechanics*,
UL FMF - *Faculty of Mathematics and Physics, University of Ljubljana*,
UP FAMNIT - *University of Primorska, Faculty of Math., Natural Sciences and Inf. Technologies*,
UP IAM - *University of Primorska, Andrej Marušič Institute*.

In Collaboration with:
Austrian Mathematical Society, Catalan Mathematical Society, Czech Mathematical Society and Slovak Mathematical Society.

Sponsored by:
ARRS *(Slovenian Research Agency)*,
EMS *(European Mathematical Society)*,
ESF *(European Science Foundation, EuroGiga GReGAS)*.

Welcome Address:
Dr. Franci Demšar, Director of Slovenian Research Agency
Prof. Dragan Marušič, Rector of University of Primorska
Assoc. Prof. Štefko Miklavič, Vice-rector of University of Primorska

Scientific Committee:
Czech Republic:
Jan Kratochvil, Charles University, Prague
Bohdan Maslowski, the president of Czech Math soc.
Slovak Republic:
Roman Nedela, Matej Bel University, Banská Bystrica
Karol Mikula, Technical University Bratislava
Austria:
Michael Drmota, Technical University, Vienna
Bernhard Lamel, University of Vienna
Catalonia:
Oriol Serra, Polytechnic University of Catalonia, Barcelona
Joaquim Ortega, Universitat de Barcelona
Slovenia:
Tomaž Pisanski, University of Primorska and University of Ljubljana (chair)
Jasna Prezelj, University of Ljubljana

ORGANIZING COMMITTEE:
Klavdija Kutnar (chair), Alen Orbanić, Tomaž Pisanski, Jasna Prezelj.

CONFERENCE VENUE:
UP FAMNIT, Glagoljaška 8, SI-6000, Koper, Slovenia.

CONFERENCE WEBSITE:
http://csasc2013.upr.si

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csasc2013@upr.si

PLENARY SPEAKERS:
John Erik Fornaess, *NTNU Trondheim, Norway; EMS distinguished speaker at CSASC 2013*
Ivan Mizera, *University of Alberta, Canada*
Primož Moravec, *University of Ljubljana, Slovenia*
Marc Noy, *Universitat Politecnica de Catalunya, Catalonia*
Günter Rote, *Freie Universität Berlin, Germany*
Gerald Teschl, *University of Vienna, Austria*
Xavier Tolsa, *Universitat Autonoma of Barcelona, Catalonia*

MINISYMPOSIA AND MINISYMPOSIA ORGANIZERS:
Algebra
- Wolfgang Herfort *(TU Wien, Austria)*
- Primož Moravec *(University of Ljubljana, Slovenia)*

Combinatorics
- Ilse Fischer *(University of Vienna, Austria)*
- Matjaž Konvalinka *(University of Ljubljana, Slovenia)*

Diferential Geometry and Mathematical Physics
- Xavier Gracia *(Barcelona Tech, Spain)*
- Olga Rossi *(University of Ostrava, Czech Republic)*

Discrete and Computational Geometry
- Oswin Aichhozer *(University of Technology, Austria)*
- Sergio Cabello *(University of Ljubljana, Slovenia)*
- Pavel Valtr *(Charles University, Czech Republic)*

Graph Theory
- Michael Drmota *(University of Vienna, Austria)*
- Jan Kratochvil *(Charles University, Czech Republic)*
- Bojan Mohar *(University of Ljubljana, Slovenia & Simon Fraser University, Canada)*
- Oriol Serra *(Polytechnic University of Catalonia, Spain)*

Mathematical Methods in Image Processing
- Vicent Caselles *(Pompeu-Fabra University, Spain)*
- Daniel Leitner *(University of Vienna, Austria)*
- Mariana Remesikova *(Slovak University of Technology, Slovakia)*

Numerical Methods for Partial Differential Equations
- Peter Frolkovič *(Slovak University of Technology, Slovakia)*

Pep Mulet *(University of Valencia, Spain)*

Proving in Mathematics Education at University and at School

Roman Hašek *(University of South Bohemia, Czech Republic)*

Zlatan Magajna *(University of Ljubljana, Slovenia)*

Walther Neuper *(Graz University of Technology, Austria)*

Pavel Pech *(University of South Bohemia, Czech Republic)*

Jordi Saludes *(University Polytechnica of Catalonia, Spain)*

Dušan Vallo *(University of Nitra, Slovakia)*

Wolfgang Windsteiger *(University of Linz, Austria)*

Several Complex Variables

Franc Forstnerič *(University of Ljubljana, Slovenia)*

Martin Kolar *(Masaryk University, Czech Republic)*

Bernhard Lamel *(University of Vienna, Austria)*

Joaquim Ortega-Cerda *(University of Barcelona, Spain)*

Symmetries in Graphs, Maps and Other Discrete Structures

Aleksander Malnič *(University of Ljubljana and University of Primorska, Slovenia)*

Norbert Seifter *(Montanuniversität Leoben, Austria)*

Primož Šparl *(University of Ljubljana, Slovenia)*

EuroGiga Session

Oswin Aichhozer *(University of Technology, Austria)*

Jan Kratochvil *(Charles University, Czech Republic)*

Tomaž Pisanski *(University of Ljubljana and University of Primorska, Slovenia)*

Günter Rote *(Freie Universität Berlin, Germany)*

General Session

Jasna Prezelj *(University of Ljubljana, Slovenia)*

Poster Session

Tomaž Pisanski *(University of Ljubljana and University of Primorska, Slovenia)*

SPECIAL EVENTS

SUNDAY, JUNE 9:

- Milestones: On the Development of Graph Theory in Slovenia, Boštjan Kuzman, University of Ljubljana and IMFM, Slovenia (poster exhibition).

  Since its very modest beginnings in the 1970's, Graph Theory in Slovenia has grown to become one of the most fruitful and internationally recognized branches of Slovenian scientific output today. The exhibition presents a set of posters, called Milestones. Each of them represents a certain step, either major or minor, in the development of the field in Slovenia: from the first lecture notes, scientific results, published papers and doctoral theses to international collaborations, celebrated publications, editorial positions, establishment of new institutions, scientific journals and other projects.

MONDAY, JUNE 10:

- Welcome Evening.

  Welcome address by the Director of the Slovenian Research Agency, Dr. Franci Demšar, Welcome address by the Rector of the University of Primorska, Prof. Dragan Marušič, and a short presentation of the history of Mathematics at the University of Primorska by the Vice-rector of the University of Primorska, Assoc. Prof. Štefko Miklavič followed by a banquet.

TUESDAY, JUNE 11:

- Conference Excursion.

WEDNESDAY, JUNE 12:

- EuroGiga Session - Steering Committee Meeting.

- Conference Dinner.

Plenary Talks

Plenary Speakers:
John Erik Fornaess, *NTNU Trondheim, Norway; EMS distinguished speaker at CSASC 2013*
Ivan Mizera, *University of Alberta, Canada*
Primož Moravec, *University of Ljubljana, Slovenia*
Marc Noy, *Universitat Politecnica de Catalunya, Catalonia*
Günter Rote, *Freie Universität Berlin, Germany*
Gerald Teschl, *University of Vienna, Austria*
Xavier Tolsa, *Universitat Autonoma of Barcelona, Catalonia*

Convexity in Complex Analysis

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In complex analysis in higher dimension it is often easier to do analysis on convex domains. Sometimes one can obtain convexity after changes of coordinates. I will discuss this topic, including joint recent work with Erlend F. Wold and Klas Diederich.

Borrowing Strength via Shape Constraints and Convex Optimization

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We discuss one instance of so-called "borrowing strength" in statistics, in the context of compound decision strategy also referred to as the empirical Bayes approach. We show how certain plausible qualitative restrictions (in the vein of monotonicity, convexity, logarithmic concavity and similar) are capable of regularizing (without introducing ambiguous tuning parameters) the otherwise ill-posed problem of estimating a probability density, or the subsequent decision rule, via maximum likelihood method. Then we illustrate how the proposed methods become practically feasible through modern convex optimization algorithms - and at the same time, how the (convex) optimization theory opens new perspectives in the topic. Some data from popular sports are used in the examples.

Joint work with Roger Koenker (University of Illinois) and Mu Lin (University of Alberta).

Bogomolov multipliers of groups

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The Bogomolov multiplier is a group theoretical invariant isomorphic to the unramified Brauer group of a given quotient space, and represents an obstruction to the problem of stable rationality of fixed fields. In this talk we survey some recent results regarding Bogomolov multipliers. We derive a homological version of the Bogomolov multiplier, prove a Hopf-type formula, find a five term exact sequence corresponding to this invariant, and describe the role of the Bogomolov multiplier in the theory of central extensions. An algorithm for computing the Bogomolov multiplier is developed. We define the Bogomolov multiplier within K-theory and show that proving its triviality is equivalent to solving a long standing problem posed by Bass.

Zero-one laws for minor-closed classes of graphs

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Let G be a class of labelled graphs endowed with a probability distribution on the set $G(n)$ of graphs in G with n vertices. We say that a zero-one law holds in G if every first order graph property holds or does not hold in $G(n)$ with probability 1 as n goes to infinity. Many zero-one laws have been established for the classical binomial model $G(n,p)$ of random graphs, as well as for other classes such as random regular graphs. In this talk we present a zero-one law for connected graphs in a class of graphs G closed under taking minors (edge deletion and contraction) with the property that all forbidden minors of G are 2-connected. Interesting classes of this kind include trees and planar graphs. A zero-one law does not hold for non-necessarily connected graphs in G as, for instance, the probability of having an isolated vertex tends to a constant strictly between 0 and 1. For arbitrary graphs in G we prove a convergence law, that is, every first order property has a limiting probability. These results hold more generally for properties expressible in monadic second order logic. On the other hand, given a fixed surface S, we prove a convergence law in first order logic for the class of graphs embeddable in S (this class is closed under minors but the forbidden minors are not necessarily 2-connected). Moreover, we prove that the limiting probabilities of first order properties do not depend on S. (Joint work with Peter Heinig, Tobias Müller and Anushc Taraz).

Congruence testing of point sets in three and four dimensions

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I will survey algorithms for testing whether two given finite geometric objects are congruent. Under reasonable assumptions, the objects can be reduced to (labeled) point sets. I will introduce the two important techniques for congruence testing, namely dimension reduction and set pruning, and I will indicate how these techniques might lead for the first time to an algorithm for four dimensions with near-linear running time. As a by-product, one can find all symmetries of a geometric object, and thereby (in principle) obtain a classification of the finite symmetry groups of Euclidean space (the subgroups of O(4)).

Peakon asymptotics for the dispersionless Camassa-Holm equation

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We discuss direct and inverse spectral theory for the isospectral problem of the dispersionless Camassa-Holm equation, where the weight is allowed to be a finite signed measure. In particular, we prove that this weight is uniquely determined by the spectral data and solve the inverse spectral problem for the class of measures which are sign definite. The results are applied to deduce several facts for the dispersionless Camassa-Holm equation. In particular, we show that initial conditions with integrable momentum asymptotically split into a sum of peakons as conjectured by McKean.

Singular integrals, rectifiability, and the David-Semmes problem

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The notion of rectifiability plays an essential role in the L^2 boundedness of some important operators arising in complex and harmonic analysis, such as the Cauchy and Riesz transforms. Indeed, by a well known result of David, it turns out that the Cauchy transform originates an operator bounded in L^2 with respect to the arc length measure on (AD regular) rectifiable curves of the plane. In the converse direction, the L^2 boundedness of the Cauchy transform with respect to arc length on a set E implies the rectifiability of E. In this talk I will report on analogous results concerning the n-dimensional Riesz transform in R^{n+1} which are due to Nazarov, Tolsa and Volberg. These results have applications to the characterization of the removable singularities for Lipschitz harmonic functions in R^{n+1}.

Minisymposium on Algebra

Organizers
Wolfgang Herfort *(TU Wien, Austria)*
Primož Moravec *(University of Ljubljana, Slovenia)*

Groups, vector fields and cohomology calculations

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This talk will begin with a brief review of group cohomology and discrete vector fields. It will then explain how discrete vector fields can be used to compute the integral cohomology of a range of groups including certain finite simple groups, certain crytallographic groups and certain arithmetic groups.

A twisting function for finite groups

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Gil Kaplan invented a twisting function $t(x,y)=(y^{-1}xy, x^{-1}yx)$ where x and y are from a finite group G. When t is bijective he proved that G is solvable. Together we refined some of these results. E.g., when t has prime order p for an odd prime p then G is already nilpotent.

Non-universal commutator relations

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It has been a longstanding goal of group theory to somehow describe if not characterize finite p-groups. In the 1940's, P. Hall proposed to tackle the problem by considering groups only up to their commutator structure, a suggestion that has turned out to be quite efficient. Many authors have since studied the relations between commutators, in particular some universal ones via the exterior product and more recently the Bogomolov multiplier. The commutators in a finite group may however well be related in a non-universal manner. We will take a look at the building blocks of these groups, i.e. minimal groups possessing non-universal relations, and show how their restricted structure enables a probabilistic study of the universality of commutator relations.

Capable p-groups

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A group G is called capable if there exists a group H such that $H/Z(H)$ is isomorphic to G. It was recognised by P. Hall that capability has application in classifying p-groups. This application was developed and applied by M. Hall and Senior to classify the groups of order 64. There are several methods for determining whether a p-group is capable. In this talk we will review these methods and describe classes of groups p-group for which we have a complete description of those that are capable. Recent and ongoing work in this area includes the 2-generator p-groups of class 2 and the special p-groups of rank 2.

The Persistence Lattice

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The intrinsic relation between lattice theory and topology has been reestablished with the works of M. H. Stone. Persistent homology is a recent addition to topology, where it has been applied to a variety of problems including to data analysis. It has been in the center of the interest of computational topology for the past twenty years. In this talk we will introduce a generalized version of persistence based on lattice theory, unveiling universal rules and reaching deeper levels of understanding. Its algorithmic construction leads to two operations on homology groups which describe a diagram of spaces as a complete Heyting algebra, a generalization of a Boolean algebra which also suffices a topological dual space. Unlike the lattice of subspaces of a vector space, these lattice operations are constructed using equalizers and coequalizers that guarantee distributivity. This interpretation reduces to known definitions of persistence in the cases of standard persistence, zigzag persistence and multi-dimensional persistence. We will further discuss some of the properties of this lattice, the algorithmic implications of it, and possible applications.

Profinite methods in abstract groups

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I shall review some results in abstract groups that are obtained using profinite graphs and groups. I will concentrate on properties like conjugacy separability in abstract groups.

Coprime subdegrees in finite primitive groups and completely reducible linear groups

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This work was inspired by a question of Gabriel Navarro about orbit lengths of groups acting on finite vector spaces. If a finite group H acts irreducibly on a finite vector space V, then for every pair of non-zero vectors, their orbit lengths a, b have a non-trivial common factor. This could be interpreted in the context of permutation groups. The group VH is an affine primitive group on V and a, b are orbit lengths of the point stabiliser H, that is, a and b are subdegrees of VH. This raises a question about subdegrees for more general primitive permutation groups. Coprime subdegrees can arise, but (we show) only for three of the eight types of primitive groups. Moreover it is never possible to have as many as three pairwise coprime subdegrees.

Minisymposium on Combinatorics

Organizers
Ilse Fischer *(University of Vienna, Austria)*
Matjaž Konvalinka *(University of Ljubljana, Slovenia)*

A triangular gap of side 2 in a sea of dimers in a 60 degree angle

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We consider a triangular gap of side 2 in a 60 degree angle on the triangular lattice whose sides are zigzag lines. We study the interaction of the gap with the corner as the rest of the angle is completely filled with lozenges (a lozenge is a unit rhombus consisting of two lattice triangles that share an edge). We show that the resulting correlation is governed by the product of the distances between the gap and its five images in the sides of the angle. This provides a new aspect of the parallel between the correlation of gaps in dimer packings and electrostatics developed by the first author in previous work.

Fully Packed Loops in a triangle: matchings, paths and puzzles

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Fully Packed Loop configurations (FPLs) are subgraphs of a square grid such that each internal node is of degree two. While these objects arise naturally in a statistical physics context as a model for ice, they also lead to intriguing enumerative problems. Fully Packed Loop configurations in a triangle (TFPLs) first appeared in the study of ordinary Fully Packed Loop configurations where they were used to show that the number of FPLs with a given link pattern that has m nested arches is a polynomial function in m. It soon turned out that TFPLs possess a number of other nice properties. For instance, they can be seen as a generalized model for Littlewood-Richardson coefficients, thereby establishing an unexpected link to algebra. I will present a new combinatorial approach to the enumeration of TFPLs.

Splittable Permutation Classes

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We say that a permutation p is 'merged' from permutations q and r, if we can color the elements of p red and blue so that the red elements are order-isomorphic to q and the blue

ones to r. With Claesson and Steingrímsson, we have shown, as a special case of more general results, that every permutation that avoids the subpermutation 1324 can be merged from a permutation that avoids 132 and a permutation that avoids 213. This is a simple example of a property called splittability: we say that a hereditary permutation class C is 'splittable', if it has two proper hereditary subclasses A and B such that any element of C can be obtained by merging an element of A with an element of B. In my talk, I will show how splittability helps in enumeration of restricted permutations, explain how splittability relates to other Ramsey-type properties, and point out a close connection between splittability of certain permutation classes and the notion of χ-boundedness of circle graphs. I will then report on the recent progress in identifying which principal permutation classes are splittable.

Geometric realization of r-Tamari lattices

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Tamari lattice is the lattice of all parenthesizations of a string, where two parenthesizations are in a relation if we can get one from the other by using the associative rule $(xy)z->x(yz)$. It is a classical result that the Tamari lattice can be realized as the 1-skeleton (edges) of the associahedron. Recently, the r-Tamari lattice was defined, and F. Bergeron has conjectured that it can be realized as the 1-skeleton of a certain polyhedral subdivision of the associahedron. I will present a proof of this conjecture (joint work with I. Pak and H. Thomas).

Towards the directed cycle double cover conjecture

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I present some results obtained jointly with Andrea Jimenez and Mihyun Kang.

Clusters, generating functions and asymptotics for consecutive patterns in permutations

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We use the cluster method to enumerate permutations avoiding consecutive patterns. We reprove and generalize in a unified way several known results and obtain new ones, including some patterns of length 4 and 5, as well as some infinite families of patterns of a given shape. By enumerating linear extensions of certain posets, we find a differential equation satisfied by the inverse of the exponential generating function counting occurrences of the pattern. We prove that for a large class of patterns, this inverse is always an entire function. We also complete the classification of consecutive patterns of length up to 6 into equivalence classes, proving a conjecture of Nakamura.

Holonomic sequences: some special cases, some generalizations

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A useful way to classify sequences which appear in combinatorial enumeration is by the type of recurrences which they do (or do not) satisfy. Holonomic sequences are those satisfying homogeneous linear recurrences with polynomial coefficients, whose well-known special cases include sequences satisfying linear recurrences with constant coefficients, and hypergeometric sequences whose consecutive-term ratio is a rational function of the term index. We will consider closure properties of the less well-known d'Alembertian and Liouvillian sequences, sketch the simplest possible algorithms for finding such solutions of linear recurrences with polynomial coefficients, and present an alternative proof of a recent result of Reutenauer's that Liouvillian sequences are precisely the interlacings of d'Alembertian ones. Then we will move to multivariate sequences where, even for linear recurrences with constant coefficients, the situation is much more complicated. Although large, the class of holonomic sequences still fails to include several important and relatively simple sequences encountered in combinatorial enumeration, such as ordinary powers, Stirling numbers, and Eulerian numbers. So it seems necessary to turn attention to more general classes of sequences which retain some but not all of the nice properties of holonomic ones.

Minisymposium on Diferential Geometry and Mathematical Physics

Organizers
Xavier Gracia *(Barcelona Tech, Spain)*
Olga Rossi *(University of Ostrava, Czech Republic)*

Geometric structures in the Hamilton-Jacobi equation

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A better understanding of the Hamilton-Jacobi equation can be obtained by a careful analysis of the relevant geometric structures that are involved in it. This analysis is performed by working on an appropriate generalisation of the Hamilton-Jacobi equation following the lines of the article by Cariñena et al (2006).

A geometric analysis of dynamical systems with singular Lagrangians

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The aim is to find a "dynamical picture", i.e. geometric structure of the complete solution of equations of motion of a singular Lagrangian, and study symmetries of the corresponding implicit Euler-Lagrange equations. In case of regular Lagrangians the dynamics are completely described by a one-dimensional foliation of the phase space. For singular Lagrangians the structure of solutions is much more complicated, and to find it one has to apply the so-called geometric constraint algorithm which provides a system of final constraint submanifolds. This method is a mathematically correct setting for the heuristic Dirac algorithm. Contrary to the geometric approach the Dirac algorithm often provides incomplete or confusing results. Our aim is to analyze completely the dynamics and find all symmetries of a concrete singular Lagrangian system by the geometric approach.

Almost Osserman structures on natural Riemann extensions

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In this lecture we study natural Einstein Riemann extensions from torsion-free affine manifolds to their cotangent bundles. Such a Riemann extension is always a semi-Riemannian manifold of signature (n,n). It is well-known that, if the base manifold is a torsion-less affine two-manifold with skew-symmetric Ricci tensor, or, a flat affine space, we obtain a (globally) Osserman structure on T^*M. If the new base manifold is an arbitrary direct product of the simple affine manifolds mentioned above, we found that the resulting structures on T^*M are not Osserman but only "almost Osserman", in the sense that the Jacobi operator has to be restricted from the whole set of unit space-like vectors (or unit time-like vectors,

respectively) to a complement of a subset of measure zero. We also find that the characteristic polynomial of the (restricted) Jacobi operator in the cotangent bundle depends only on the full dimension n of the base manifold, and it is the same as for the flat affine space This is a joint research with Masami Sekizawa, Tokyo Gakugei University.

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The inverse variational problem in nonholonomic mechanics

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The inverse problem of the calculus of variations in a nonholonomic setting is studied. The concept of constraint variationality of a mechanical system is introduced, based on a nonholonomic variational principle. Variational properties of mechanical systems of the first order with general constraints are presented. It is proved that constraint variationality is equivalent with the existence of a closed representative of the class of 2-forms characterizing the nonholonomic system. This result and resulting constraint Helmholtz conditions of variationality represent basic geometrical properties of constraint variational systems. Examples are presented as well, concerning planar motions and a particle in special relativity theory.

A new approach to the vakonomic mechanics

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The aim of this paper is to show that the Lagrange–d'Alembert and its equivalent the Gauss and Appel principle are not the only way to deduce the equations of motion of the nonholonomic systems. Instead of them, here we consider the generalization of the Hamiltonian principle for nonholonomic systems with nonzero transpositional relations. By applying this variational principle which takes into the account transpositional relations different from the classical ones we deduce the equations of motion for the nonholonomic systems with constraints that in general are nonlinear in the velocity. These equations of motion coincide, except perhaps in a zero Lebesgue measure set, with the classical differential equations deduced from d'Alembert–Lagrange principle.

Lagrangian and Hamiltonian duality

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Lagrangian and Hamiltonian formalism certainly belong to the most useful and extensively used mathematical frameworks in physics. The relationship between these two theories is provided by the Legendre transformation, and is one-to-one when the Lagrangian is regular: in such a case the Legendre transformation is a local diffeomorphism. In the standard treatment of many important physical systems, like for example Dirac, Maxwell and Yang-Mills fields or gravity, the symmetry between the Lagrangian and Hamiltonian side is broken, and the theory of integrable Hamiltonian systems does not have a corresponding Lagrangian counterpart. In my talk I will present Lepage manifolds which extend symplectic and multisymplectic structures and provide a background for a more general covariant Hamiltonian formalism. For a number of traditionally singular Lagrangians we obtain a Hamiltonian system which is in a direct correspondence with the Lagrangian system, avoiding the use of Dirac constraints.

Affine transformations and Lie algebroids

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The work of Kentaro Yano on the Lie derivative nearly sixty years ago was important in establishing the properties of infinitesimal symmetries of various types of geometric object, in particular of spaces with an affine connection. In this talk I shall discuss an approach to this problem using Lie groupoids of affine maps, and I shall show how the associated Lie algebroids may usefully be represented using a particular type of projectable vector field. This work is part of a larger project on Cartan geometries being undertaken jointly with Mike Crampin.

Constrained Noetherian symmetries and conservation laws of nonholonomic systems

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The set of constrained Noetherian symmetries of nonholonomic mechanical systems of the first order is studied and the corresponding conservation laws are presented.

Symplectic scalar curvatures on supermanifolds

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In Riemannian geometry, scalar curvature is introduced starting from the Riemann curvature tensor associated to a connection, by taking two successive contractions with respect to a metric compatible with the given connection. This contraction process could be (in principle) done with any 2-covariant non-degenerate tensor, compatible with the connection, and such that it has a geometrical interest; a symplectic form, for instance. However, the combined symmetries of the Riemann tensor and the symplectic form lead to a trivial situation. In symplectic supermanifolds, these difficulties are no longer present for a certain class of symplectic superforms, and the structure which arises (a Fedosov supermanifold) is very interesting from a physical point of view. In the talk, I will define the odd symplectic scalar curvature for these supermanifolds, and discuss their physical relevance.

Minisymposium on Discrete and Computational Geometry

Organizers
Oswin Aichhozer *(University of Technology, Austria)*
Sergio Cabello *(University of Ljubljana, Slovenia)*
Pavel Valtr *(Charles University, Czech Republic)*

On the computational complexity of Erdös-Szekeres and related problems in $\mathbf{R}^3$

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The Erdös-Szekeres theorem states that, for every k, there is a number n_k such that every set of n_k points in general position in the plane contains a subset of k points in convex position. If we ask the same question for subsets whose convex hull does not contain any other point from the set, this is not true: as shown by Horton, there are sets of arbitrary size that do not contain an empty 7-gon. We will discuss computational aspects of these problems. In particular, while it is known that computing a maximum size subset in (empty) convex position in R^2 is in P, both problems becomes NP-hard in R^3. Also, while deciding whether there exists a k-subset in convex position in R^3 is trivially fixed-parameter tractable (due to the The Erdös-Szekeres theorem itself), the problem becomes $W[1]$-hard when emptiness and strict convexity conditions are imposed.

When FO properties are efficiently solvable on interval graphs

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FO (first-order logic) properties include, for instance, the dominating set and subgraph isomorphism problems. We investigate the question, on which subclasses of interval graphs these problems have efficient (parameterized) algorithms–while this is the case of unit interval graphs, no such general algorithmic metatheorem is possible on all interval graphs. We prove that fixed-parameter tractability of FO holds on interval representations using any finite set of interval lengths, but cannot be true when any infinite dense set of lengths is allowed.

On Universal Point Sets and Simultaneous Geometric Embeddings

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A set P of points in R^2 is n-universal, if every planar graph on n vertices admits a plane straight-line embedding on P. Answering a question by Kobourov, we show that there is no n-universal point set of size n, for any $n \geq 15$. Conversely, we use a computer program to show that there exist universal point sets for all $n \leq 10$ and to enumerate all corresponding order types. Finally, we describe a collection G of 7′393 planar graphs on 35 vertices that do not admit a simultaneous geometric embedding without mapping, that is, no set of 35 points in the plane supports a plane straight-line embedding of all graphs in G. (Joint work with Jean Cardinal and Vincent Kusters.)

Realizability of Planar Straight-Line Graphs as Straight Skeletons

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The straight skeleton is a skeleton structure similar to the (generalized) Voronoi diagram. Since their introduction to computational geometry by Aichholzer et al. two decades ago, straight skeletons turned out to be a useful tool for a large number of applications in different areas of science and industry. The straight skeleton S(H) of a planar straight-line graph (PSLG) H consists of straight-line segments only. Hence, $S(H)$ can itself be interpreted as a PSLG (with some edges forming rays to infinity). Different algorithms and implementations were presented to compute $S(H)$ for a PSLG H. In this talk we will investigate the reverse question of computing $S(H)$: Is a given PSLG G realizable as the straight skeleton $S(H)$ of a PSLG H? In other words, find H such that $S(H) = G$. In joint work with Therese Biedl and Martin Held, we developed a method that reduces the problem of finding a suitable H to finding a line that intersects a set of convex polygons. We can find these polygons and all such lines in $O(n \log n)$ time, where n denotes the number of edges of G. It turns out that the same technique can also be used to find a suitable set of points whose Voronoi diagram realizes a given PSLG G. Thereby, we complete a partial solution for the problem Voronoi-realizability provided by Ash and Broker in 1985.

An improved lower bound on the maximum number of non-crossing spanning trees

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We address the problem of counting geometric graphs on point sets. Using analytic combinatorics we show that the so-called double chain point configuration of N points has $\Omega^*(12.31^N)$ non-crossing spanning trees and $\Omega^*(13.40^N)$ non-crossing forests. This improves the previous lower bounds on the maximum number of non-crossing spanning trees and of non-crossing forests among all sets of N points in general position given by Dumitrescu, Schulz, Sheffer and Tóth in 2011. A new upper bound of $O^*(22.12^N)$ for the number of non-crossing spanning trees of the double chain is also obtained.

Recursive regularity and the finest regular coarsening

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We introduce the notion of recursive regularity. A polyhedral subdivision of a point set is said to be recursively regular if it can be coarsened by a regular subdivision that divides the original one into regular parts. The class of such subdivisions is a subset of the visibility-acyclic subdivisions and a superset of the regular subdivisions of a point set. However, the associated graph of flips is not necessarily connected. We relate recursively-regular subdivisions to the concept of finest regular coarsening and give a simple algorithmic characterization of the class.

Polycubes

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Polycubes are polyforms made of cubes of the same size joined face to face. Various algebraical, geometrical, topological, combinatorial and symmetrical properties of polycubes may be studied. The boundary of a non-singular polycube is a surface (every boundary point has a neighborhood homeomorphic to a disc). We focus on the morphology of such polycubes: 1) We present an algebraic description of such a boundary (an atlas with labeled edges) and show how various "global informations" about the non-singular polycube $\mathscr{P}$ (e.g. the number of its cubes) may be obtained from this "local information" (about the shape of its boundary). The same method (motivated by the ideas and techniques of H. Abelson and A. di Sessa from their book *Turtle Geometry*, 1986) may be applied to other 2D and 3D-polyforms made of regular polygons or Platonic solids. 2) A classification of different types of boundary vertices and boundary faces of non-singular polycubes is presented, from which the basic relations between various parameters of polycubes are easily obtained.

Discrete Voronoi Game

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Two players alternately claim vertices of a graph for t rounds. In the end, the remaining vertices are divided such that each player receives the vertices that are closer to his or her claimed vertices. We prove that there are graphs for which the second player gets almost all vertices in this game, but this is not possible for bounded-degree graphs. For trees, the first player can get at least one quarter of the vertices, and we give examples where she can get only little more than one third of them.

Parametric discrete Morse theory

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Discrete Morse theory introduced by Robin Forman in 1998 is a combinatorial version of smooth Morse theory. It has proven to be a useful tool for computing homology of cell complexes and persistent homology of filtered cell complexes, and is also widely used in topological data analysis. We will present a parametric version of discrete Morse theory and an algorithm based on it for tracking critical features in data.

Terrain visibility with multiple viewpoints

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We study the problem of visibility in polyhedral terrains, in the presence of multiple viewpoints. We consider a triangulated terrain with $m > 1$ viewpoints (or guards) located on the terrain surface. A point on the terrain is considered *visible* if it has an unobstructed line of sight to at least one viewpoint. We study several natural and fundamental visibility structures: (1) the visibility map, which is a partition of the terrain into visible and invisible regions; (2) the colored visibility map, which is a partition of the terrain into regions whose points have exactly the same visible viewpoints; and (3) the Voronoi visibility map, which is a partition of the terrain into regions whose points have the same closest visible viewpoint. We study the complexity of each structure for both 1.5D and 2.5D terrains, and provide efficient algorithms to construct them. Our algorithm for the visibility map in 2.5D terrains improves on the only existing algorithm in this setting.

Untangling two systems of noncrossing curves

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We consider two systems of curves $(\alpha_1,\dots,\alpha_m)$ and $(\beta_1,\dots,\beta_n)$ drawn on M, which is a compact two-dimensional orientable surface of genus $g \geq 0$ and with $h \geq 1$ holes. Each α_i and each β_j is either an arc meeting the boundary of M at its two endpoints, or a closed curve. The α_i are pairwise disjoint except for possibly sharing endpoints, and similarly for the β_j. We want to "untangle" the β_j from the α_i by a self-homeomorphism of M; more precisely, we seek a homeomorphism $\varphi\colon M \to M$ fixing the boundary of M pointwise such that the total number of crossings of the α_i with the $\varphi(\beta_j)$ is as small as possible. This problem is motivated by an application in the algorithmic theory of embeddings and 3-manifolds. We prove that if M is planar, i.e., $g = 0$, then $O(mn)$ crossings can be achieved (independently of h), which is asymptotically tight, as an easy lower bound shows. For M of arbitrary genus, we obtain an $O((m+n)^4)$ upper bound, again independent of h and g. The proofs rely, among others, on a result concerning simultaneous planar drawings of graphs by Erten and Kobourov.

Balanced 6-holes in bichromatic point sets

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We consider an Erdös type question on k-holes (empty k-gons) in bichromatic point sets. For a bichromatic point set $S = R \cup B$, a balanced $2k$-hole in S is spanned by k points of R and k points of B. We show that if $|R| = |B| = n$, then the number of balanced 6-holes in S is at least $\frac{1}{45}n^2 - \Theta(n)$.

Minisymposium on Graph Theory

Organizers

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Bucolic graphs and complexes

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Median graphs are one of the central classes of graphs in metric graph theory. They arise in different guises and applications, and relate to many other mathematical structures. Several natural non-bipartite generalizations that capture various properties of median graphs have also been studied, in particular quasi-median graphs, weakly median graphs and fiber-complemented graphs. In this talk we present recently introduced class of the (strongly) bucolic graphs, that are a common generalization of median and of bridged graphs (the latter graphs are also widely known as the graphs in which there are no isometric cycles of length more than 3). We prove that bucolic graphs are precisely the retracts of Cartesian products of weakly bridged graphs; in turn they are exactly the weakly modular graphs satisfying some local conditions formulated in terms of forbidden induced subgraphs. Moreover, finite bucolic graphs can be obtained by gated amalgamations from products of weakly bridged graphs. Bucolic complexes, whose 1-skeletons are precisely bucolic graphs, can be defined as simply connected prism complexes satisfying some local combinatorial conditions. We show that locally-finite bucolic complexes are contractible, and satisfy some nonpositive-curvature-like properties. In particular, we prove the fixed point theorem for finite group actions on such complexes. This is a joint work with J. Chalopin, V. Chepoi, T. Gologranc and D. Osajda.

Threshold coloring and unit cube contact representation of graphs

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Given a partition of edges of a graph G into *near* and *far* edges, a *threshold coloring* is a labeling of $V(G)$ so that every pair of vertices adjacent with a *near* edge receive integer labels that are closer than a certain threshold, and every pair of vertices adjacent with a *far* edge receive labels at greater distance. Not every planar graph is threshold colorable, yet several subclasses of planar graphs admit a threshold coloring. Applying the concept of threshold colorings to infinite planar grids we were able to show that, for example, every subgraph of a hexagonal tessellation of the plane admits a unit-cube contact representation.

Point-circle configurations and inscribability of polytopes and graphs

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We call a graph G inscribable of order m (in brief, m-inscribable) if its vertices can be located on the sphere S^2 in such a way that for each vertex v, the vertices at distance m from

v lie in a common plane ($m = 1,2,...$). If, in particular, G is planar and 3-connected, then, on account of Steinitz' characterization theorem, we can define the same property for a 3-polytope P whose 1-skeleton is isomorphic to G. If the planes in the definition above are all distinct, then G (respectively P) admits a point-circle configuration of type (n_k), where n is the number of vertices of G and k is the number of mth neighbours of v. Examples are the Platonic and Archimedean solids; they are all 1-inscribable, and some of them are 2-inscribable. In this talk we present, besides sporadic examples and finite classes, some infinite series of m-inscribable graphs and polyhedra. We also raise some open problems. The results presented here were obtained partly in joint work with Tomaž Pisanski.

Planar Emulators Conjecture Is Nearly True for Cubic Graphs

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We prove that a cubic nonprojective graph cannot have a finite planar emulator, unless one of two very special cases happen (in which the answer is open). This shows that Fellows' planar emulator conjecture, disproved for general graphs by Rieck and Yamashita in 2008, is nearly true on cubic graphs, and might very well be true there definitely.

Symmetry breaking in graphs and motion conjectures

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This talk is concerned with automorphism breaking of finite and infinite graphs. Albertson and Collins [1] introduced the *distinguishing number* $\mathscr{D}(G)$ of a graph G as the least cardinal d such that G has a labeling with d labels that is only preserved by the trivial automorphism. This concept has spawned numerous papers on finite and infinite graphs. Here we focus on the infinite motion conjecture of Tom Tucker and generalizations. In particular, we present partial results pertaining to the conjecture, a generalization to uncountable graphs, and results that support the conjecture and its generalizations. The starting point is

Lemma 1 *(Motion Lemma, Russell and Sundaram [5]) Let the motion $m(G)$ of a graph G be the minimum number of vertices that is moved by any nonidentity automorphism of G. Then $2^{\frac{m(G)}{2}} \geq |\mathrm{Aut}(G)|$ implies $\mathscr{D}(G) \leq 2$.*

The immediate generalization to infinite graphs is the Motion Conjecture, with Tucker's Infinite Motion Conjecture as a special case:

Conjecture 2 *(Motion Conjecture [2]) Let G be a connected, infinite graph with infinite motion $m(G)$. Then $2^{m(G)} \geq |Aut(G)|$ implies $\mathscr{D}(G) \leq 2$.*

Conjecture 3 *(Tucker's Infinite Motion Conjecture [6]) Let G be a connected, locally finite infinite graph with infinite motion $m(G)$. Then $\mathscr{D}(G) \leq 2$.*

Both conjectures are open, but partial results and connections to other structures will be presented in the talk. We list one is by Florian Lehner [4] and another one by Cuno, Imrich and Lehner [2].

Theorem 4 *The Infinite Motion Conjecture is true for graphs of growth $O\left(2^{(1-\epsilon)\frac{\sqrt{n}}{2}}\right)$.*

Theorem 5 *Let G be an infinite, connected graph with infinite motion. If $m(G) \geq |\mathrm{Aut}(G)|$, then $\mathscr{D}(G) \leq 2$.*

For countable G this is easily shown by induction, for graphs G with larger cardinality by transfinite induction. We have the following corollary.

Corollary 6 *Let G be an uncountably infinite, connected graph with infinite motion, and suppose that $2^{m(G)} > |Aut(G)|$. Then, under the assumption of the general continuum hypothesis, $\mathscr{D}(G) \leq 2$.*

For the analogous result for countably infinite, connected graphs one assumes the CH. However, if the graphs are locally finite, then the CH is not needed. This was shown in [3] and follows from results of either Halin, Trofimov or Evans.

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Extending Partial Representations of Graphs

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The partial representation extension problem is a recently introduced generalization of the recognition problem. In this problem, aside a graph a part of a representation is given. The question is whether this partial representations can be extended to a representation of the entire graph. For example in the case of interval graphs, a part of intervals is pre-drawn

and the question is whether the remaining intervals can be added. The partial representation extension problem clearly generalizes the recognition problem; an input of the recognition problem corresponds to an input of the partial representation problem in which the partial representation is empty. Therefore, we study complexity of this problem for classes for which recognition is solvable in polynomial time. It is surprising that in most of these cases, the partial representation extension problem is also polynomially solvable. In this talk, we review results of last few years concerning these problems, together with their connections to other types of problems dealing with restricted representations. We discuss interval graphs, proper and unit interval graphs, chordal graphs, permutation and function graphs, circle graphs and other graph classes.

On b-perfect graphs

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Most of the parameters of graphs related to vertex coloring, as it's the case of the chromatic number, tend to minimize the number of used colors. On the contrary, other parameters tend to maximize this number. A b-coloring of a graph is a proper coloring of its vertices such that each color class contains a vertex that has a neighbor in all other color classes, and the b-chromatic number of a graph G is the largest integer k such that G admits a b-coloring with k colors. A graph is b-perfect if the b-chromatic number is equal to the chromatic number for every induced subgraph of G. Any such a graph can be optimally colored in linear time. In this work, we give a characterization of the class of b-perfect graphs by a family of 22 forbidden subgraphs. We also present a polynomial-time algorithm to find a maximum clique in every b-perfect graph.

On CIS Circulants

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A well-covered graph is a graph in which all maximal stable sets are of the same size, or in other words, they are all maximum. A CIS graph is a graph in which every maximal stable set and every maximal clique intersect. A circulant is a Cayley graph over a cyclic group. It is not difficult to show that a circulant G is a CIS graph if and only if G and its

complement G are both well-covered and the product of the stability numbers of G and its complement equals the number of vertices. It is also easy to demonstrate that both families, the circulants and the CIS graphs, are closed with respect to the operations of taking the complement and lexicographic product. We study the structure of the CIS circulants. It is well-known that all P_4-free graphs are CIS. In addition to the simple family of the P_4-free circulants, we construct a non-trivial sparse but infinite family of CIS circulants. We are not aware of any CIS circulant that could not be obtained from graphs in this family by the operations of taking the complement and lexicographic product.

On the probability of planarity of a random graph near the critical point

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Consider the uniform random graph $G(n,M)$ with n vertices and M edges. Erdös and Rényi (1960) conjectured that the limit $\lim P[G(n,n/2) \text{ is planar}]$ exists and is a constant strictly between 0 and 1. Luczak, Pittel and Wierman (1994) proved this conjecture and Janson, Luczak, Knuth and Pittel (1993) gave lower and upper bounds for this probability. In this work we determine the exact probability of a random graph being planar near the critical point $M = n/2$. More precisely, for each u, we find an exact analytic expression for $p(u) = \lim P[G(n, n/2(1 + u\,n^{-1/3}) \text{ is planar}]$. In particular, we obtain that $p(0)$ is approximately equal to 0.99780. Additionally, we are also capable to extend these results to classes of graphs closed under taking minors. This is a joint work with Marc Noy (UPC-Barcelona) and Vlady Ravelomanana (LIAFA-Paris), available on-line at http://arxiv.org/abs/1204.3376.

1-Hamilton-connected claw-free graphs

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A graph G is Hamilton-connected if G has a hamiltonian (u,v)-path for any pair of vertices u, v, and, for an integer k, a graph G is k-Hamilton-connected if the graph $G - X$ is Hamilton-connected for every set X of vertices with $|X| = k$. Specifically, G is 1-Hamilton-connected if $G - x$ is Hamilton-connected for every vertex x of G. Obviously, a Hamilton-connected graph is 3-connected, and a k-Hamilton-connected graph is $(k+3)$-connected. In the talk we first present a closure concept for 1-Hamilton-connectedness in claw-free graphs

such that, if G' is a closure of a claw-free graph G, then (i) G' is 1-Hamilton-connected if and only if G is 1-Hamilton-connected, (ii) G' is the line graph of a multigraph, and (iii) for some vertex x of G, $G'-x$ is the line graph of a multigraph with at most two triangles or at most one double edge. We then discuss some applications of the closure concept to some equivalent versions and partial solutions of the Thomassen's Conjecture (every 4-connected line graph is hamiltonian). Joint work with Petr Vrana, Pilsen.

Optimal Erdös-Pósa property for pumpkins

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A class of graphs F satisfies the Erdös-Pósa property if there exists a function f such that, for every integer k and every graph G, either G contains k vertex-disjoint subgraphs each isomorphic to a graph in F, or there is a set $S \subseteq V(G)$ of at most $f(k)$ vertices such that $G \setminus S$ has no subgraph in F. Erdös and Pósa [1965] proved that the set of all cycles satisfies this property with $f(k) = O(k \cdot log(k))$. Given a connected graph H, let $M(H)$ be the class of graphs that can be contracted to H. Robertson and Seymour [1986] proved that $M(H)$ satisfies the Erdös-Pósa property if and only if H is planar. The function f derived from the proof of this result is super-exponential, and this has been the best general upper bound for almost 30 years. Some months ago, Chekuri and Chuzhoy [2013] proved that $f(k) = O(k \cdot \text{polylog}(k))$. On the other hand, it is known that for any planar graph H containing a cycle, it holds that $f(k) = \Omega(k \cdot \log(k))$, so it is interesting to find particular cases of planar graphs H for which this lower bound is attained. In this talk we present how to obtain an asymptotically optimal function $f(k) = O(k \cdot \log(k))$ for the c-pumpkin, which is the graph with two vertices linked by $c > 0$ parallel edges, and can be seen as a natural generalization of a cycle. This is joint work with Samuel Fiorini and Gwenaël Joret.

Spectral radius of rooted product of graphs

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The rooted product of a graph H by a sequence of rooted graphs G_i, $i \in V(H)$, is obtained by identifying the vertex i of H with the root of G_i. The rooted product of graphs was defined by Godsil and McKay in 1978, and they also determined its characteristic polynomial. Here we consider the special case when all rooted graphs are isomorphic either to a given rooted graph G or to a single-vertex graph (in other words, copies of G are attached to a subset of vertices of H only). We study the behavior of the principal eigenvector of such rooted product and resolve a 2009 conjecture by Belardo, Marzi and Simic on the spectral radius of rooted product of H with a sequence of stars of equal size.

Minisymposium on Mathematical Methods in Image Processing

Organizers
Vicent Caselles *(Pompeu-Fabra University, Spain)*
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Shape from Silhouette Consensus

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Many applications in computer vision require the 3D reconstruction of a shape from its different views. When the available information in the images is just a binary mask segmenting the object, the problem is called shape from silhouette (SfS). As first proposed by Baumgart, the shape is usually computed as the maximum volume consistent with the given set of silhouettes. This is called visual hull, a term coined by Laurentini who also studied its theoretical aspects. In real multi-view applications, silhouette masks are extracted from the different views by background subtraction techniques that segment foreground objects. These silhouettes often contain errors due to noise, calibration inaccuracies or background subtraction errors (false alarms and miss-detections) derived from occlusions, illumination changes, moving background or similar colors in the foreground and background. In those cases, when the shape is computed with the visual hull, as the intersection of the back-projected silhouettes in the 3D space, the resulting shapes are incomplete. We propose a shape-from-silhouette algorithm that is robust to inconsistent and incomplete silhouettes. The recovery of the shape that best fits the available data (silhouettes) is formulated as a continuous energy minimization problem. The energy is based on the error between the silhouettes and the shape plus a regularization term. Thanks to the characterization of the visible surface in each view, we consider the error in the volume space. As a result, we obtain an iterative volume-based algorithm that evolves the initial shape to the shape that is in general agreement with the silhouettes, thus being robust to errors in the silhouettes.

Optical Flow on Evolving Surfaces: Mathematical Model

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We extend the concept of optical flow to a dynamic non-Euclidean setting. Optical flow is traditionally computed from a sequence of flat images. In this talk we introduce variational motion estimation for images that are defined on an evolving surface. Volumetric microscopy images depicting a live zebrafish embryo serve as biological motivation.

Adaptive Finite Volume Method For Solving Diffusion Equations On A Consistent Quadtree Grid

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We present new finite volume method for solving diffusion PDEs used in image processing on adaptive grids, i.e. grids adapted to the data with the aim to decrease the number of unknowns in computations [1], [4]. The diffusion equations are solved on the consistent adaptive grid built by modifying the quadtree structure in such way, that the connection of representative points of two adjacent finite volumes is perpendicular to their common boundary. First we present the scheme for the linear heat equation and evaluate its EOC by subsequent refinement of a selected fixed initial grid. To solve more general diffusion equations we adjust the recently developed methods [3] which utilizes all necessary information locally using the values on edges which are updated using the conservation law principles. Such methods evaluate the gradients of solution by using representative points which are midpoints of the edges. This requirement if not fulfilled in our consistent adaptive grid, so we present the method how to evaluate solution gradient on this type of grids. We apply the newly developed approaches to numerical solution of the regularized Perona-Malik equation [2].

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Optical Flow on Evolving Surfaces: Numerical Aspects

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We extend the concept of optical flow to a dynamic non-Euclidean setting. Optical flow is traditionally computed from a sequence of flat images. We introduce variational motion estimation for images that are defined on an evolving surface. Volumetric microscopy images depicting a live zebrafish embryo serve as biological motivation. In this talk we discuss numerical aspects, a possible surface parametrisation from noisy test data, and present numerical results.

Plant root tracking in 2-dimensional neutron radiographic images

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Root system architecture is essential for plant nutrient and water uptake and is therefore crucial for plant development. Root system responses to heterogeneous soil conditions are of highest interest in plant nutrition, plant hydrology as well as plant breeding. Root architectural development includes architectural, morphological, anatomical as well as physiological traits. For the systematic investigation of such complex biological systems mathematical modelling is inevitable. An entire parametrisation of a root architectural model needs (a) elaborate experimental work (b) appropriate imaging techniques (c) advanced image analysis. In the last years there has been enormous progress in imaging techniques in terms of cost and image resolution, while there has been less progress in automated data evaluation. We present a new approach for recovering root architectural parameters from 2-dimensional images of root systems. Its novelty is that the root tracking algorithm is based on a dynamic root architecture model. In this way it can be decided from a root system developmental point of view whether a specific path in the graph represents a root or not. This method helps in particular to distinguish root overlaps from branches and favours the analysis of root development over a sequence of images. We do not go into the details about the segmentation step, but we focus on the parametrisation of a root system model. The described algorithm starts with a sequence of segmented 2-dimensional images showing

dynamic development of a root system. For each image morphological operators are used for skeletonisation. Based on this, a graph is created and analysed by graph theoretic methods. In this work, we exemplify the approach with 2-dimensional NR images of lupin-root systems grown in mesocosms filled with a sandy substrate.

Computational reconstruction of zebrafish early embryogenesis by nonlinear PDE methods of image processing

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In the talk we present mathematical models and numerical methods which lead to early embryogenesis reconstruction and extraction of the cell lineage tree from the large-scale 4D image sequences. Robust and efficient finite volume schemes for solving nonlinear PDEs related to filtering, object detection and segmentation of 3D images were designed to that goal and studied mathematically. They were parallelized for massively parallel computer clusters and applied to the mentioned problems in developmental biology. The presented results were obtained in cooperation of groups at Slovak University of Technology, Bratislava, CNRS, Paris and University of Bologna.

A non-local variational approach for P+XS image fusion

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In this work, we present a nonlocal variational model for fusing the information given by a panchromatic image at high resolution and the spectral multichannel at lower resolution in order to get the high resolution of the multispectral images. Our approach is based on the Caselles et al work [1]. In this paper, the authors give a functional model based on the main assumption that the geometry of the spectral images is contained in the topographic map of the panchromatic image. In our study, by the contrary, we assume that we can infer the geometry of the spectral channels at high resolution by using the NL-means operator,

proposed initially for denoising purposes in [2], to transport the high frequency information from the true panchromatic image to the high resolution of the multispectral images. The other two terms of the proposed model, first the relation between the panchromatic image to the spectral channels and, on the other, the relation between the low and high resolution of the spectral images, are the same as those proposed in [1]. We study theoretically the proposed functional model to get existence and uniqueness of the minimum. Finally, we show some experiments and we discuss the results.

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A Simple and Robust Cell Detection Algorithm

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In this talk we present our advancements in designing a robust but simple algorithm for detection of cells in biological image data. Simplicity of this algorithm is to be understood as reduction of its user-defined parameters, which results in reduced calibration time. A starting point for us was the FBLSCD (Flux-Based Level-Set Center Detection) algorithm, and we studied the impact of its parameters, namely curvature and advection coefficients, image intensity threshold and stopping time, on its behaviour. Consequently, we have developed the LSOpen (Level-Set morphological Opening) algorithm, which doesn't use curvature term and the stopping time is chosen automatically. This novel algorithm performs at least as good as FBLSCD, with reduced user input and calibration, thus making the process of cell detection more automatic.

Tracking of cell nuclei movement and division in time series of 3D images

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We present a method for tracking the cell movement and divisions in early zebrafish embryo development. First, we create an approximate segmentation of 4D tubular structures representing time-space cell nuclei shapes. Then we compute a combined 4D distance function d1 using all cell nuclei identifiers in all time steps and a 4D distance function d2 from the boundaries of the segmented tubular structures. Using the difference of these two distance functions d1-d2 we construct a potential field in which a backtracking in the steepest descent direction gives cell trajectories. The computational results, their visualization and further analysis will be presented.

Minisymposium on Numerical Methods for Partial Differential Equations

Organizers
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Method of fundamental solutions for gravity field modelling of the Earth

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The method of fundamental solutions (MFS) is used to derive the geopotential and its first derivatives from the second derivatives observed by the GOCE satellite mission. The MFS is based on the fundamental solution of a partial differential equation that represents its basis functions. In contrast to the boundary element method, the MFS is an inherent mesh-free method and avoids the numerical integration of singular fundamental solution introducing a fictitious boundary outside the domain, i.e. below the Earth's surface, where the source points are located. In this study we present how a depth of the fictitious boundary influences accuracy of the obtained numerical solution on or above the Earth's surface. In case that the source points are located directly on the Earth's surface we apply ideas of the singular boundary method that isolate singularities of the fundamental solution and its derivatives. As input data we use the Tzz components of the gravity disturbing tensor observed by GOCE satellite mission. They are filtered by the nonlinear diffusion filtering and then unknown coefficients in the source points are obtained by solving linear system of equations. Finally the disturbing potential and gravity disturbances on or above the Earth's surface are evaluated. The large-scale parallel computations are performed on the cluster with 1TB of the distributed memory. The obtained numerical solutions are compared with the GOCO03S satellite-only geopotential model, i.e. with the solution based on the spherical harmonics approach.

Flux-based level set method

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Level set methods are popular algorithms in applied mathematics to treat dynamic interfaces. There are many variants of such numerical methods, and the flux-based level set method [3] has some distinct features among them. The method is based on finite volume discretization rather than more usual finite difference approximation. In such a way the method is defined with no additional difficulties for general computational grids. In the case of passive transport with incompressible flow (i.e. the divergence free velocity) the method takes into the account the local conservation of the fluid on finite volumes. The high-resolution flux-based level set method is second order accurate in space and time for smooth parts of the solution and compares very well with other second order accurate methods [4]. It has been used successfully in some engineering, e.g. [2], and biomedical applications, e.g. [1]. Recent development of the method are concentrated on semi-implicit time discretization methods [5] that treats the inflow and outflow fluxes differently. Such methods, at least if first order accurate, are unconditionally stable with respect to the choice of time steps.

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IMEX methods for models for vertical equilibrium multiphase flow

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IMEX methods are a suitable choice for the solution of nonlinear convection-difussion equations, since the stability restrictions coming from the explicitly treated convective part, are much less severe than those that would be deduced from an explicit treatment of the diffusive term. We combine an explicit Runge-Kutta scheme for the convective part and an implicit one for the diffusive part. The application of these schemes to multiphase flow models requires the solution of highly nonlinear systems of equations. We show numerical examples that confirm the efficieny of the methods proposed.

Discrete duality finite volume scheme for numerical solution of regularized level set equation

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Discrete duality finite volume (DDFV) scheme established in recent years for elliptic problems is used for solving regularized level set equation. Semi-implicit DDFV numerical scheme for the solution of the regularized curvature driven level set equation is derived in 2D and 3D. Stability and convergence of the numerical solution to the weak solution is proved in 2D. Numerical experiments in 2D and 3D concerning accuracy and experimental order of convergence for presented schemes are included.

A high order finite volume scheme for the numerical solution of an atherosclerosis model

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This work is devoted to the numerical simulation of an atherosclerosis model, proposed by El Khatib et al. (2007). The numerical simulation is carried out by means of a finite volume scheme based on high-order ADER methodology. Concerning the asymptotic behaviour of the solutions, the numerical examples show that a small perturbation of a healthy steady state makes the system evolve to a disease equilibrium for some choice of the parameters. We apply our numerical scheme to determine if each initial datum in a huge family of initial data is attracted by a disease equilibrium or by a healthy steady state. Simultaneously we compute the steady states.

Numerical methods for the Heston model

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The presentation is devoted to the numerical solution of the two-dimensional stochastic volatility Heston model aimed to find a fair price of a financial derivative contract. The governing backward parabolic partial differential differential equation will be derived and main points concerning boundary conditions will be highlighted. In order to find the solution we propose a diamond-cell-based numerical scheme and show its experimental order of convergence. Finally we introduce a split inflow-implicit/outflow-explicit variant of the first scheme as well as its stabilized version. On numerical tests we show their accuracy and their ability to keep the discrete minimum-maximum principle.

Analysis of component-wise finite difference WENO schemes for conservation laws

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High Resolution Shock Capturing (HRSC) schemes are nowadays one of the most used schemes for the computation of accurate numerical approximations to the solution of hyperbolic systems of conservation laws. Most of these schemes emerge form a clever combination of an upwinding framework, in which the discretization of the equations on a mesh is performed according to the direction of propagation of information on that mesh, and a high order interpolation method as a mechanism to prevent the creation and evolution of spurious numerical oscillations. We center our work on the use of component-wise schemes as an alternative to the use of characteristic wise schemes, based on the use of the spectral decomposition of the Jacobian matrix of the fluxes for upwinding, because in many cases this information is not available or is quite difficult to obtain. We explore some flux-splitting schemes, such as the Global Lax Friedrichs flux-splitting (GLF) and one based on using a biased flux-splitting that uses the estimated values of the minimum and maximum eigenvalues of the Jacobian matrix of the fluxes, instead of the spectral radius of it, as GLF schemes do. This new scheme reduces the spurious oscillations that may appear when using GLF scheme. To reduce this oscillatory behavior we also work on redesigning the weights used in the WENO reconstructions proposed in [G.-S. Jiang and C.-W. Shu, Efficient implementation of weighted ENO schemes, J. Comput. Phys., 126(1), 1996] in our HRSC schemes. We compare the results obtained using a global definition of the smoothness indicators developed in

[D. Levy, G.Puppo and G.Russo, A fourth-order central weno scheme for multidimensional hyperbolic systems of conservation laws, SIAM J. Sci. Comput. 24, 2002], using the weights defined by Yamaleev and Carpenter in [N.K. Yamaleev and M.H. Carpenter, A systematic methodology for constructing high-order energy stable WENO schemes, J. Comput. Phys., 228, 2009] and finally the new weights, proposed in [F. Arandiga, M.C. Marti and P. Mulet, Weights design for maximal order WENO schemes, to appear], to prove that when using our proposed weights we reduce the oscillatory behavior while maintaining the high resolution of the scheme.

IMEX methods for diffusively corrected multi-species kinematic flow models

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Explicit schemes for the solution of nonlinear convection-diffusion equations have severe time step restrictions for accurate simulations with dominant diffusion. Therefore Implicit-explicit (IMEX) methods are suitable for the solution of those equations, since the stability restrictions, coming from the explicitly treated convective part, are much less severe than those that would be deduced from an explicit treatment of the diffusive term. These schemes usually combine an explicit Runge-Kutta scheme for the time integration of the convective part with a diagonally implicit one for the diffusive part. The application of these schemes to multi-species kinematic flow models with strongly degenerate diffusive corrections requires the solution of highly nonlinear and non-smooth systems of algebraic equations. We propose a regularization of the diffusion coefficients in the model and suitable techniques for getting a globally convergent Newton-Raphson-based nonlinear solver for those equations. Numerical examples arising from models of polydisperse sedimentation and multiclass traffic flow confirm the efficiency of the methods proposed.

Quantitative photoacoustic imaging

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Photoacoustic imaging is a hybrid tomographic technique based on the photoacoustic effect. Tissue irradiated by a short laser pulse generates an ultrasound signal (due to thermal

expansion) which can be measured by ultrasound transducers. From these measurements, the ultrasound initial pressure can be reconstructed uniquely by photoacoustic inversion. The goal of quantitative photoacoustic imaging is to determine spatially varying optical material parameters (absorption and scattering coefficients) from these initial pressure data, a highly ill-posed problem. Recent works on this subject showed that in general, unique reconstruction is impossible. To overcome this problem, we propose a restriction to piecewise constant parameters, for which the problem can be shown to admit a unique solution.

Evolution of surfaces with tangential redistribution of points

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We present an original method for improving numerical solution of equations modeling evolution of surfaces and other manifolds. The technique uses tangential movement of points along the surface during the evolution process. We show how an appropriately chosen tangential velocity helps to obtain a correct solution of the discretized problem. We present several test examples and practical applications.

A semi-Lagrangian AMR scheme for 2D transport problems in conservation form

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We propose a numerical instrument to solve, in 1D and 2D, transport problems written in conservation form. The integrand function evolves following the laws described by an advection field, whose expression depends on the nature of the system studied. Common

issues in the simulation of such problems are the appearance or movement of large gradients, the filamentation of the phase space or the presence of vortices, in which cases many discretization points are required, while smooth zones could be given less resolution. If a Fixed-Mesh (FM) discretization is used, then the choice of meshing the whole domain at the highest resolution is forced, which makes the numerical method time-consuming. Adaptive-Mesh-Renement (AMR) schemes describe different zones of the domain with different resolutions; the grid hierarchy is updated after each time step depending on the features of integrand function. The transport stages are solved by means of a PWENO-semi-Lagrangian (SL) strategy, extended to the 2D setting by means of a second-order Strang splitting. We show several 2D benchmark tests (Vlasov-Poisson, deformation flows, guiding-center and Kelvin-Helmholtz instabilities) of which we discuss the quality and the speedup with respect to a FM strategy. We show the preliminary results relative to the application of our strategy to a Vlasov-Maxwell system for the description of a laser penetrating into a plasma.

Stability in Dynamic Elastographic Imaging

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Hybrid imaging techniques couple different imaging modalities in order to maximize contrast and resolution. In general, a ground modality provides interior data, from which the material parameters are then reconstructed in a second step, given a PDE model. We treat the elastography problem, where the displacement vector field is given and the Lamé parameters are sought. The estimation of the elastic parameters is a nonlinear inverse problem. Recently, methods for proving stability of the linearized form of those problems were provided by Kuchment and Bal for conductivity imaging, using redundant elliptic systems. In this talk, we treat the elasticity problem by the method of Bal. The application of the stability results is in proving convergence of the iterative numerical solution for the elastographic imaging problem.

Minisymposium on Proving in Mathematics Education at University and at School

Organizers

Roman Hašek *(University of South Bohemia, Czech Republic)*
Zlatan Magajna *(University of Ljubljana, Slovenia)*
Walther Neuper *(Graz University of Technology, Austria)*
Pavel Pech *(University of South Bohemia, Czech Republic)*
Jordi Saludes *(University Polytechnica of Catalonia, Spain)*
Dušan Vallo *(University of Nitra, Slovakia)*
Wolfgang Windsteiger *(University of Linz, Austria)*

Computer assisted proving in secondary school mathematics

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Different ways of the use of computer in proving in secondary school mathematics will be discussed. By means of particular examples, the author, former secondary school teacher, now teacher educator, will illustrate advantages and disadvantages of the computer assisted proving in secondary school mathematics. The aim of the presentation is to contribute to the discussion about the use of TP software in pre-university mathematics.

Hypotheses production tool - a means for learning deductive proving

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Verification of a claim is just one of the aims of proving in school geometry and, in general, in school mathematics. Often other aspects of proofs and proving are more important, e.g. explanation, systematisation, communication. These aims mutually interact with the used technology and also with the proving related content. Introducing new technologies into school geometry thus requires a re-evaluation of the aims of proving and also a reconsideration of the curricular content. This is the case of dynamic geometry and, to a bigger extent, in the case of computer theorem provers. As a complement to dynamic geometry systems and a possible alternative to computer theorem provers a different kind of tool is proposed: a hypotheses production tool. Contrary to dynamic geometry systems, which emphasise changes in dynamic geometric constructions, the hypothesis production tool looks for (less visible) invariants in geometric constructions. These invariants are considered as hypotheses and are used as steps in proving claims about a considered construction. It is up to students to find connections between the hypotheses, to provide deductive arguments between them and to organise the arguments into a proof. Such approach gives rise to certain obstacles, but supports the currently recognised aims of proving in school geometry and is rather coherent.

Promises of Computer-Theorem-Prover technology for education

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Computer Theorem Provers (TP) are becoming ready for industrial use – and raise demands to educate engineers in “Formal Methods”, based on mechanised mathematics, modeling and proving. This demand calls for rethinking mathematics education in general – and for adapting TPs to educational requirements. Particular educational requirements are: (1) check user input automatically, flexibly and reliably – TPs are made for proving, and input

establishes a proof situation (2) give exhaustive explanations on request by learners – knowledge underlying TPs is human readable (not program code) (3) propose a next step if learners get stuck – the greatest challenge for TPs. This talk will relate several TP-based systems to these three requirements and thus give examples for discussion: What are further requirements from education to TP technology? How can TP-based education in proving narrow the gap between high-school math and academic math?

The use of DGS and CAS in proving theorems

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The use of dynamic geometry systems (DGS) and computer algebra systems (CAS) changed methods of teaching mathematics at all school levels considerably. Dynamic features of DGS enable to do several activities which were not possible in the past, for instance dynamic experimentation with geometric figures, stating conjectures, searching for loci of points or visual proving. On the other hand with CAS we are able to prove exactly mathematical theorems. In the talk we will present several topics from geometry in a plane with the stress on the use of DGS and CAS at schools.

Proving in secondary school mathematics

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There are two different approaches to proofs presentation in secondary school mathematics: 1) proofs, as a special separate topic, 2) proofs, as a part of mathematics building. Although proving has an irreplaceable position in the mathematics curricula, its priority in mathematics education is steadily marginalized by students as well as by teachers. The presentation will describe the current status of proving in secondary school mathematics and how the use of computers and visualisation could increase the popularity of this field of mathematics.

Theorema 2.0: Automated and Interactive Theorem Proving in Math Education

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The Theorema system is a mathematical assistant system that is designed to support a mathematician during all phases of mathematical activity. The focus lies, however, on proving mathematical theorems. Theorema employs algorithms that aim at generating proofs in

a “natural style” that can then also be presented in a style similar to how proofs are given in textbooks.

In the context of teaching the method of proving (for math/CS students at undergraduate university level) the system can be used in fully automated mode or interactive mode. In fully automated mode students state the proposition to be proven, compose the knowledge base, then just hit the “Prove”-button, and finally get the successful proof, which they can study as if it was given to them by the teacher. In case of a failing proof, the proof can still be displayed and the reason for failure can be investigated (which is in many cases a very valuable exercise for students!). In interactive mode, students can interfere the automated proof generation in various ways, e.g. the choice of the next inference rule to apply, choice of the branch in which to proceed with the proof, choice of variable instantiation, etc. While in the learning phase, the interactive mode is very useful because it proposes the student only inference rules that are actually applicable in the current state, and it eliminates errors in the execution of a rule, e.g. when performing a wrong rewrite or instantiation step.

With this talk, we want to initiate discussions on how to teach the method of proving to students at different levels. In particular, we are interested in opinions whether computer-support in this kind of teaching is desirable and, if yes, what are the requirements for computer systems to be used in the classroom.

Minisymposium on Several Complex Variables

Organizers
Franc Forstnerič *(University of Ljubljana, Slovenia)*
Martin Kolar *(Masaryk University, Czech Republic)*
Bernhard Lamel *(University of Vienna, Austria)*
Joaquim Ortega-Cerda *(University of Barcelona, Spain)*

Boundaries of analytic sets

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We show that a compact, connected, oriented, CR manifold of hypersurface type in C^n is extended to a "strip" complex variety Y in C^n. The extension is obtained as a union of discs attached to M at points of local minimality (Trepreau-Tumanov); this extension "propagates" to points where minimality fails by a generalized Hanges-Treves theorem on account of the fact that these points are connected to the formers by a CR orbit. From a variant of the Hans Lewy theorem, we know that analytic sets extend across pseudoconcave boundaries, and from the Sperling-Rothstein theorem the different "patch extensions" glue up to a complex variety W sheeted overe C^n. Altogether, we obtain the extension of M to a complex variety W, that is, the Harvey-Lawson theorem. If M is pseudoconvex, then W encounters Y before touching its boundary M; in particular, W is smooth in a neighborhood of M. (If, in addition, M is contained in a pseudoconvex boundary to which it is not complex tangential), then in fact W belongs to C^n.) Once one realizes M as a boundary taken in a smooth way, one gets the answer to a conjecture by Kohn: the range of the di-bar tangential to M is closed.

Bifurcations currents for endomorphisms of P^k

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The Mane-Sad-Sullivan theorem is a basic result concerning the stability of holomorphic families of rational maps on the Riemann sphere. We parially extend it to families of endomorphisms of P^k using pluripotential techniques. This is a joint work with Christophe Dupont.

On projective domains admitting a plurisubharmonic defining function

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We consider a smoothly bounded domain in complex projective space, which admits a plurisubharmonic defining function. We discuss the existence of 1-convex boundary points for such a domain.

Inhomogeneous random zero sets

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We construct random point processes in the complex plane that are asymptotically close to a given doubling measure. The processes we construct are the zero sets of random entire functions that are constructed through generalised Fock spaces. We show that the average distribution of the zero set is close to the given doubling measure, and that the variance is much less than the variance of the corresponding Poisson point process. This indicates that the zero sets are more 'rigid' processes than the Poisson process. If there is time I will also mention some results on the 'hole probability', the probability that there are no zeroes in a given set, which gives another measure of the 'rigidity' of the zero set. This is joint work with Xavier Massaneda and Joaquim Ortega-Cerdà.

On some bilinear problems on weighted Hardy-Sobolev spaces

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If w is a weight in $\mathbf{S}^n$, the weighted Hardy-Sobolev space $H^p_s(w)$, $0 \le s$, $0 < p < +\infty$, consists of functions f holomorphic in $\mathscr{B}^n$ such that if

$$f(z) = \sum_k f_k(z)$$

is its homogeneous polynomial expansion, and

$$(I+R)^s f(z) := \sum_k (1+k)^s f_k(z),$$

we have that

$$\|f\|^p_{H^p_s(w)} := \sup_{r<1} \int_{\mathbf{S}^n} |(I+R)^s f(r\zeta)|^p \, w(\zeta) d\sigma(\zeta) < +\infty.$$

For fixed $0 < s,t < n$, and w a weight in the Muckenhoupt class $\mathscr{A}_p$, we study the positive Borel measures μ on the unit sphere of $\mathbb{C}^n$, $\mathbf{S}^n$, for which the following bilinear problem holds: There exists $C > 0$ such that for any $f \in H^2_s(w)$, $g \in H^2_t(w)$,

$$\sup_{\rho<1} \left| \int_{\mathbf{S}^n} f(\rho\zeta)\overline{g(\rho\zeta)} d\mu(\zeta) \right| \le C \|f\|_{H^2_s(w)} \|g\|_{H^2_t(w)}.$$

We will give characterizations of this bilinear problem in two situations: for s,t non necessarily equal, under some restrictions on s,t and the weight w, and when $s = t$ in a more general situation. (Joint work with Joaquín M. Ortega.)

Partial rigidity of degenerate CR embeddings into spheres

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We shall consider degenerate CR embeddings f of a strictly pseudoconvex hypersurface $M \subset \mathbb{C}^{n+1}$ into a sphere $\mathbb{S}$ in a higher dimensional complex space $\mathbb{C}^{N+1}$. The degeneracy of the mapping f will be characterized in terms of the ranks of the CR second fundamental form and its covariant derivatives. In 2004, the speaker, together with X. Huang and D. Zaitsev, established a rigidity result for CR embeddings f into spheres in low codimensions. A key step in the proof of this result was to show that degenerate mappings are necessarily contained in a complex plane section of the target sphere (partial rigidity). In the 2004 paper, it was shown that if the total rank d of the second fundamental form and all of its covariant derivatives is $< n$ (here, n is the CR dimension of M), then $f(M)$ is contained in a complex plane of dimension $n+d+1$. The converse of this statement is also true, as is easy to see. When the total rank d exceeds n, it is no longer true, in general, that $f(M)$ is contained in a complex plane of dimension $n+d+1$, as can be seen by examples. In this talk, we shall show that (well, explain how) when the ranks of the second fundamental form and its covariant derivatives exceed the CR dimension n, then partial rigidity may still persist, but there is a "defect" k that arises from the ranks exceeding n such that $f(M)$ is only contained in a complex plane of dimension $n+d+k+1$. Moreover, this defect occurs in general, as is illustrated by examples.

Spectral properties of the $\overline{\partial}$-Neumann operator

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The spectrum of the $\overline{\partial}$-Neumann Laplacian on the Fock space $L^2(\mathbb{C}^n, e^{-|z|^2})$ is explicitly computed. It turns out that it consists of positive integer eigenvalues each of which is of infinite multiplicity. Spectral analysis of the $\overline{\partial}$-Neumann Laplacian on the Fock space is closely related to Schrödinger operators with magnetic field and to the complex Witten-Laplacian.

New criterion for the algebraic volume density property

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This is a report on a joint work with Shulim Kaliman. We start by reminding definitions and importance of the notions of density property and volume density property introduced by Varolin. To prove that a manifold has one of these properties can be a cumbersome calculation with Lie brackets of vector fields. We present a criterion, proved using the theory of coherent sheafs, which can reduce the calculations to a minimum. In particular it can

be applied to give a very short proof of our main result in Kaliman, S., Kutzschebauch, F.: The algebraic volume density property for affine algebraic manifolds. Invent. Math. 181 (2010), 605–647, which says that linear algebraic groups have the volume density property with respect to the left invariant (Haar) form. As another application on can prove that all homogenous spaces G/H (G linear algebraic, H reductive) admitting a left invariant form have the volume density property.

J-holomorphic discs attached to a maximal real submanifold

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We study the neighborhood of an embedded J-holomorphic disc attached along its boundary to a maximal totally real submanifold in an almost complex manifold. In particular, we provide sufficient conditions for the set of all nearby attached J-holomorphic discs to be a manifold. Further, we present an application concerning deformations of stationary J-holomorphic discs.

Biholomorphic Equivalence in the infinite type case

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We talk about recent joint work with Martin Kolar about the biholomorphic classification of infinite type hypersurfaces in $\mathbb{C}^2$. We will put an emphasis on examples of hypersurfaces which support symmetries, discuss general bounds on the dimension of automorphism groups, and give a number of applications.

The Strip Problem for L^p functions

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In this talk, new results for using the 1-dimensional extension property to determine analyticity are discussed. The case under consideration is what has been referred to as the strip problem. Let C be a strictly convex closed curve in the complex plane whose horizontal translates C_t fill out a strip S. Given a function $f(z)$ defined on the strip, such that the restriction of f to each C_t has a holomorphic extension to the domain D_t, show that f is holomorphic. Very general theorems of this type, including results in several variables, have been proved for real analytic functions; some more specialized theorems have been proved for the strip problem, for functions continuous on the closed strip. The current results are for

curves which are very general, but not completely generic, perturbations of an ellipse. The motivation for this research was to demonstrate that theorems of this type can be proved for L^p functions. Also, restricting to the case of the strip allows one to consider rather difficult geometrical problems; success here may lead to new theorems in several variables. The techniques involve a very detailed examination of a certain complexified problem, as well as some specialized wedge extension theorems.

Equidistribution estimates for Fekete points on complex manifolds

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I will present a joint work with Nir Lev. We study the equidistribution of Fekete points in a compact complex manifold. These are extremal point configurations defined through sections of powers of a positive line bundle. Their equidistribution is a known result. The novelty of our approach is that we relate them to the problem of sampling and interpolation on line bundles, which allows us to estimate the equidistribution of the Fekete points quantitatively. In particular we estimate the Kantorovich-Wasserstein distance of the Fekete points to its limiting measure.

L^2-extension of cohomology classes from a non-smooth divisor

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I will report on a joint project with Elizabeth Wulcan and Håkan Samuelsson-Kalm. Recently, Berndtsson generalized the Ohsawa-Takegoshi-Manivel L^2-extension theorem for holomorphic functions to the case of $\overline{\partial}$-closed forms of higher degree. He proved an L^2-extension theorem for $\overline{\partial}$-closed forms from a smooth divisor in a compact manifold with good (i.e. universal) L^2-estimates under very mild natural positivity assumptions. Similar work had been done before by Manivel, Demailly, Koziarz and others. We are now interested in the extension of L^2-cohomology classes also from a non-smooth divisor Y (in a compact manifold X). In that case, one first needs to address the question what kind of forms shall be extended and how forms on X shall be linked to the given form on Y. For this purpose, we develop an adjunction formula for the Grauert-Riemenschneider canonical sheaf of the singular variety Y. This formula can be used to set up a bimeromorphically invariant form of the extension problem. By a resolution of singularities, we can thus reduce the problem to the smooth case (treated by Berndtsson), and obtain an L^2-extension theorem under quite mild positivity assumptions (but without universal estimates).

Plurisubharmonic Polynomials

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I will talk about some new developments in the study of plurisubharmonic polynomials. Jointly with G. Bharali I have been working on bumping of pseudoconvex domains with real analytic boundary. In our study we met an obstacle that prevented us from getting an optimal result for all such domains. Recently we have been able to prove a theorem that removes this obstacle.

L^2 Interpolation for generalized Bargmann-Fock spaces from a singular hypersurface

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We will discuss a result on L^2 interpolation to the ambient space, of data given on a singular hypersurface in C^n, with respect to so-called generalized Bargmann-Fock L^2 norms. It is known that the ability to interpolate all data places restrictions on the singularities, but the precise restrictions are not yet known. We will consider so-called transversal singularities, which include for example simple normal crossing singularities (but with additional uniformity conditions on the angles between the transverse planes). The actual constraint on the hypersurface, which is global, is known as uniform flatness. It was introduced by Ortega Cerda, Schuster and the speaker in the context of smooth hypersurfaces, and it is here generalized to the singular case. We will recall the notion of density of the hypersurface, and show that if the density is less than 1 (according to our normalization) then interpolation is possible. We will also show that uniform flatness is not necessary, either in the smooth or singular case, thus answering in the negative a question posed in the aforementioned work of Ortega Cerda, Schuster and the speaker. This is joint work with Vamsi Pingali.

Minisymposium on Symmetries in Graphs, Maps and Other Discrete Structures

Organizers

Aleksander Malnič *(University of Ljubljana and University of Primorska, Slovenia)*

Norbert Seifter *(Montanuniversität Leoben, Austria)*

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Monomial Isomorphisms of Cyclic Codes

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For cyclic codes, there are multiple notions of isomorphism. For example, we can consider isomorphisms that only permute the coordinates of codewords, or isomorphisms that not only permute the coordinates of codewords but also multiply each coordinate by a scalar (not necessarily the same scalar for each coordinate) as it permutes the codewords. Isomorphisms of cyclic codes of the first kind have been studied - we will call them permutation isomorphisms - and our purpose is to begin study of the second kind of isomorphism - which we call monomial isomorphisms. We give examples of cyclic codes that are isomorphic by monomial isomorphisms that are not isomorphic by permutation isomorphisms. We find necessary conditions to reduce the solution of when two cyclic codes are monomially isomorphic to the solution of when two cyclic codes are permutation isomorphic, and applying results in the literature, give an explicit (shortest possible) list of permutation isomorphism which must be checked to determine if two cyclic codes are monomial isomorphic for most lengths over most finite fields. Our results also hold for some codes which are not cyclic.

On Generalized Cayley Graphs

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Generalized Cayley graphs were defined by D.Marušič, R. Scapellato and N. Zagaglia Salvi in 1992. They studied properties of such graphs, mostly related to double coverings of graph. They also posed a question whether there exists a generalized Cayley graph which is vertex-transitive but not Cayley graph. In this talk, as an affirmative answer to this question, we will present an infinite family of such graphs.

Cubic symmetric graphs having an abelian automorphism group with two orbits

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Finite connected cubic symmetric graphs of girth 6 have been classified by K. Kutnar and D. Marušič (*J. Combin. Theory Ser. B* **99** (2009), 162–184), in particular, each of these graphs has an abelian automorphism group with two orbits on the vertex set. In this paper all cubic symmetric graphs with the latter property are determined. In particular, with the exception of the graphs K_4, $K_{3,3}$, Q_3, $GP(5,2)$, $GP(10,2)$, $F40$ and $GP(24,5)$, all the obtained graphs are of girth 6.

Pentavalent arc-transitive bicirculants

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A *bicirculant* is a graph admitting an automorphism with two cycles of equal length in its cycle decomposotion. A graph is said to be *arc-transitive* if its automorphism group acts transitively on the set of its arcs. In this talk I will present a recent complete classification of connected pentavalent arc-transitive bicirculants. This is joint work with Iva Antončič and Ademir Hujdurović.

Arc-transitive cyclic regular covers of dodecahedron graph

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In this talk I will introduce all the arc-transitive cyclic regular covers of the dodecahedron graph using a new approach of constructing regular covers given by Conder and Ma. Two families of infinite 3-arc-transitive abelian regular covers of the dodecahedron graph will be introduced which gives more concrete examples that for a s-arc-transitive graph there exists $(s+1)$-arc-transitive covering graphs.

VT graphs of given degree and diameter

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A $(k;D)$-graph is a (finite, simple) k-regular graph of diameter D. The Degree/Diameter Problem is the problem of determining the order $n(k;D)$ of the largest $(k;D)$-graphs. The well-known Moore bound serves as an upper bound on the order of $(k;D)$-graphs. In terms of k and D, it can be stated as follows: $M(k;g) = 1+k+k(k-1)+\cdots+k(k-1)^{D-1}$. In our talk we show that for any fixed degree $k \geq 3$ and any positive integer K the largest vertex-transitive $(k;D)$ graph has size at most $M(k;D)-K$ for almost all (in the asymptotic sense) diameters D.

Generating Admissible Covers of Graphs

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I will present certain computational aspects of lifting automorphisms along regular covering projections of graphs. Joint work with Rok Požar.

Almost totally branched covers between regular maps

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A map is a 2-cell decomposition of a closed surface. A map on an orientable surface is called orientably regular if its group of orientation-preserving automorphisms acts transitively on the set of darts (edges endowed with an orientation). We investigate orientably regular maps with an unfaithful action of the automorphism group simultaneously at vertices and faces. In particular, we say that a covering $p\colon \mathcal{N} \to \mathcal{M}$ between orientably regular maps is *almost totally branched* if its group of covering transformations is a product XY, $X \leq \mathrm{Fix}_{\mathcal{N}}(F)$, $Y \leq \mathrm{Fix}_{\mathcal{N}}(V)$, where $\mathrm{Fix}_{\mathcal{N}}(F)$ and $\mathrm{Fix}_{\mathcal{N}}(V)$ fix pointwisely the face-centres and the vertices of $\mathcal{N}$, respectively. We first show that every branched covering $p\colon \mathcal{N} \to \mathcal{M}$ can be written as a composition $p = p_1 \circ p_2 \circ p_3$, where p_3 is smooth and p_2 is almost totally branched. Next we determine the structure of the covering transformation group G of an almost totally branched covering. Three cases can happen, either G is nonabelian containing an abelian subgroup of index two, or it is a product of two cyclic groups, or G is cyclic. In the nonabelian case we dermine the presentation of G. As an application we investigate orientably regular maps which are regular covers over platonic maps with a cyclic group of covering transformations. We describe all such maps in terms of parametrised group presentations. This generalises the work of Jones and Surowski [Cyclic regular coverings of the Platonic maps, *European J. Combin.* **21** (2000), 333–345] classifying the cyclic regular coverings over platonic maps with branched points exclusively at vertices, or at face-centres.

From Matrix to Graph Theory

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In matrix theory a 'preserver problem' demands a characterization of all maps Φ on a certain set $\mathcal{M}$ of matrices, which leave some function, subset, or relation invariant. In the case a symmetric binary relation R is preserved, such maps Φ are precisely the endomorphisms of the graph Γ with the vertex set $V(\Gamma) = \mathcal{M}$ and the edge set $E(\Gamma) = \{\{m_1, m_2\} : m_1 R m_2\}$. Hence a 'preserver problem' demands a characterization of all endomorphisms of the graph Γ. Often there are some additional assumptions on maps Φ, and we are interested, for example, in characterization of all automorphisms, bijective endomorphisms, etc. In graph theory, a finite graph is a *core*, if all its endomorphisms are automorphisms. In this talk some

cores will be presented that arise from matrix structures. These graphs are often highly 'symmetrical' and generalize some of the most famous graphs. Moreover, the endomorphisms of some graphs are related to maps that preserve the speed of light on a 4-dimensional Minkowski space-time.

Abstract Polygonal Complexes

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We briefly outline a theory of abstract polygonal complexes and their representations. The theory enables a uniform approach to maps on surfaces and their polyhedral representations. In particular, the relationship between automorphism groups of abstract polygonal complexes and the symmetry groups of their geometric representation is explored. The talk will be illustrated by computer implementation of most important features of this theory.

Solvable Regular Coverings of Graphs

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Covering techniques have received considerable attention over the years, with its main incentive in constructing regular coverings of graphs with specific symmetry properties. Accordingly, one would like to find algorithms that would deliver answers to certain natural questions regarding symmetry issues of graphs and their coverings; this adds further motivation to the topic. In the talk we will discuss certain algorithmic aspects related to solvable regular coverings.

Generalized ends of groups and graphs

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Roughly speaking an end of a graph $G(V,E)$ is an equicalence class of one-way infinite paths such that any two different equivalence classes can be sparated from each other by removing a finite subset S of $V(G)$. In this talk we consider infinite subsets of $V(G)$ with certain growth rates which can be separated from each other by a connected subgraph of G with smaller growth rate. Following the ideas presented in a paper of Stallings we not only generalize the concept of ends, but also some of the well-known results about ends of graphs.

Cayley graphs on abelian groups

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Let G be a group and let S be an inverse-closed subset of G. The *Cayley graph* $\mathrm{Cay}(G,S)$ is the graph with vertex-set G and with g being adjacent to h if and only if $gh^{-1} \in S$. It is easy to see that G acts regularly as a group of automorphisms of $\mathrm{Cay}(G,S)$ by right multiplication. Moreover, if G is abelian and ι is the automorphism of G mapping every element to its inverse, then ι acts an as automorphism of $\mathrm{Cay}(G,S)$ fixing the identity. We prove that, in an appropriate sense, almost all Cayley graphs on an abelian group G have $G \rtimes \langle \iota \rangle$ as their full automorphism group. This settles a conjecture of Babai and Godsil from 1982. This is joint work with Ted Dobson and Pablo Spiga.

EuroGiga Session

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Oswin Aichhozer *(University of Technology, Austria)*

Jan Kratochvil *(Charles University, Czech Republic)*

Tomaž Pisanski *(University of Ljubljana and University of Primorska, Slovenia)*

Günter Rote *(Freie Universität Berlin, Germany)*

Steering Committee Meeting

- Jan Kratochvil, Charles University, Czech Republic (GraDR - Graph drawings and representations),
- Oswin Aichholzer, Graz University of Technology, Austria (ComPoSe - Combinatorics of point sets and arrangement of objects),
- Günter Rote, Freie Universität Berlin, Germany (VORONOI - Spacial decompositions and graphs),
- Tomaž Pisanski, University of Ljubljana, Slovenia (GReGAS - Geometric representations and symmetries of graphs, maps, and other discrete structures and applications in science),
- Aigars Ekers, ESF (via internet).

Open to the members of EuroGiga and guests.

General Session

Organizers

Jasna Prezelj *(University of Ljubljana, Slovenia)*

Differential equations in complex domain and spherical real hypersurfaces

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We use a remarkable connection between real hypersurfaces in complex space and second-order differential equations in complex domains for the study of nonminimal real hypersurfaces in complex affine 2-space. We find necessary and sufficient conditions for a local CR-mapping at a Levi nondegenerate point into a sphere (if the latter exists) to extend holomorphically to the complex locus. As an application, we prove the bound $\dim \mathrm{aut}(M,0) \leq 5$ for the infinitesimal automorphism algebra of an arbitrary nonminimal at the origin Levi-nonflat hypersurface in C^2. This work is joint with R.Shafikov.

Poster Session

Organizers

Tomaž Pisanski *(University of Ljubljana and University of Primorska, Slovenia)*

A CSASC history of combinatorics and graph theory

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In this case a CSASC history is a Catalan Slovenian Austrian Slovak and Czech history starting with the famous Catalan scholar Ramon Llull in the 13th century and followed by a short discussion of combinatorics and graph theory in the last 50 years since the conference of Smolenice in Slovakia in 1963, including the conference of Prachatice in Bohemia in 1990, and the many conferences in Bled in Slovenia since 1991. Of course, not only the conferences will be discussed but also mathematicians and their combinatorics and graph theory involved. Last but not least, the part concerning Austria will be a step back into the 19th century discussing an involved Austrian mathematician.

Combinatorial configurations – the state of the art

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Configurations are linear regular uniform hypergraphs, mainly discussed in a geometrical language, closely related to bipartite graphs, combinatorial designs and similar structures. The current knowledge will be discussed together with the discussion how future research should go on. Probably also more general structures such as lambda-configurations will be considered. For further information see the corresponding article in the Handbook of Combinatorial Designs.

Configurations – history and notation

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In this talk I shall give a short survey on configurations as combinatorial and geometrical discrete structures from a historical point of view with a special focus on the question of notation. Configurations were formally defined in 1876 by Reye and investigated mainly in the last quarter of the nineteenth century and in the last 30 years with a long break in between. Due to the special aspect of this symposium the questions of symmetry will play a considerable role.

Some Results for Roman-Domination Number of Cardinal Product of Paths and Cycles

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For a graph $G=(V,E)$, *a Roman dominating function* (RDF) is a function $f\colon V\to\{0,1,2\}$ satisfying the condition that every vertex u for which $f(u)=0$ is adjacent to at least one vertex v for which $f(v)=2$. The weight of an RDF equals $w(f)=\sum_{v\in V}f(v)=|V_1|+2|V_2|$. An RDF for which $w(f)$ achieves its minimum is called *a γ_R-function* and its weight, denoted by $\gamma_R(G)$, is called *a Roman domination number*.

In this paper we determine the lower and the upper bound for $\gamma_R(P_m\times P_n)$ as well as the exact value of

$$\lim_{m,n\to\infty}\frac{P_m\times P_n}{mn}$$

where $P_m\times P_n$ stands for the cardinal product of two paths. We also generalize some results concerning cardinal product of two cycles $C_m\times C_n$.

A FEW WORDS ABOUT THE UNIVERSITY OF PRIMORSKA

Established in 2003, the University of Primorska (UP) is the youngest of the three state universities in Slovenia. It consists of six Faculties: Faculty of Mathematics, Natural Sciences, and Information Technologies (UP FAMNIT), Faculty of Education, Faculty of Humanities, Faculty of Management, Faculty of Tourism, and Faculty of Health Care; and two research institutes, the Science and Research Centre, and the Andrej Marušič Institute (UP IAM).

With their international faculty and many research links all over the world, UP FAMNIT and its research counterpart UP IAM are at the forefront of the academic development of UP. Student enrollment at UP FAMNIT has grown from approximately 100 in its first academic year (2007/08), to 700 in the current academic year (2012/13).

UP FAMNIT offers BSc, MSc and PhD Degree programs in Mathematics, while faculty members carry out their research at UP IAM. Thus far, collaboration between UP FAMNIT and UP IAM has resulted in the following mathematical conferences and meetings:

- AC^2 - Algebraic Combinatorics on the Adriatic Coast, Koper, Slovenia: 2003, 2004, 2008, 2009.
- Korea - Slovenia International Conference On Combinatorial and Computational Mathematics, Koper, Slovenia, 2007.
- International Workshop on Symmetries of Graphs and Networks SYGN 2010, Rogla, Slovenia: 2010, 2012.
- International Algebraic Graph Theory Summer School 2011, Rogla, Slovenia, 2011.
- 7th Slovenian International Conference on Graph Theory, Bled, Slovenia, 2011.
- PhD Summer School in Discrete Mathematics, Rogla, Slovenia: 2012, 2013.
- Computers in Scientific Discovery 6, Portorož, Slovenia, 2012.
- Workshop on Combinatorial Algorithms in Bioinformatics, Koper, Slovenia, 2012.
- Ljubljana-Leoben Seminar, Bovec, Slovenia, 2012.
- Algebraic, Topological and Complexity Aspects of Graph Covers, Bovec, Slovenia, 2013.
- International Conference on Graph Theory and Combinatorics, dedicated to Prof. Dragan Marušič's 60th Birthday, Koper, Slovenia, 2013.

Visit `www.famnit.upr.si` for more information on UP FAMNIT's graduate program in Mathematics. Visit `www.iam.upr.si` for more information on research at UP IAM in Mathematics and related fields.

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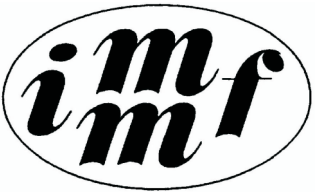

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