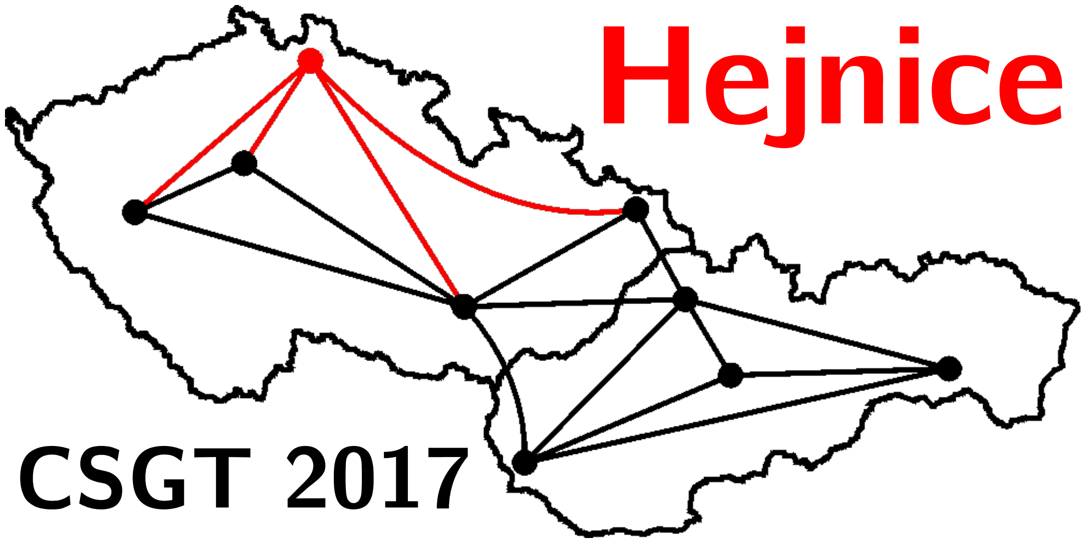
52nd Czech-Slovak conference on Graph Theory



Radek Hušek, Tomáš Masařík, Robert Šámal (eds.)

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Preface

Let us greet you in Hejnice, a small town near the tripoint of the Czech Republic, Poland, and Germany in the International Center for Spiritual Renewal located in a colourful baroque monastery.

We believe that this year's conference will succeed to fulfill your expectations. Our invited talks shall essentially contribute to this intent. These will be given by

- František Kardoš (University of Bordeaux),
- Marcin Kozik (Jagiellonian University, Kraków),
- Zuzana Masáková (Czech Technical University, Prague),
- Patrice Ossona de Mendez (CNRS EHESS, Paris),
- Marcin Pilipczuk (University of Warsaw),
- Edita Rollová (University of West Bohemia, Pilsen),
- Martin Škoviera (Comenius University, Bratislava), and
- Martin Tancer (Charles University, Prague).

We would like to thank for help with the organization of this conference to Tomáš Masařík, Jan Musílek, Radek Hušek, and Peter Korcsok. I shall also stress that several other colleagues willingly assisted us with this effort. I am much obliged to all of them. We would like to emphasize that the conference would not be possible to arrange without the support of Liberec branch of the Union of Czech Mathematicians and Physicists, the Center of Excellence – Institute for Theoretical Computer Science (CE-ITI), of the Department of Applied Mathematics of the Charles University, Computer Science Institute of Charles University and Faculty of Science, Humanities and Education of Technical University of Liberec. We thank for the hospitality of of the International Center for Spiritual Renewal in Hejnice who did their best to arrange a pleasant stay for all of us. We also thank company Znovín a.s. for their generous gift.

Dear colleagues, we wish you to bring home new ideas for your research and also only pleasant memories on this week spent in Hejnice.

Robert Šámal, Martina Šimůnková, Jan Kratochvíl, Jiří Fiala

Contents

Schedule of Talks

Monday

- ▮ 9:00 – 10:00 **Martin Škoviera: *Snarks that cannot be covered with four perfect matchings*** [16]
- 10:30 – 10:50 Roman Nedela: *Nullstellensatz and the recognition of snarks* [35]
- 10:55 – 11:15 Robert Lukoťka: 6-*circuits in* 2-*factors of cubic graphs* [31]
- 11:20 – 11:30 Edita Máčajová: *Smallest nontrivial snarks with oddness 4* [32]
- 11:35 – 11:45 Mária Janicová: *Proper colour-homogeneity of regular graphs* [26]
- 11:50 – 12:00 Radek Hušek: *Homomorphisms of Cayley graphs and Cycle Double Covers* [25]
- ▮ 14:00 – 15:00 **Zuzana Masáková: *Combinatorics on words in quasicrystals and number theory*** [12]
- 15:30 – 15:50 Roman Soták: *New bound for generalized nonrepetitive sequences* [37]
- 15:55 – 16:15 Borut Lužar: *Results on locally irregular edge-coloring* [32]
- 16:20 – 16:30 Ida Kantor: *Minimum difference representations of graphs* [28]
- 16:50 – 17:00 Dalibor Frončk: *Products of cycles labeled by cyclic groups* [22]
- 17:05 – 17:15 Petr Kovář: *Supermagic graphs with many different degrees* [30]
- 17:20 – 17:30 Adam Silber: *Chromatic index of graphs for incomplete round-robin tournaments* [37]
- 17:35 – 17:45 Matěj Krbeček: *On modified handicap labelings* [30]
- 17:50 – 18:00 Mirko Horňák: *On one of directed versions of the 1-2-3 Conjecture* [24]
- 18:05 – 18:15 Juraj Valiska: *Conflict-free connection of graphs* [38]

Tuesday

- ▮ 9:00 – 10:00 **Martin Tancer: *Untangling graphs and curves on surfaces*** [17]
- 10:30 – 10:50 Hans Raj Tiwary: *Convex Hull of Walks in a Graph* [38]
- 10:55 – 11:15 Igor Fabrici: *Unique-maximum total coloring of plane graphs* [22]
- 11:20 – 11:30 Mária Maceková: *Light edges in plane graphs with prescribed dual edge weight* [33]
- 11:35 – 11:45 Martina Sabová: *On existence of cycles of specific lengths in planar graphs with restricted minimum degree and edge weight* [36]
- 11:50 – 12:00 Erika Vojtková: *Structure of k-planar graphs* [39]
- ▮ 14:00 – 15:00 **Marcin Kozik: *Algebraist's view on CSP*** [11]
- 15:30 – 15:50 Jack Koolen: *On edge-regular graphs with regular cliques* [29]
- 15:55 – 16:15 Robert Jajcay: *Automorphism groups of Praeger-Xu graphs* [25]
- 16:20 – 16:30 Tatiana Jajcayova: *Applications of Bass-Serre Theory to inverse semigroups* [**??**]

Wednesday

- 9:00 – 10:00 **Marcin Pilipczuk: *The square root phenomenon, subexponential algorithms, and low treewidth pattern covering in planar graphs*** [14]
- 10:30 – 10:50 Petr Gregor: *Multiple message broadcasting in the 1-in port model* [23]
- 10:55 – 11:15 Dušan Knop: *Target Set Selection in Dense Graphs* [29]
- 11:20 – 11:30 Tomáš Masařík: *Parameterized complexity of metatheorems of fair deletion problems* [33]
- 11:35 – 11:45 Jana Maxová: *Cover-incomparability graphs of posets* [34]
- 11:50 – 12:00 Ján Mazák: *Traveling salesman problem in cubic graphs* [34]

Thursday

- 9:00 – 10:00 **Edita Rollová: *Signed graphs – flows and related topics*** [15]
- 10:30 – 10:50 Martina Mockovčiaková: *Star chromatic index of subcubic graphs* [35]
- 10:55 – 11:15 Tomáš Kaiser: *Decomposing planar graphs* [27]
- 11:20 – 11:30 Jan Ekstein: *Revisiting the Hamiltonian Theme in the Square of a Block* [21]
- 11:35 – 11:45 Adam Kabela: *Bounding shortness exponent of tough maximal planar graphs* [27]
- 11:50 – 12:00 Jan Bok: *Extremal Problems for Wiener Index* [20]
- 14:00 – 15:00 **František Kardoš: *Graph-theoretic properties and invariants of fullerene graphs*** [10]
- 15:30 – 15:50 Štefan Gyürki: *Constructions of directed strongly regular graphs with the aid of voltage graphs and quotient graphs* [23]
- 15:55 – 16:15 Marcel Abas: *A construction of large Cayley digraphs of given degree and diameter* [20]
- 16:20 – 16:30 István Estélyi: *An infinite family of cubic vertex-transitive Haar graphs that are not Cayley graphs* [21]

Friday

- 9:00 – 10:00 **Patrice Ossona de Mendez: *Modeling Limits*** [13]
- 10:30 – 10:50 Jan Hubička: *Very sparse graphs are Ramsey* [24]
- 10:55 – 11:15 Maria Saumell Mendiola: *A median-type condition for graph tiling* [36]
- 11:20 – 11:30 Peter Zeman: *Jordan-like characterizations of automorphism groups for restricted classes of graphs* [39]
- 11:35 – 11:45 Pavel Klavík: *Jordan-like characterization of automorphism groups of planar graphs* [28]
- 11:50 – 12:00 Michael Kubesa: *Factorizations of complete graphs into tadpoles* [31]

Schedule

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
8:00		Breakfast	Breakfast	Breakfast	Breakfast	Breakfast
9:00		Invited Talk	Invited Talk	Invited Talk	Invited Talk	Invited Talk
10:00		Coffee Talks	Coffee Talks	Coffee Talks	Coffee Talks	Coffee Talks
11:00						
12:00		Lunch	Lunch	Lunch	Lunch	Lunch
13:00						
14:00	Arival	Invited Talk	Invited Talk	Trip	Invited Talk	Departure
15:00		Coffee Talks	Coffee Talks		Coffee Talks	
16:00		Talks	Museum			
17:00	Welcome Party				Excursion	
18:00		Dinner	Dinner	Dinner	Concert	
19:00					Banquet with Wine Degustation	
20:00						
21:00						

Invited Talks

František Kardoš

University of Bordeaux, France

Graph-theoretic properties and invariants of fullerene graphs

coauthors: Riste Škrekovski (University of Ljubljana, Slovenia),
Vesna Andova (Ss. Cyril and Methodius University, Skopje, Macedonia)

Fullerene graphs are cubic, 3-connected, planar graphs with exactly 12 pentagonal faces, while all other faces are hexagons. Fullerene graphs are mathematical models of fullerene molecules, i.e., molecules comprised only by carbon atoms different than graphites and diamonds. We give a survey on combinatorial properties of fullerene graphs, with a focus on graph invariants that can possibly correlate with the fullerene molecule stability, such as: the bipartite edge frustration, the independence number, the saturation number, the number of perfect matchings, etc. Some questions concerning enumeration and generation of fullerene graphs and other related graph families will also be discussed.

Marcin Kozik
Jagiellonian University, Kraków, Poland

Algebraist's view on CSP

In the past decade the algebraic approach to Constraint Satisfaction Problem produced a number of interesting results in the decision, maximization and approximation versions of the problem. I will introduce some of these results and attempt to clarify what makes a problem amenable to algebraic approach.

Zuzana Masáková

Czech Technical University, Prague

Combinatorics on words in quasicrystals and number theory

Quasicrystals are solids whose atoms are not arranged periodically like crystals, however, they exhibit a certain degree of arrangement that allows for a “nice” diffraction pattern. They show symmetries that are forbidden on crystals. Their popularity rose again in 2011 with the award of the Nobel Prize for Chemistry to their discoverer Dan Shechtman. We will show construction of aperiodic sets, which are the most commonly used model for atomic positions in these substances, and, on examples, show that physical problems can also motivate purely combinatorial issues such as palindromicity and critical exponent of infinite words. This type of question can be found in other areas of mathematics, such as number theory. We will show one of such applications where the so-called diofantic exponent can be used in diofantic approximations. We will show our result estimating the diofantic exponent of Sturmian words.

Patrice Ossona de Mendez
CNRS EHESS, Paris, France

Modeling Limits

A sequence of graphs is FO-convergent if the probability of satisfaction of every first-order formula converges. A graph modeling is a graph, whose domain is a standard probability space, with the property that every definable set is Borel. It was known that FO-convergent sequence of graphs do not always admit a modeling limit, and it was conjectured that this is the case if the graphs in the sequence are sufficiently sparse. Precisely, two conjectures were proposed:

1. If a FO-convergent sequence of graphs is residual, that is if for every integer d the maximum relative size of a ball of radius d in the graphs of the sequence tends to zero, then the sequence has a modeling limit.
2. A monotone class of graphs $\mathcal{C}$ has the property that every FO-convergent sequence of graphs from $\mathcal{C}$ has a modeling limit if and only if $\mathcal{C}$ is nowhere dense, that is if and only if for each integer p there is $N(p)$ such that the pth subdivision of the complete graph on $N(p)$ vertices does not belong to $\mathcal{C}$.

In this talk we present the proof of both conjectures. This solves some of the main problems in the area and among others provides an analytic characterization of the nowhere dense–somewhere dense dichotomy.

Marcin Pilipczuk
University of Warsaw, Poland

The square root phenomenon, subexponential algorithms, and low treewidth pattern covering in planar graphs

Planar graphs enjoy strong combinatorial properties that can be exploited algorithmically. While most NP-hard graph problems remain NP-hard on planar graphs, usually the worst-case complexity of the best known algorithm drops from exponential (e.g., of the form $2^{O(n)}$) to subexponential (e.g., $2^{O(\sqrt{n})}$). This behavior, dubbed *the square root phenomenon*, has been intensively studied in the recent years from the point of view of parameterized complexity.

For many problems, the subexponential algorithm stems from the elegant theory of *bidimensionality*. However, for some problems related to the Subgraph Isomorphism problem, one needs a different tool. We show that, given a planar graph G and an integer k, it is possible in polynomial time to randomly sample a subset A of vertices of G with the following properties:

- A induces a subgraph of G of treewidth $\tilde{O}(\sqrt{k})$, and
- for every connected subgraph H of G on at most k vertices, the probability that A covers the whole vertex set of H is at least $(2^{\tilde{O}(\sqrt{k})} \cdot n^{O(1)})^{-1}$, where n is the number of vertices of G.

Together with standard dynamic programming techniques for graphs of bounded treewidth, this result gives a versatile technique for obtaining (randomized) subexponential parameterized algorithms for problems on planar graphs, usually with running time bound $2^{\tilde{O}(\sqrt{k})}n^{O(1)}$. The technique can be applied to problems expressible as searching for a small, connected pattern with a prescribed property in a large host graph; examples of such problems include DIRECTED k-PATH, WEIGHTED k-PATH, VERTEX COVER LOCAL SEARCH, and SUBGRAPH ISOMORPHISM, among others.

In the talk I will first briefly describe the background and the theory of bidimensionality, and then discuss and sketch the proof of the aforementioned low treewidth pattern covering statement.

Edita Rollová
University of West Bohemia, Pilsen

Signed graphs – flows and related topics

A *signed graph* is a graph G together with a mapping, the *signature* of G, which assigns a sign, $+$ or $-$, to each edge. A *vertex-switching* at a vertex v of G is an operation that inverts the sign of each edge of G incident with v. Two signed graphs G_1 and G_2 are considered to be *equivalent* if their underlying graphs are the same and the signature of G_1 can be obtained from the signature of G_2 by a series of vertex-switching.

To obtain an *orientation* of a signed graph, each edge, including loops, is regarded as consisting of two half-edges which receive their individual orientations following this rule: a positive edge is required to have one half-edge directed from and the other half-edge directed to its end-vertex, while a negative edge is required to have both half-edges directed either towards or from their respective end-vertices. An oriented signed graph is often called a *bidirected graph*.

A *nowhere-zero flow* on a signed graph G is an assignment of an orientation and a nonzero value from an abelian group A to each edge of G in such a way that at each vertex the sum of in-flowing values equals the sum of out-flowing values. Nowhere-zero flows on signed graphs equivalent to all-positive graphs correspond to nowhere-zero flows on their underlying (unsigned) graphs. Thus, nowhere-zero flows on signed graphs generalise the concept of nowhere-zero flows on graphs.

In the talk we focus on nowhere-zero integer flows, that is, nowhere-zero A-flows where $A = \mathbb{Z}$. We compare this concept with the one for unsigned case, present current results for signed graphs, and, finally, state its connection to related topics such as zero-sum flows and signed circuit covers.

Martin Škoviera

Comenius University, Bratislava

Snarks that cannot be covered with four perfect matchings

coauthors: Edita Máčajová (Comenius University, Bratislava)

The celebrated Berge-Fulkerson conjecture suggests that every bridgeless cubic graph can have its edges covered with at most five perfect matchings. Since three perfect matchings suffice if and only if the graph in question is 3-edge-colourable, uncolourable cubic graphs fall into two classes: those that can be covered with four perfect matchings, and those that require at least five. Cubic graphs that cannot be covered with four perfect matchings are extremely rare. Among the 64,326,024 snarks (uncolourable cyclically 4-edge-connected cubic graphs with girth at least five) on up to 36 vertices there are only *two* graphs that cannot be covered with four perfect matchings – the Petersen graph and a snark of order 34.

In this talk we show that coverings with four perfect matchings can be described with the help of nowhere-zero flows whose values lie in the configuration of six lines spanned by four points of the 3-dimensional projective geometry $PG(3, 2)$ in general position. This characterisation provides a convenient tool for investigation of graphs that do not admit such a cover and enables a great variety of constructions of snarks that cannot be covered with four perfect matchings. In particular, with the combined forces of several constructions we can prove that for each even integer $n \geq 44$ there exists at least one snark of order n that has no cover with four perfect matchings.

Martin Tancer

Charles University, Prague

Untangling graphs and curves on surfaces

coauthors: J. Matoušek, E. Sedgwick, U. Wagner, A. Hubard, V. Kaluža and A. de Mesmay

During the talk we will discuss results on untangling systems of curves or graphs on surfaces. One relevant setting is that we are given two systems A and B of pairwise disjoint curves and we aim to minimize the number of A-B intersections if we allow to modify B by a homeomorphism of the surface. We provide bounds on this number polynomial in size of A and B, independent of the genus of the surface. Partial answer to this question is an essential step in an algorithm deciding whether a given 2-complex embeds in $\mathbb{R}^3$.

The proof uses simultaneous drawings of graphs with few bends as a tool. Then, it is in turn related to Fáry theorem in the plane and a question whether it can be extended to other surfaces (with suitable metric). We will also slightly discuss this direction.

Contributed Talks

Marcel Abas

Slovak University of Technology in Bratislava

A construction of large Cayley digraphs of given degree and diameter

coauthors: Tomáš Vetrík (Department of Mathematics and Applied Mathematics, University of the Free State, Bloemfontein, South Afric)

The number of vertices of a digraph of diameter k and maximum degree d is at most $1 + d + d^2 + \cdots + d^k$. This number $M_{d,k}$ is the Moore bound for diameter k and degree d. The order of largest Cayley digraph of diameter k and degree d is denoted by $C(d,k)$.

In this talk we present a construction of Cayley digraphs of order $2k\lfloor d/2 \rfloor^k$ which yields the bound $C_{d,k} \geq 2k\lfloor d/2 \rfloor^k$ for odd $k \geq 3$ and $d \geq \frac{3^k}{2k} + 1$.

Jan Bok

Charles University, Prague

Extremal Problems for Wiener Index

I will talk about the recent development on the several conjectures regarding the Wiener index. This graph parameter is also known as the gross status, the transmission number or the distance of a graph. The Wiener index of a graph is defined as the sum of the lengths of the shortest paths between all pairs of vertices. The index is well-studied and it is related to chemical graph theory. I will discuss in detail my recent result on the problem of finding the maximum Wiener index among unicyclic graphs on n vertices with bipartition sizes p and q, where $n = p + q$. Furthermore, I will present open problems related to this result.

Jan Ekstein

University of West Bohemia, Pilsen

Revisiting the Hamiltonian Theme in the Square of a Block

coauthors: Herbert Fleischner (TU Wien)

The square of a graph G, denote G^2, is a graph obtained from G joining by an edge any two vertices which have a common neighbor. Famous Fleischner's theorem from 1974 says that G^2 of a 2-connected graph is hamiltonian. In the same year, it was even shown that this result implied that G^2 is hamiltonian connected for a 2-connected graph by Chartand et al.

Now we open this problem once again and we want to find hamiltonian cycles and hamiltonian paths in the square of a 2-connected graph using some edges from G. The final new results should be the best possible in this sence.

István Estélyi

University of West Bohemia, Pilsen

An infinite family of cubic vertex-transitive Haar graphs that are not Cayley graphs

coauthors: Tomaž Pisanski, Marston Conder

Estélyi and Pisanski raised a question whether there exist Haar graphs, i.e., graphs that are bipartite and admit a semiregular group of symmetries acting regularly on each part, that are vertex-transitive but non-Cayley. In the talk we construct an infinite cubic family of such graphs, using doubly generalized Petersen graphs. The smallest example has 40 vertices and is the well-known Kronecker cover over the dodecahedron graph $GP(10, 2)$, occurring as the graph '40' in the Foster census of connected symmetric trivalent graphs.

Igor Fabrici

P. J. Šafárik University, Košice

Unique-maximum total coloring of plane graphs

coauthors: Simona Rindošová (P. J. Šafárik University, Košice)

The well-known Total Coloring Conjecture asserts that every graph of maximum degree Δ admits a total $(\Delta+2)$-coloring. Moreover, it is known that every planar graph of maximum degree $\Delta \geq 9$ is totally $(\Delta+1)$-colorable. If we restrict the condition of different colors for adjacent edges in a total coloring of a plane graph to facially-adjacent edges only (i.e. adjacent edges which are consecutive in the cyclic order of edges around their common endvertex), the graph becomes facially-proper totally 6-colorable [Fabrici, Jendroľ, Voigt, 2016].

A facially-proper unique-maximum total k-coloring of a plane graph G is a facially-proper total coloring with colors $1, \ldots, k$ such that, for each face of G, the maximum used color occurs exactly once on its elements (i.e. vertices and edges). In this talk we present upper bounds on the corresponding chromatic number for plane graphs and particular subclasses.

Dalibor Fronček

University of Minnesota Duluth, U.S.A.

Products of cycles labeled by cyclic groups

coauthors: Sylwia Cichacz-Przenioslo (AHG-UST Krakow), James McKeown (University of Miami), John McKeown (University of Minnesota Duluth), Michael McKeown (University of Minnesota Duluth)

A graph $G = (V, E)$ with $|V| = p, |E| = q$ is called Γ-*distance magic* if there exists a bijection f from V to an Abelian group Γ of order p such that the *weight* $w(x)$ of each vertex x is equal to the same *magic element* μ. In other words,

$$w(x) = \sum_{xy \in E} f(y) = \mu$$

for all $x \in V$ and some $\mu \in \Gamma$. The labeling is called a Γ-*distance magic labeling*. Similarly, G is called Γ-*vertex magic* (or just Γ-*magic*) if there exists a bijection h from E to an Abelian group Γ of order q such that the weight $w(x)$ of each vertex x is again constant, that is,

$$w(x) = \sum_{xy \in E} h(xy) = \mu$$

for all $x \in V$ and some $\mu \in \Gamma$. The labeling is called a Γ-*vertex magic edge labeling* or just Γ-*magic labeling*.

The presenter and Sylwia Cichacz investigated Γ-distance magic labelings of Cartesian products $C_m \square C_n$ for $\Gamma = \mathbb{Z}_{mn}$ and some other groups. We present some preliminary results on $\mathbb{Z}_q$-vertex magic labeling of Cartesian products of two or more cycles.

Petr Gregor

Charles University, Prague

Multiple message broadcasting in the 1-in port model

coauthors: Riste Škrekovski (University of Ljubjana), Vida Vukašinović (Jožef Stefan Institute)

In the 1-in port model, every vertex of a synchronous network can receive each time unit at most one message. Moreover, every received message can be sent out to neighbors only in the next time unit (no buffers) and never to already informed vertex (no repeats). We consider simultaneous broadcasting of multiple messages from the same source in such model. We use a general concept of level-disjoint partitions with a subgraph extension technique for efficient spreading information within this concept. This approach with so called biwheels leads to simultaneous broadcasting of optimal number of messages on a wide class of graphs in optimal time. In particular, we provide tight results for bipartite tori, meshes, hypercubes, Knödel graphs, circulant graphs.

Štefan Gyürki

Matej Bel University, Banská Bystrica

Constructions of directed strongly regular graphs with the aid of voltage graphs and quotient graphs

A *directed strongly regular graph* (DSRG) with parameters (n, k, t, λ, μ) is a regular directed graph on n vertices with valency k such that every vertex is incident with t undirected edges; the number of directed paths of length 2 directed from a vertex x to another vertex y is λ, if there is an arc from x to y and μ otherwise. In the talk we consider constructions of DSRGs which use the technique of *voltage assignments*, also known as *lifts*. This technique creates larger graphs from smaller ones. We also investigate the other direction: which interesting graphs can be found in a larger DSRG as quotient graph or induced subgraph.

The author gratefully acknowledges the contribution of the Scientific Grant Agency of the Slovak Republic under the grant 1/0988/16, as well as the constribution of the Slovak Research and Development Agency under the projects APVV 0136-12 and APVV 0220-15.

Mirko Horňák

P. J. Šafárik University, Košice

On one of directed versions of the 1-2-3 Conjecture

coauthors: Jakub Przybyło (AGH University of Science and Technology, Kraków, Poland), Mariusz Woźniak (AGH University of Science and Technology, Kraków, Poland)

Given a digraph D, we want to assign to arcs of D integers from the set $\{1, \dots, k\}$ in such a way that, if $(x, y) \in E(D)$, then the sum on the arcs in-coming to x is distinct from the sum on the arcs out-going from y. As usual, we are looking for a minimum k in such an assignment. We prove that in general there is no constant bounding from above the mentioned minimum. On the other hand, for a large class of digraphs we show (we conjecture) that the minimum is at most 4 (at most 3, respectively).

Jan Hubička

Charles University, Prague

Very sparse graphs are Ramsey

coauthors: David Evans (Imperial Colledge London), Jaroslav Nešetřil (Charles University, Prague)

Class $\mathcal{K}$ of finite structures is Ramsey class if for every choice of $A, B \in \mathcal{K}$ there exists $C \in \mathcal{K}$ such that for every coloring of its substructures isomorphic to A with 2 colors there exists an isomorphic copy of B in C where all copies of A are monochromatic. It is a classical result of Nešetřil and Rödl that the class of all ordered graphs is Ramsey. In this talk we will discuss a class of k-sparse graphs (that is graphs which can be oriented in a way that outdegree of every vetex is at most k). We show that this class is Ramsey only of the orientation is fixed first. The class of k-sparse graphs corresponds to the Hrushovski's predimension construction which and leads to a negative answer to one of open questions in the area about existence of precompact Ramsey expansion for every age of omega-categorical structure.

Radek Hušek

Charles University, Prague

Homomorphisms of Cayley graphs and Cycle Double Covers

coauthors: Robert Šámal

We study the following conjecture of Matt DeVos: If there is a graph homomorphism from Cayley graph $\mathrm{Cay}(M, B)$ to another Cayley graph $\mathrm{Cay}(M', B')$ then every graph with (M, B)-flow has (M', B')-flow. This conjecture was originally motivated by the flow-tension duality. We show that a natural strengthening of this conjecture does not hold in all cases but we conjecture that it still holds for an interesting subclass of them and we prove a partial result in this direction.

We also show that for both original conjecture and our variations of it there exists a universal B' for each group B (i.e. if the conjecture holds for this B' then it holds for any other B'). The flows in B' which witness the conjecture are in fact (in one-to-one mapping to) oriented cycle double covers of the given graph with $|B'|$ cycles. Hence the conjecture implies Oriented Cycle Double Cover Conjecture with 6 cycles.

Robert Jajcay

Comenius University, Bratislava

Automorphism groups of Praeger-Xu graphs

coauthors: Primož Potočnik (University of Ljubljana, Slovenia),
Steve Wilson (Northern Arizona University, U.S.A.)

Praeger-Xu graphs are highly symmetric tetravalent graphs that exhibit a number of unusual properties. We discuss the full automorphism groups as well as the smallest vertex-transitive automorphism groups of these graphs, and investigate a surprising connection to cyclic error-correcting codes.

Tatiana Jajcayová
Comenius University, Bratislava

Applications of Bass-Serre Theory to inverse semigroups

Free groups, free products of groups, amalgamated free products and HNN-extesions of groups are closely related concepts. Using Bass-Serre Theory, they can be treated uniformly in the context of group actions on graphs. A group acting on a tree without inversions is the fundamental group of a related graph of groups, and conversely, every such fundamental group acts on some tree without inversions. We shall use this theory to study structure of amalgams and HNN-extensions of inverse semigroups.

Mária Janicová
P. J. Šafárik University, Košice

Proper colour-homogeneity of regular graphs

coauthors: Kateryna Bala (Pavol Jozef Šafárik University, Košice, Slovakia), Borut Lužar (Faculty of Information Studies, Novo mesto, Slovenia), Tomáš Madaras (Pavol Jozef Šafárik University, Košice, Slovakia), Roman Soták (Pavol Jozef Šafárik University, Košice, Slovakia)

A proper colouring of vertices of a graph G such that the number of colours in the neighbourhood of any vertex equals k is called k-homogeneous colouring. The palette of colour-homogeneity of G is defined as a set of all positive integers k for which G admits a k-homogeneous colouring. We explore properties and present some results on homogeneous colourings, in particular for regular graphs and for selected graph operations.

Adam Kabela

University of West Bohemia, Pilsen

Bounding shortness exponent of tough maximal planar graphs

We continue the study of non-Hamiltonian graphs with the property that removing an arbitrary set of vertices disconnects the graph into a relatively small number of components. We present families of maximal planar (chordal planar) such graphs whose longest cycles are short. More formally, the properties which we study are the toughness of graphs and the shortness exponent of classes of graphs.

We improve the upper bound on the shortness exponent of the class of $\frac{5}{4}$-tough maximal planar graphs presented by Harant and Owens (1995). In addition, we present two generalizations of a similar result of Tkáč (1996) who considered 1-tough maximal planar graphs; and we remark that one of these generalizations gives a tight upper bound. We also present two ways of improving the upper bound of Böhme et al. (1999); considering the class of 1-tough planar 3-trees, and 1-tough chordal planar graphs. The main used tools are the 'gluing lemma' of Harant and Owens (which we fix), and the Radoszewski and Rytter's (2011) characterization of trees whose square has a Hamilton path (which we restate using forbidden subgraphs).

Tomáš Kaiser

University of West Bohemia, Pilsen

Decomposing planar graphs

coauthors: Arthur Hoffmann-Ostenhof (TU Wien), Kenta Ozeki (Yokohama National University)

Hoffmann-Ostenhof conjectured in 2011 that every connected cubic graph G admits an edge-decomposition into a spanning tree of G, a 2-regular subgraph and a matching. We outline a proof of the planar case of this conjecture and discuss some related problems.

Ida Kantor

Charles University, Prague

Minimum difference representations of graphs

coauthors: Zoltan Furedi (Renyi Institute, Budapest)

A *k-min-difference representation* of a graph G is an assignment of a set A_i to each vertex $i \in V(G)$ such that $ij \in E(G) \Leftrightarrow \min |A_i \setminus A_j|, |A_j \setminus A_i| \geq k$. The smallest k such that there exists a k-min-difference representation of G is denoted by $\rho(G)$. Balogh and Prince proved in 2009 that for every k there is a graph G with $\rho(G) \geq k$. We prove that there are constants $c_1, c_2 > 0$ such that $c_1 n/(\log n) < \rho(G) < c_2 n/(\log n)$ holds for almost all bipartite graphs G on $n+n$ vertices. We prove results for some related parameters as well. Lots of open problems remain.

Pavel Klavík

Charles University, Prague

Jordan-like characterization of automorphism groups of planar graphs

In 1975, Babai characterized which abstract groups can be realized as the automorphism groups of planar graphs. In this paper, we give a more detailed and understandable description of these groups. We describe stabilizers of vertices in connected planar graphs as the class of groups closed under the direct product and semidirect products with symmetric, dihedral and cyclic groups. The automorphism group of a connected planar graph is then obtained as a semidirect product of a direct product of these stabilizers with a spherical group. The formulation of the main result is new and original. Moreover, it gives a deeper in the structure of the groups. As a consequence, automorphism groups of several subclasses of planar graphs, including 2-connected planar, outerplanar, and series-parallel graphs, are characterized. Our approach translates into a quadratic-time algorithm for computing the automorphism group of a planar graph which is the first such algorithm described in detail.

Dušan Knop

Charles University, Prague

Target Set Selection in Dense Graphs

coauthors: Pavel Dvořák, Tomáš Toufar

In this paper we study the Target Set Selection problem, a fundamental problem in computational social choice, from a parameterized complexity perspective. Here for a given graph and a threshold for each vertex the task is to find a set of vertices to activate (called target set) which activates whole graph. A vertex outside the target set becomes active if the number of activated vertices in its neighborhood is at least its threshold.

We give two parameterized algorithms for a special case where each vertex has threshold set to half of its neighbors (the so called Majority Target Set Selection problem) for parameterizations by neighborhood diversity and twin cover number of the input graph.

From the opposite side we give hardness proof for the Majority Target Set Selection problem when parameterized by (a restriction of) the modular-width – a natural generalization of both previous structural parameters. We show that the Target Set Selection problem parameterized by the neighborhood diversity when there is no restriction on the thresholds is W[1]-hard.

Jack Koolen

USTC, Hefei, China

On edge-regular graphs with regular cliques

coauthors: Gary Greaves (NTU)

In the 1980's Neumaier studied edge-regular graphs with regular cliques, where a regular clique is a clique C such that for any vertex outside has a constant number of neighbours in C. He asked the question whether there exist edge-regular graphs with regular cliques that are not strongly regular. In this talk i will present several constructions of such graphs.

Petr Kovář

VŠB – Technical University of Ostrava

Supermagic graphs with many different degrees

coauthors: Michal Kravčenko, Matěj Krbeček, Adam Silber

Let $G = (V, E)$ be a graph with m edges. Let a be an integer. A bijection $f : F \to \{a, a+1, \ldots, a+m-1\}$ is called a *supermagic labeling* of G if for every vertex v the sum of edge-labels of all edges adjacent to v is equal to the same integer k. The constant k is the *magic constant* of f and any graph which admits a supermagic labeling is a *supermagic graph.* The concept of magic graphs (with arbitrary real labels) is one on the oldest labeling concepts. It originated by Sedláček in 1963. Supermagic labelings were introduced by Stewart in 1967.

Dozens of papers have been published on supermagic labelings, mostly providing constructions of supermagic labelings of a specific class of graphs as well as some necessary conditions for the graph to allow a supermagic labeling. The proofs are mostly constructive, providing a labeling technique for regular or almost regular graphs. Some supermagic graphs with different degrees were provided by Ivančo and Semaničová in 2005 or Ivančo and Polláková in 2012 and 2014. In this talk we present a general construction of supermagic graphs with arbitrarily many different degrees.

Matěj Krbeček

VŠB – Technical University of Ostrava

On modified handicap labelings

coauthors: Petr Kovář

Let G be a simple graph with n vertices. Let $A = \{1, 2, \ldots, \frac{n}{2}\} \cup \{\frac{n+4}{2}, \ldots, n+1\}$ and $f : V \to A$ be a bijection where the weight of v is $w(v) = \sum_{u \in N(v)} f(u) = l + f(v)$ for some positive integer l. f is called a generalized handicap labeling. This definition naturally weakens the requirement that the vertex labels are from $A = \{1, 2, \ldots, n\}$. We show the existence of such labelings for many even-regular graphs.

Michael Kubesa
VŠB – Technical University of Ostrava

Factorizations of complete graphs into tadpoles

coauthors: Tom Raiman

A tadpole (also a *canoe paddle*) is a graph that arises from a cycle and a path so that we glue a terminal vertex of a path to an arbitrary vertex of a cycle. In this paper we show that all tadpoles factorize a complete graph K_{2n+1} if n is odd. We use similar methods which are used for isomorphic factorizations of complete graphs K_{2n} into spanning trees. In section 4 of this paper we show that our methods do not work for isomorphic factorizations of K_{2n+1} into tadpoles if n is even.

Robert Lukoťka
Comenius University, Bratislava

6-circuits in 2-factors of cubic graphs

We proof that a bridgeless cubic graph G of girth 6 on n vertices has a 2-factor F such that at most $9/13 \cdot n$ vertices of G are in circuits of length 6 of F. Dvořák, Kráľ, and Mohar [Z. Dvořák, D. Kráľ, B. Mohar: Graphic TSP in cubic graphs, arXiv:1608.07568] proved that every simple 2-connected cubic graph on n vertices contains a spanning closed walk of length at most $9/7 \cdot n - 1$. Using the ideas from the result about 6-circuits, we provide an alternative and shorter proof of this statement. The modified proofs opens additional paths to improve the result of Dvořák, Kráľ, and Mohar.

Borut Lužar

Faculty of Information Studies, Novo mesto, Slovenia

Results on locally irregular edge-coloring

coauthors: Jakub Przybyło, Roman Soták

A graph is *locally irregular* if the neighbors of every vertex v have degrees distinct from the degree of v. A *locally irregular edge-coloring* of a graph G is a (not necessarily proper) edge-coloring such that the graph induced on the edges of any color class is locally irregular. It is conjectured that 3 colors suffice for a locally irregular edge-coloring. Recently, Bensmail et al. [J. Bensmail, M. Merker, and C. Thomassen, *Decomposing graphs into a constant number of locally irregular subgraphs*, to appear in European J. Combin. 60, 2017, 124–134] proved that 328 colors suffice for locally irregular edge-coloring of every graph, and moreover, if the graph is bipartite, then 10 colors are always enough. Using a combination of existing results, we present an improvement of these two bounds, setting the current best upper bounds to 216 and 7, respectively. Additionally, we present a proof of an upper bound 4 for locally irregular edge-coloring of subcubic graphs.

Edita Máčajová

Comenius University, Bratislava

Smallest nontrivial snarks with oddness 4

coauthors: Jan Goedgebeur, Martin Škoviera

The oddness of a bridgeless cubic graph G is the smallest number of odd circuits in a 2-factor of G. Oddness is one of the most important invariants of snarks because several important conjectures in graph theory can be reduced to snarks of oddness 4 or larger. In this talk we deal with the problem of determining the smallest order of a nontrivial snark of oddness 4. (Here 'nontrivial' means girth at least 5 and cyclic connectivity at least 4.) We prove that the smallest order of a nontrivial snark with oddness 4 and cyclic connectivity 4 is 44. The proof relies on a detailed analysis of 3-edge-colourings conflicting on a cycle-separating 4-edge-cut, an extensive computer search, and the following result of of Andersen, Fleischner and Jackson (1988): If G is a cyclically 4-edge-connected cubic graph and G' a component arising from the removal of a cycle-separating 4-edge-cut from G, then G' can be completed to a cyclically 4-edge-connected graph by adding at most two vertices. We also provide an alternative proof of this result.

Mária Maceková

P. J. Šafárik University, Košice

Light edges in plane graphs with prescribed dual edge weight

coauthors: Katarína Čekanová (P. J. Šafárik Unitrversity in Košice)

In 1955 Kotzig proved that every 3-connected plane graph contains an edge such that the sum of the degrees of its endvertices is at most 13. This result was later extended to all planar graphs having minimum degree 3. The plane graph $K_{2,r}, r \geq 2$, shows that analogue of Kotzig theorem cannot be extended in general for graphs with minimum degree 2.

Let G be a plane graph. The minimum dual edge weight of G is the number

$$w^*(G) = \min\{\deg(\alpha) + \deg(\beta) : \alpha, \beta \in F, \alpha \neq \beta, \alpha, \beta \text{ have a common edge}\}.$$

In this talk we give some results on the structure of edges in plane graphs with minimum degree 2 and given dual edge weight.

Tomáš Masařík

Charles University, Prague

Parameterized complexity of metatheorems of fair deletion problems

coauthors: Dušan Knop (Charles University, Prague), Tomáš Toufar (Charles University, Prague)

Deletion problems are those where given a graph G and a graph property π, the goal is to find a subset of vertices (or edges) such that after its removal the graph G will satisfy the property π. Typically, we want to minimize the number of elements removed. In fair deletion problems we change the objective: we minimize the maximum number of deletions in a neighborhood of a single vertex. We study the parameterized complexity of metatheorems, where a graph property is expressed in a graph logic, of deletion problems with respect to several structural parameters of the graph.

The list of our results for the Vertex Deletion problem:

- The problem is W[1]-hard on tree-depth for any logic that can express an edgeless graph.
- The problem has an FPT algorithm for MSO_1 logic on graphs with bounded neighborhood diversity or twin cover.

The list of our results for the Edge Deletion problem:

- The problem is W[1]-hard on tree-depth for First order logic.
- The problem has an FPT algorithm for MSO_2 logic on graphs with bounded vertex cover.

Jana Maxová

VŠCHT, Prague

Cover-incomparability graphs of posets

coauthors: Miroslava Dubcová (VŠCHT), Pavla Pavlíková (VŠCHT), Daniel Turzík (VŠCHT)

We deal with posets and graphs associated to them. Cover graphs, comparability graphs and incomparability graphs are standard ways how to associate a graph to a given poset. The notion of cover-incomparability graph (vertices x and y are adjacent iff x covers y, or y covers x, or x and y are incomparable) is relatively new. It was motivated by the theory of transit functions on posets.

Complexity problems concerning this topic were extensively studied. While the recognition problem for cover graphs is NP-complete, the recognition problem for comparability graphs (and hence also for incomparability graphs) is polynomial.

We show that the recognition problem for cover-incomparability graphs is in general NP-complete, while for e.g. trees, k-trees, distance-hereditary graphs or Ptolemaic graphs it is polynomial. For all chordal graphs the complexity of the recognition problem is open.

Ján Mazák

Comenius University, Bratislava

Traveling salesman problem in cubic graphs

coauthors: Robert Lukoťka

The traveling salesman problem (TSP) is an NP-hard problem known for being hard even to approximate. This talk focuses on recent developments in bounds on the approximation factor for TSP in cubic graphs with unweighted edges. In particular, we prove that for any $\varepsilon > 0$, there exists a simple 2-connected planar cubic graph G_2 with no traveling salesman tour of length shorter than $(1.25 - \varepsilon) \cdot |V(G_2)|$, and a 3-connected simple cubic graph G_3 with no traveling salesman tour of length shorter than $(1.125 - \varepsilon) \cdot |V(G_3)|$. The first of these bounds, a lower bound of 1.25 on the approximation factor, complements the recently established upper bound of 9/7 (roughly 1.2857).

Martina Mockovčiaková

University of West Bohemia, Pilsen

Star chromatic index of subcubic graphs

coauthors: Borut Lužar (Faculty of Information Studies, Novo mesto, Slovenia), Roman Soták (UPJŠ, Košice, Slovakia)

A proper edge-coloring of a graph G is a *star edge-coloring* if there is neither bichromatic path nor bichromatic cycle of length four in G. In 2013 Dvořák, Mohar, and Šámal showed that 7 colors are enough for a star edge-coloring of subcubic graphs. They suggested to study a list version of this problem and asked whether 7 colors are enough also for list star edge-coloring of subcubic graphs. In this talk, we discuss results regarding subcubic graphs and answer the question above, i.e. prove that the list star chromatic index of such graphs is at most 7.

Roman Nedela

University of West Bohemia, Pilsen

Nullstellensatz and the recognition of snarks

coauthors: Jan Karabáš (Univerzita Mateja Bela, Banská Bystrica), Martin Škoviera (Fakulta matematiky, fyziky a informatiky, Univerzita Komenského, Bratislava)

It is well-known that the problem of existence of a 3-edge-colouring of a cubic graph is NP-hard. However, it transpires that to make a progress in investigation of snarks (nontrivial non-3-edge-colourable cubic graphs) one needs to make experiments with cubic graphs with at least 100 vertices. To do it, we have to implement an algorithm solving the colouring problem for such graphs in real time. Most of the available implementations use the idea of back-tracking to find a 3-edge-colouring directly, or to prove that none 3-edge-colouring exists. Recently, an entirely new idea which allows to attack the problem indirectly appeared in a paper De Loera, Lee, Malkin and Margulies [J. Symb. Comp. 2011]. It is based on the famous Hilbert's Nullstellensatz. In our talk we show how the 3-edge-colourability problem translates to a problem of finding a certificate for (non)solution of a certain associated system of polynomial equations over a field of characteristic 2. In particular, it can be translated to a question on a Boolean algebra associated with the investigated graph. Experiments with particular examples give a hope to get an implementation which will be able to solve the problem for graphs which are infeasible by the nowadays programs.

Martina Sabová

P. J. Šafárik University, Košice

On existence of cycles of specific lengths in planar graphs with restricted minimum degree and edge weight

coauthors: Mária Maceková (P. J. Šafárik University, Košice),
Tomáš Madaras (P. J. Šafárik University, Košice)

A set S of cycles of different lengths is unavoidable in an infinite graph family $\mathcal{G}$ if each graph $G \in \mathcal{G}$ contains a cycle from S; further, S is minimal unavoidable if it is unavoidable and, for each proper subset $S' \subset S$, there exists an infinite subfamily $\mathcal{G}' \subseteq \mathcal{G}$ such that no graph from $\mathcal{G}'$ contains a cycle from S'. We explore minimal unavoidable sets of cycles in plane graphs under various constraints on their minimum vertex degree or minimum edge weight; we also present some negative results on sets of cycles which are not unavoidable.

Maria Saumell Mendiola

Czech Academy of Science, Prague

A median-type condition for graph tiling

coauthors: Diana Piguet (Czech Academy of Sciences)

Komlós [Komlós: Tiling Turán Theorems, Combinatorica, 2000] determined the asymptotically optimal minimum degree condition for covering a given proportion of vertices of a host graph by vertex-disjoint copies of a fixed graph H. We show that the minimum degree condition can be relaxed in the sense that we require only a given fraction of vertices to have the prescribed degree.

Adam Silber

VŠB – Technical University of Ostrava

Chromatic index of graphs for incomplete round-robin tournaments

coauthors: Petr Kovář (VŠB – Technical University of Ostrava)

In the last couple of years, there has been a number of articles dealing with the scheduling of incomplete tournaments. A complete, fair incomplete, equalized incomplete, and handicap incomplete round robin tournaments have been introduced. The properties of the touranaments are slightly different depending on whether they mimic the difficulty of the complete touranament or a certain advantage is given to weaker teams. But one property is common for all cases when every team plays against the same number of opponents.

For example, to shedule equalized incomplete tournament, the 1-distance magic graphs are used. By a 1-distance magic graph we denote such a graph $G = (V, E)$ which allows distance magic labelling λ, a bijection from the set of vertices to $\{1, 2, \dots, |V(G)|\}$ such that the sum of the labels of adjacent vertices is equal to the same number for each vertex. Many constructions of these graphs are known. We are interested in chromatic index of these graphs to help us determine how many rounds of the tournament will be needed.

Roman Soták

P. J. Šafárik University, Košice

New bound for generalized nonrepetitive sequences

coauthors: František Kardoš (Université de Bordeaux, LaBRI, France)

A sequence $S = s_1 \dots s_n$ is said to be *nonrepetitive* if no two adjacent blocks of S are identical. In 1906 Thue proved that there exist arbitrarily long nonrepetitive sequences over 3-element set of symbols. We study a generalization of nonrepetitive sequences involving arithmetic progressions introduced by Currie and Simpson in 2002. A sequence $S = s_1 \dots s_n$ is said to be *nonrepetitive up to modulo k* if every sequence $s_i s_{i+j} s_{i+2j} \dots$ is nonrepetitive for any $1 \leq i, j \leq k$.

For every $\varepsilon > 0$ we find arbitrarily long sequences nonrepetitive up to modulo k over at most $(1 + \varepsilon)k + c\sqrt{k}$ symbols. This improves a previous bounds of $2k + 10\sqrt{k}$ [Grytzuk, Kozik and Wikowski, 2011] and $2k$ [Kranjc, Lužar, Mockovčiaková and Soták, 2015].

Hans Raj Tiwary

Charles University, Prague

Convex Hull of Walks in a Graph

Let G be a graph and W be the set of all walks of length (at most) n. We consider the covex hull of the characteristic vectors of these walks and show that this polytope can be obtained as the projection of a polytope with only polynomial number of facets. We also present some applications.

Juraj Valiska

P. J. Šafárik University, Košice

Conflict-free connection of graphs

coauthors: Július Czap (Technical University in Košice),
Stanislav Jendroľ (P. J. Šafárik University in Košice)

An edge-colored graph G is conflict-free connected if any two of its vertices are connected by a path, which contains a color used on exactly one of its edges. We investigate the smallest number of colors needed for a coloring of edges of G in order to make it conflict-free connected. We show that the answer is easy for 2-connected graphs and very difficult for other connected graphs, including trees.

Erika Vojtková

P. J. Šafárik University, Košice

Structure of k-planar graphs

coauthors: Igor Fabrici (P. J. Šafárik University, Košice)

Graphs that can be drawn in the plane so that every edge is crossed at most k-times are called k-planar graphs. We deal mainly with 3-planar triangle-free graphs, for which we have improved general upper bound for their number of edges. In addition, we also present some structural properties of these graphs.

Peter Zeman

Charles University, Prague and University of West Bohemia, Pilsen

Jordan-like characterizations of automorphism groups for restricted classes of graphs

We describe a technique to determine the automorphism group of a geometrically represented graph, by understanding the structure of the induced action on all geometric representations. Using this, we characterize automorphism groups of interval, permutation and circle graphs. We combine techniques from group theory (products, homomorphisms, actions) with data structures from computer science (PQ-trees, split trees, modular trees) that encode all geometric representations.

We prove that interval graphs have the same automorphism groups as trees, and for a given interval graph, we construct a tree with the same automorphism group which answers a question of Hanlon [Trans. Amer. Math. Soc 272(2), 1982]. For permutation and circle graphs, we give Jordan-like inductive characterizations by semidirect and wreath products. We also prove that every abstract group can be realized by the automorphism group of a comparability graph/poset of the dimension at most four.

List of participants

Marcel Abas (Slovak University of Technology in Bratislava)
Jan Bok (Charles University, Prague)
Anna Dresslerová (Comenius University, Bratislava)
Jan Ekstein (University of West Bohemia, Pilsen)
István Estélyi (University of West Bohemia, Pilsen)
Igor Fabrici (P. J. Šafárik University, Košice)
Jiří Fiala (Charles University, Prague)
Dalibor Fronček (University of Minnesota Duluth, U.S.A.)
Petr Gregor (Charles University, Prague)
Štefan Gyürki (Matej Bel University, Banská Bystrica)
Mirko Horňák (P. J. Šafárik University, Košice)
Jan Hubička (Charles University, Prague)
Radek Hušek (Charles University, Prague)
Robert Jajcay (Comenius University, Bratislava)
Tatiana Jajcayová (Comenius University, Bratislava)
Mária Janicová (P. J. Šafárik University, Košice)
Adam Kabela (University of West Bohemia, Pilsen)
Tomáš Kaiser (University of West Bohemia, Pilsen)
Ida Kantor (Charles University, Prague)
František Kardoš (University of Bordeaux, France)
Pavel Klavík (Charles University, Prague)
Dušan Knop (Charles University, Prague)
Jack Koolen (USTC, Hefei, China)
Peter Korcsok (Charles University, Prague)
Tereza Kovářová (VŠB – Technical University of Ostrava)
Petr Kovář (VŠB – Technical University of Ostrava)
Marcin Kozik (Jagiellonian University, Kraków, Poland)
Jan Kratochvíl (Charles University, Prague)
Matěj Krbeček (VŠB – Technical University of Ostrava)
Michael Kubesa (VŠB – Technical University of Ostrava)
Robert Lukoťka (Comenius University, Bratislava)
Borut Lužar (Faculty of Information Studies, Novo mesto, Slovenia)
Edita Máčajová (Comenius University, Bratislava)
Mária Maceková (P. J. Šafárik University, Košice)
Zuzana Masáková (Czech Technical University, Prague)
Tomáš Masařík (Charles University, Prague)
Jana Maxová (VŠCHT, Prague)
Ján Mazák (Comenius University, Bratislava)
Martina Mockovčiaková (University of West Bohemia, Pilsen)
Jan Musílek (Charles University, Prague)
Roman Nedela (University of West Bohemia, Pilsen)
Helena Nyklová (Charles University, Prague)
Patrice Ossona de Mendez (CNRS EHESS, Paris, France)
Marcin Pilipczuk (University of Warsaw, Poland)
Tom Raiman (VŠB – Technical University of Ostrava)
Edita Rollová (University of West Bohemia, Pilsen)
Martina Sabová (P. J. Šafárik University, Košice)
Robert Šámal (Charles University, Prague)
Maria Saumell Mendiola (Czech Academy of Science, Prague)
Adam Silber (VŠB – Technical University of Ostrava)
Martina Šimůnková (Technická Univerzita Liberec)
Martin Škoviera (Comenius University, Bratislava)
Roman Soták (P. J. Šafárik University, Košice)
Martin Tancer (Charles University, Prague)
Hans Raj Tiwary (Charles University, Prague)
Juraj Valiska (P. J. Šafárik University, Košice)
Erika Vojtková (P. J. Šafárik University, Košice)
Peter Zeman (Charles University, Prague and University of West Bohemia, Pilsen)