Dear combinatorialists,

the Colloquium on Combinatorics was established in 1981 and has since been held annually in seven cities throughout Germany. It has grown to an established conference that covers all areas of Combinatorics and Discrete Mathematics in a broad sense, including combinatorial aspects in Algebra, Geometry, Optimization and Computer Science.

It is our great pleasure to host the 38th Colloquium on Combinatorics. This year we welcome 85 participants. The program includes 63 contributed talks, organised in four parallel sessions, and five invited talks on a broad range of combinatorial topics.

Please note that we have allocated 25-minute slots for the contributed talks, which includes 20 minutes for the presentation, two minutes for discussion, and three minutes for room change.

We sincerely thank our sponsors *Paderborn University* and the *Collaborative Research Centre (Sonderforschungsbereich 901) On-the-fly computing*.

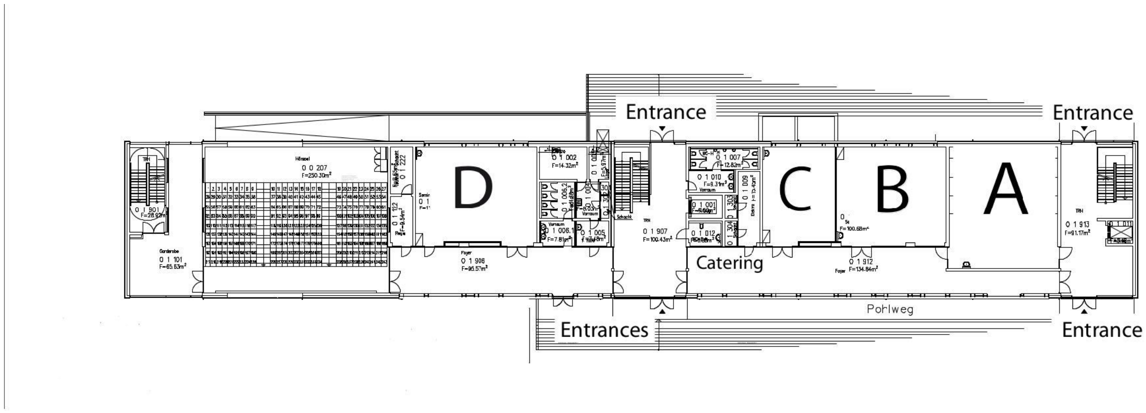
We hope you enjoy the conference.

Kai-Uwe Schmidt
Eckhard Steffen

Colloquium on Combinatorics — 8/9 November 2019
Discrete Mathematics — Paderborn University

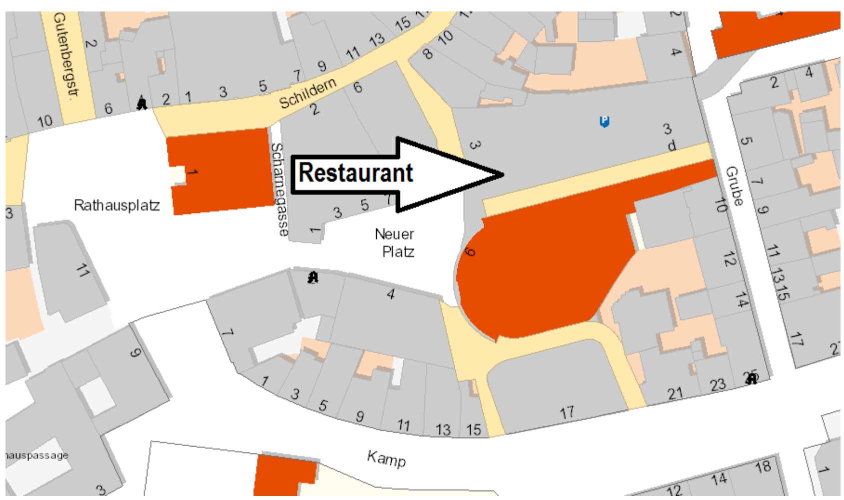
All **talks** will be in Building-O on the Main Campus (Pohlweg 51, 33098 Paderborn)

Invited talks	:	Room A
Contributed talks	:	Rooms A, B, C, D
Coffee and snacks	:	Foyer
Registration desk	:	Foyer
Library	:	Building-BI on the main campus



The **registration desk** is open on Friday from 8:00 to 18:00 and on Saturday from 8:00 to 17:00. The **library** is open on Friday from 7:30 to 24:00 and on Saturday from 9:00 to 21:00.

The **dinner** will take place at the restaurant *Bobberts* (Neuer Platz 3, Downtown Paderborn) on Friday at 19:00.



Bus lines 4 (to Heinz-Nixdorf Wendeschleife) and 9 (to Hauptbahnhof) run from the university to the restaurant. The bus stops nearest to Bobberts are: *Kamp* and *Rathausplatz*.

Busses leave at bus stop *Uni/Südring* at 17:28 (Line 9), 17:46 (Line 4), 17:58 (Line 9), 18:16 (Line 4), 18:28 (Line 9). It takes about 10 minutes to the restaurant.

(The complete bus schedule is available at `www.padersprinter.de`.)

COLLOQUIUM ON COMBINATORICS — 8/9 NOVEMBER 2019
DISCRETE MATHEMATICS — PADERBORN UNIVERSITY

Food options on campus

Location	Hours	Choice	Payment
Mensa Academica	11:15 – 13:30 (**only Friday**)	large variety	cash / DeliCard
Mensa Forum	11:15 – 13:30 (**only Friday**)	vegan/regular	**only DeliCard**
Grill/ Café	09:00 – 16:00 (**only Friday**)	burgers/steaks/salads	cash / DeliCard
Bona Vista	08:00 – 15:00 (**only Friday**)	waffles/coffee/smoothies	cash / DeliCard
Caféte	08:00 – 15:45 on Friday 10:00 – 14:00 on Saturday	some variety	cash / DeliCard

More information: `http://www.studentenwerk-pb.de/en/food-services/`

Notice that in the Mensa Forum (vegan Food) **no cash payment** is possible. You need a DeliCard. You can get a guest DeliCard at the DeliCard device, which is located in the entrance area of the Mensa.

Cost of the guest DeliCard: A deposit of 5 EUR plus the amount you top up.

Restitution of the unused amount: Use the same device to get back the unused money and the deposit.

(In case that the money return capacity is too low, a voucher will be issued. To get your money back, return this voucher to the staff in the Caféte before 14:00 on Saturday.)

Thursday, 7 November 2019

18:00 *Get together and registration* at **Bobberts** (Neuer Platz 3, Downtown Paderborn)

Friday, 8 November 2019

08:30 *Registration*

09:00 - 09:05 *Opening*

09:05 - 10:00 **Benny Sudakov (Zurich)**
"Halfway to Rota's basis conjecture"

10:00 - 10:30 *Coffee break*

10:30 - 12:05 **Parallel sessions**

12:05 - 13:15 *Lunch*

13:15 - 14:50 **Parallel sessions**

14:50 - 15:20 *Coffee break*

15:20 - 16:15 **Nicole Megow (Bremen)**
"Combinatorial optimization with explorable uncertainty"

16:15 - 16:25 *Short break*

16:25 - 17:20 **Alexander Pott (Magdeburg)**
"Almost perfect nonlinear functions"

19:00 *Dinner* at **Bobberts** (Neuer Platz 3, Downtown Paderborn)

Saturday, 9 November 2019

08:45 - 10:20 **Parallel sessions**

10:20 - 10:50 *Coffee break*

10:50 - 12:25 **Parallel sessions**

12:25 - 13:25 *Lunch*

13:25 - 14:20 **Miguel Angel Fiol (Barcelona)**
"Spectra and eigenspaces of arbitrary lifts of graphs"

14:20 - 14:40 *Coffee break*

14:40 - 15:35 **Marco Buratti (Perugia)**
"A feast of combinatorial designs"

15:35 - 15:40 *Farewell*

Detailed program on Friday

8 November 2019

Time	Section I	Section II	Section III	Section IV
	Room: A	**Room: B**	**Room: C**	**Room: D**
09:00 - 09:05	*Opening* **Room: A**			
09:05 - 10:00	**Benny Sudakov** Halfway to Rota's basis conjecture **Room: A**			
10:00 - 10:30	*Coffee break*			
10:30 - 10:50	**D. Labbate 1** Extending perfect matchings to hamiltonian cycles in line graphs.	**T. Schweser 2** Critical digraphs	**H. Bergold 3** Topological drawings meet classical theorems of convex geometry	**S Piddock 4** Finding marked vertices with quantum walks
10:55 - 11:15	**J.P. Zerafa 5** Extending perfect matchings to hamiltonian cycles in $L(K_n)$ and $L(K_{m,m})$	**J. Wiehe 6** The chromatic polynomial of a digraph	**P. Goetschalckx 7** Local orientation-preserving symmetry preserving operations on polyhedra	**U. Tamm 8** Blockchain infrastructure: problems with cryptography and mining
11:20 - 11:40	**J. Rollin 9** Induced arboricity	**W. Hochstättler 10** A semi-strong perfect digraph theorem	**N. Van Cleemput11** 4-connected polyhedra have at least a linear number of hamiltonian cycles	**C. Deppe 12** Bounds for the capacity error function for unidirectional channels with feedback
11:45 - 12:05	**S. Glock 13** Resolution of the Oberwolfach problem	**M. Sonntag 14** Nearly all trees are edge intersection hypergraphs of 3-uniform hypergraphs	**M. Winter 15** Edge-transitive polytopes	**S. Gharibian 16** Almost optimal classical approximation algorithms for a quantum generalization of Max-Cut
12:05 - 13:15	*Lunch*			

Detailed program on Friday

8 November 2019

Time	Section I Room: A	Section II Room: B	Section III Room: C	Section IV Room: D
13:15 - 13:35	**D.R. Silaban** **17** Restricted size ramsey number for graph of P_3 versus small trees	**S. Mohr** **18** X-minors and X-spanning subgraphs	**H. Harborth** **19** Saturated vertex-to-vertex packings of integral triangles	**Y. Mogge** **20** Connector-breaker games on random boards
13:40 - 14:00	**M. Geisser** **21** On some new optimal χ-binding functions for (P_5, H)-free graphs	**M. Hatzel** **22** Avoidable paths in graphs	**F. Joos** **23** Decompositions of graphs	**K. Jansen** **24** On integer programming and convolution
14:05 - 14:25	**I. Schiermeyer** **25** Polynomial χ-binding functions for P_5-free graphs	**F. Schröder** **26** New p-centered colorings for sparse graphs	**G. Istrate** **27** The Ulam-Hammersley problem for finite partial orders.	**L. Nölke** **28** Online matching on the line with recourse
14:30 - 14:50	**K. Wijaya** **29** The subdivision of Ramsey minimal graphs of matching versus path on five vertices	**R. Lukoťka** **30** Short cycle covers of graphs	**D. Frettlöh** **31** Bounded distance equivalence in substitution tilings	**K. Grage** **32** EPTAS for machine-scheduling with bag-constraints
14:50 - 15:20	*Coffee break*			
15:20 - 16:15	**Nicole Megow** Combinatorial optimization with explorable uncertainty **Room: A**			
16:15 - 16:25	*Short break*			
16:25 - 17:20	**Alexander Pott** Almost perfect nonlinear functions **Room: A**			

Detailed program on Saturday

9 November 2019

Time	Section I Room: A	Section II Room: B	Section III Room: C	Section IV Room: D
08:45 - 09:05	**D. Mattiolo 33** Snarks with small circular flow number	**R. Steiner 34** Majority colorings of sparse digraphs	**M. Wilhelmi 35** Node-shellings of Euclidean oriented matroids	**U. Ahmad 36** Mixed fault-tolerant metric generators
09:10 - 09:30	**C. T. Zamfirescu 37** Planar hypohamiltonian oriented graphs	**S. D. Andres 38** Strong and weak perfect digraph theorems for perfect, α-perfect and strictly perfect digraphs	**S.M.C. Pagani 39** Power sum polynomials in a discrete tomography perspective	**M. A. Deppert 40** Near-linear approximation algorithms for scheduling problems with batch setup times
09:35 - 09:55	**G. Mazzuoccolo 41** Reduction of the Berge-Fulkerson conjecture to cyclically 5-edge-connected snarks	**S Wiederrecht 42** What is a ‘Directed Tree’?	**C. Brand 43** Graßmann meets Macaulay: apolarity for catalecticants	**A. Lassota 44** Near-linear time algorithm for n-fold ILPs via color coding
10:00 - 10:20	**R. Škrekovski 45** Some results and problems on unique-maximum colorings of plane graphs	**M. A. Yetim 46** Vertex labeling of graphs with interval representations	**A. Umar 47** Some combinatorial results for the partial transformation monoid	
10:20 - 10:50	*Coffee break*			

Detailed program on Saturday

9 November 2019

Time	**Section I** **Room: A**	**Section II** **Room: B**	**Section III** **Room: C**	**Section IV** **Room: D**
10:50 - 11:10	**E. Máčajová 49** Lower bound on the length of a cycle cover of a cubic graph	**T. Böhme 50** Separators in geometric graphs	**A. A. Polujan 51** Design-theoretic aspects of vectorial bent functions	**M. Scheucher 52** Using SAT solvers in combinatorics and geometry
11:15 - 11:35	**G. Rinaldi 53** Regular 1-factorizations of complete graphs and decompositions into pairwise isomorphic rainbow spanning trees	**A.R. Davtyan 54** On the deficiency of complete multipartite graphs	**K. Tabak 55** Some incidence structures within q-analogs	**T. Fluschnik 56** Polynomial-time preprocessing for weighted problems beyond additive goal functions
11:40 - 12:00	**S.-S. Kao 57** Decompose a graph into two disjoint cycles	**A.H. Gharibyan 58** On locally-balanced k-partitions of graphs	**C. Kaspers 59** A lower bound on the number of CCZ-inequivalent APN functions	**A. Skopalik 60** Simple, distributed, and powerful - improving local search for distributed resource allocation and equilibrium computation
12:05 - 12:25	**A.A.G. Ngurah 61** On super edge-magic deficiency of graphs	**K. Heuer 62** Characterising k-connected sets in infinite graphs	**I. Althöfer 63** The early Lothar Collatz and his $3n + 1$ problem	**M. Schubert 64** Decompositions of flows on signed graphs without long barbells
12:25 - 13:25	*Lunch*			
13:25 - 14:20	**Miguel Angel Fiol** Spectra and eigenspaces of arbitrary lifts of graphs **Room: A**			
14:20 - 14:40	*Coffee break*			
14:40 - 15:35	**Marco Buratti** A feast of combinatorial designs **Room: A**			
15:35 - 15:40	*Farewell*			

Invited talks

Marco Buratti (Perugia)	: A feast of combinatorial designs
Miguel Angel Fiol (Barcelona)	: Spectra and eigenspaces of arbitrary lifts of graphs
Nicole Megow (Bremen)	: Combinatorial optimization with explorable uncertainty
Alexander Pott (Magdeburg)	: Almost perfect nonlinear functions
Benny Sudakov (Zurich)	: Halfway to Rota's basis conjecture

Contributed talks

Uzma Ahmad (Lahore)	: Mixed fault-tolerant metric generators
Ingo Althöfer (Jena)	: The early Lothar Collatz and his $3n + 1$ problem
Stephan Dominique Andres (Hagen)	: Strong and weak perfect digraph theorems for perfect, α-perfect and strictly perfect digraphs
Helena Bergold (Hagen)	: Topological drawings meet classical theorems of convex geometry
Thomas Böhme (Ilmenau)	: Separators in geometric graphs
Cornelius Brand (Prague)	: Graßmann meets Macaulay: apolarity for catalecticants
Armen R. Davtyan (Yerevan)	: On the deficiency of complete multipartite graphs
Christian Deppe (Munich)	: Bounds for the capacity error function for unidirectional channels with feedback
Max A. Deppert (Kiel)	: Near-linear approximation algorithms for scheduling problems with batch setup times
Till Fluschnik (Berlin)	: Polynomial-time preprocessing for weighted problems beyond additive goal functions
Dirk Frettlöh (Bielefeld)	: Bounded distance equivalence in substitution tilings
Maximilian Geißer (Freiberg)	: On some new optimal χ-binding functions for (P_5, H)-free graphs
Sevag Gharibian (Paderborn)	: Almost optimal classical approximation algorithms for a quantum generalization of Max-Cut
Aram H. Gharibyan (Yerevan)	: On locally-balanced k-partitions of graphs
Stefan Glock (ETH Zrich)	: Resolution of the Oberwolfach problem
Kilian Grage (Kiel)	: EPTAS for machine-scheduling with bag-constraints
Pieter Goetschalckx (Ghent)	: Local orientation-preserving symmetry preserving operations on polyhedra
Heiko Harborth (Braunschweig)	: Saturated vertex-to-vertex packings of integral triangles
Meike Hatzel (Berlin)	: Avoidable paths in graphs
Karl Heuer (Berlin)	: Characterising k-connected sets in infinite graphs
Winfried Hochstättler (Hagen)	: A semi-strong perfect digraph theorem
Gabriel Istrate (Timişoara)	: The Ulam-Hammersley problem for finite partial orders.
Klaus Jansen (Kiel)	: On integer programming and convolution

Felix Joos (Hamburg)	: Decompositions of graphs
Shin-Shin Kao (Tao-Yuan City)	: Decompose a graph into two disjoint cycles
Christian Kaspers (Magdeburg)	: A lower bound on the number of CCZ-inequivalent APN functions
Domenico Labbate (Potenza)	: Extending perfect matchings to hamiltonian cycles in line graphs.
Alexandra Lassota (Kiel)	: Near-linear time algorithm for n-fold ILPs via color coding
Robert Lukoťka (Bratislava)	: Short cycle covers of graphs
Edita Máčajová (Bratislava)	: Lower bound on the length of a cycle cover of a cubic graph
Davide Mattiolo (Modena)	: Snarks with small circular flow number
Giuseppe Mazzuoccolo (Verona)	: Reduction of the Berge-Fulkerson conjecture to cyclically 5-edge-connected snarks
Yannick Mogge (Hamburg)	: Connector-breaker games on random boards
Samuel Mohr (Ilmenau)	: X-minors and X-spanning subgraphs
Anak Agung Gede Ngurah (Malang)	: On super edge-magic deficiency of graphs
Lukas Nölke (Bremen)	: Online matching on the line with recourse
Silvia M.C. Pagani (Brescia)	: Power sum polynomials in a discrete tomography perspective
Stephen Piddock (Bristol)	: Finding marked vertices with quantum walks
Alexandr A. Polujan (Magdeburg)	: Design-theoretic aspects of vectorial bent functions
Gloria Rinaldi (Modena)	: Regular 1-factorizations of complete graphs and decompositions into pairwise isomorphic rainbow spanning trees
Jonathan Rollin (Hagen)	: Induced arboricity
Manfred Scheucher (Berlin)	: Using SAT solvers in combinatorics and geometry
Ingo Schiermeyer (Freiberg)	: Polynomial χ-binding functions for P_5-free graphs
Felix Schröder (Berlin)	: New p-centered colorings for sparse graphs
Michael Schubert (Paderborn)	: Decompositions of flows on signed graphs without long barbells
Thomas Schweser (Ilmenau)	: Critical digraphs
Denny Riama Silaban (Jakarta)	: Restricted size ramsey number for graph of P_3 versus small trees
Alexander Skopalik (Enschede)	: Simple, distributed, and powerful - improving local search for distributed resource allocation and equilibrium computation
Riste Škrekovski (Ljubljana)	: Some results and problems on unique-maximum colorings of plane graphs
Martin Sonntag (Freiberg)	: Nearly all trees are edge intersection hypergraphs of 3-uniform hypergraphs
Raphael Steiner (Berlin)	: Majority colorings of sparse digraphs
Kristijan Tabak (Zagreb)	: Some incidence structures within q-analogs
Ulrich Tamm (Bielefeld)	: Blockchain infrastructure: problems with cryptography and mining

Abdullahi Umar (Abu Dhabi)	: Some combinatorial results for the partial transformation monoid
Nico Van Cleemput (Ghent)	: 4-connected polyhedra have at least a linear number of hamiltonian cycles
Johanna Wiehe (Hagen)	: The chromatic polynomial of a digraph
Sebastian Wiederrecht (Berlin)	: What is a 'Directed Tree'?
Kristiana Wijaya (Jember)	: The subdivision of Ramsey minimal graphs of matching versus path on five vertices
Michael Wilhelmi (Hagen)	: Node-shellings of Euclidean oriented matroids
Martin Winter (Chemnitz)	: Edge-transitive polytopes
Mehmet Akif Yetim (Isparta)	: Vertex labeling of graphs with interval representations
Carol T. Zamfirescu (Ghent)	: Planar hypohamiltonian oriented graphs
Jean Paul Zerafa (Modena)	: Extending perfect matchings to hamiltonian cycles in $L(K_n)$ and $L(K_{m,m})$

Further participants

Chiara Cappello (Paderborn)
Alena Ernst (Paderborn)
John Baptist Gauci (Msida)
Jessica Hagemeister (Paderborn)
Christoph Josten (Frankfurt a.M.)
Lars Kleinemeier (Paderborn)
Antje Klopp (Paderborn)
Christina Kolb (Paderborn)
Katja Mönius (Würzburg)
Marco Ricci (Hagen)
Robert Scheidweiler (Paderborn)
Kai-Uwe Schmidt (Paderborn)
Eckhard Steffen (Paderborn)
Jörn Steuding (Würzburg)
Michael Stiebitz (Ilmenau)
Pascal Stumpf (Würzburg)
Charlene Weiß (Paderborn)

Friday, 8 Nov. 2019 — Time: 09:05 - 10:00 — Room: A

Halfway to Rota's basis conjecture

BENNY SUDAKOV (Zurich)

In 1989, Rota made the following conjecture. Given n bases $B_1, \ldots, B_n$ of an n-dimensional vector space V, one can always find n disjoint bases of V, each containing exactly one element from each B_i (we call such bases transversal bases). Rota's basis conjecture remains open despite its apparent simplicity and the efforts of many researchers (for example, the conjecture was recently the subject of the collaborative "Polymath" project). In this talk, I will discuss how to find $n/2 - o(n)$ disjoint transversal bases, improving the previously best known bound of $n/\log n$. The proof also applies to the more general setting of matroids.

This is joint work with Bucic, Kwan, and Pokrovskiy

Friday, 8 Nov. 2019 — Time: 15:20 - 16:15 — Room: A

Combinatorial optimization with explorable uncertainty

NICOLE MEGOW (Bremen)

In the traditional frameworks for optimization under uncertainty, an algorithm has to accept the incompleteness of input data. Clearly, more information or even knowing the exact data would allow for significantly improved solutions. How much more information suffices for obtaining a certain solution quality? Which information shall be retrieved? Explorable uncertainty is a recently proposed framework in which parts of the input data are initially unknown, but can be obtained at a certain cost using queries. An algorithm can make queries one by one until it has obtained sufficient information to solve a given problem. The challenge lies in balancing the cost for querying and the impact on the solution quality. In this talk, we give a short overview on recent work on explorable uncertainty for combinatorial optimization problems, focussing on the minimum spanning tree problem and a scheduling problem.

Friday, 8 Nov. 2019 — Time: 16:25 - 17:20 — Room: A

Almost perfect nonlinear functions

ALEXANDER POTT (Magdeburg)

A function $f : \mathbb{F}_2^n \to \mathbb{F}_2^n$ is called almost perfect nonlinear (APN) if

$$f(x) + f(y) + f(z) + f(x + y + z) \neq 0$$

for all x, y, z such that $|\{x, y, z, x + y + z\}| = 4$. The motivation to study these functions comes from cryptography, since the defining property is somehow opposite to linearity. My talk will be a survey about APN functions. In particular, I will discuss the following three problems:

- The big open problem on APN functions is the question whether there are APN permutations if n is even. There is only one example known if $n = 6$.
- What is a good lower bound on the number of inequivalent APN functions? Very recently, Christian Kaspers and Yue Zhou showed that the members of a large family of APN functions are pairwise inequivalent, which provides the best known lower bound on the number of inequivalent functions (see also the talk by Christian Kaspers).
- Most of the known APN functions f are quadratic (which means that the derivatives $x \mapsto f(x + a) + f(x)$ are linear). Find more *nonquadratic* APN functions.

Saturday, 9 Nov. 2019 — Time: 13:25 - 14:20 — Room: A

Spectra and eigenspaces of arbitrary lifts of graphs

MIGUEL ANGEL FIOL (Barcelona)

In the study of interconnection networks with bidirectional links, there are two concepts that have shown to be very fruitful to construct good and efficient topologies. Namely, those of quotient graphs, and lifts of voltage graphs. Roughly speaking, quotient graphs allow us to give a simplified or 'condensed' version of a larger graph, while the voltage graph technique does the converse, by 'expanding' a smaller graph into its 'lift'. In this talk, we concentrate on lifts of voltage (base) graphs which have edges endowed with the elements of a finite group. Then, we describe, in a very explicit way, a method for determining the adjacency spectra and bases of all the corresponding eigenspaces of arbitrary lifts of graphs (regular or not). Thus, our study generalizes some previous results of Lovsz and Babai concerning the spectra of Cayley graphs. As some examples, we completely characterize the spectrum of a new family of graphs, which contains the generalized Petersen graphs, and the McKay-Miller-Sirn graphs, as a generalization of the Hoffman-Singleton graph. The method can also be applied to other matrices, as the Laplacian, the signess Laplacian, and the Seidel matrix.
(Joint work with C. Dalfó, S. Pavlíková and J. Sirán)

Saturday, 9 Nov. 2019 — Time: 14:40 - 15:35 — Room: A

A feast of combinatorial designs

MARCO BURATTI (Perugia)

Given the notion of a combinatorial design of an assigned order v, the first natural – but sometimes also the most difficult – question is to establish its existence. After that, one can consider several other problems such as, for instance, to say something on the number $N(v)$ of these designs up to isomorphism.
In this talk I would like to focus my attention on this interesting question. If v is reasonably small, one can determine $N(v)$ precisely by means of some, possibly heavy, computer work. This is not feasible for large orders v but one can try to give a lower bound on $N(v)$ by means of some theoretical arguments. Sometimes this can be achieved by applying suitable composition constructions; starting from a frugal bunch of designs of suitable orders smaller than v and assembling them together, one could obtain a rich banquet of designs of the desired order v. More interesting in my opinion is when the knowledge of a single design leads to a feast of other designs of the same order by suitably "distorting" the given one.
I will tell/show how some of these methods allowed to obtain exponential bounds on the number of Steiner 2-designs, semiboolean Steiner quadruple systems, Hamiltonian cycle systems in some old papers of mine. In particular, I will speak about one of my current obsessions: a feast of cyclic Steiner triple systems.

Friday, 8 Nov. 2019 — Time: 10:30 - 10:50

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1 — Section I — Room A — 10:30 - 10:50

Extending perfect matchings to hamiltonian cycles in line graphs.

DOMENICO LABBATE (Potenza)

A graph has the Perfect–Matching–Hamiltonian property (for short the PMH–property) if each of its perfect matchings can be extended to a hamiltonian cycle. In this talk we establish some sufficient conditions for a graph G in order to guarantee that its line graph $L(G)$ has the PMH–property.

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2 — Section II — Room B — 10:30 - 10:50

Critical digraphs

THOMAS SCHWESER (Ilmenau)

The chromatic number $\chi(D)$ of a digraph D is the minimum number of colors needed to color the vertices of D such that each color class induces an acyclic subdigraph of D. A digraph D is k-critical if $\chi(D) = k$ but $\chi(D') < k$ for all proper subdigraphs D' of D. We examine methods for creating infinite families of critical digraphs, the *Dirac join* and the directed and bidirected *Hajós join*. We prove that a digraph D has chromatic number at least k if and only if it contains a subdigraph that can be obtained from bidirected complete graphs on k vertices by (directed) Hajós joins and identifying non-adjacent vertices. Building upon that, we show that a digraph D has chromatic number at least k if and only if it can be constructed from bidirected K_k's by using directed and bidirected Hajós joins and identifying non-adjacent vertices (so called Ore joins), thereby transferring a well-known result of Urquhart to digraphs.

3 — Section III — Room C — 10:30 - 10:50

Topological drawings meet classical theorems of convex geometry

HELENA BERGOLD (Hagen)

In this talk we discuss classical theorems from Convex Geometry such as Carathéodory's Theorem, Colorful Carathéodory and Helly's Theorem in a more general context of topological drawings of K_n. In a topological drawing the edges of the graph are drawn as simple closed curves such that every pair of edges have at most one common point. We give a new proof for a generalized version of Carathéodory's Theorem [Balko, Fulek, Kynčl '15] and present a family of topological drawings with arbitrary large Helly number.

Joint work with Stefan Felsner, Manfred Scheucher, Felix Schröder and Raphael Steiner.

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4 — Section IV — Room D — 10:30 - 10:50

Finding marked vertices with quantum walks

STEPHEN PIDDOCK (Bristol)

Consider the problem of finding any one of a number of marked vertices in a graph. One classical randomised algorithm is to simply randomly explore the graph until a marked element is found. It is well known that such a random walk on a graph can be studied by viewing the graph as an electrical network. In particular the expected time until hitting a marked element is bounded above by $2RW$ where R is the electrical resistance between the initial vertex and the marked vertices and W is the number of edges in the graph (or the sum over all edge weights in a weighted graph).
Belovs designed a quantum algorithm which detects the existence of marked elements, by applying the standard phase estimation routine to a quantum random walk operator (this operator can be thought of as a generalisation of a step of the classical random walk). The analysis uses the same electrical network ideas and shows that the runtime is $\tilde{O}(\sqrt{RW})$. However the algorithm only outputs whether or not the set of marked vertices is empty, without giving an example marked vertex in the case when it is non-empty. In this talk I will discuss how his algorithm can be adjusted to actually *find* a marked vertex in a comparable runtime.

Friday, 8 Nov. 2019 — Time: 10:55 - 11:15

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5 — Section I — Room A — 10:55 - 11:15

Extending perfect matchings to hamiltonian cycles in $L(K_n)$ and $L(K_{m,m})$

JEAN PAUL ZERAFA (Modena)

A graph has the Perfect-Matching-Hamiltonian property (for short the PMH property) if every perfect matching can be extended to a hamiltonian cycle. Let G be a hamiltonian graph. It can be easily shown that the line graph of G, denoted by $L(G)$, is hamiltonian as well. We have recently studied the PMH property in the line graphs of various classes of graphs. In particular, we show that if G is a complete graph K_n or a balanced complete bipartite graph $K_{m,m}$ of even size, then, every perfect matching in $L(G)$ can be extended to a hamiltonian cycle.

Joint work with Marién Abreu (University of Basilicata), John Baptist Gauci (University of Malta), Domenico Labbate (University of Basilicata) and Giuseppe Mazzuoccolo (University of Verona).

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6 — Section II — Room B — 10:55 - 11:15

The chromatic polynomial of a digraph

JOHANNA WIEHE (Hagen)

In 1982 V. Neumann-Lara introduced the dichromatic number of a digraph D as the smallest integer k such that the vertices V of D can be colored with k colors and each color class induces an acyclic digraph.
Counting the number of such colorings with k colors can be done by counting so-called Neumann-Lara-coflows (NL-coflows), which build a polynomial in k. In this talk we will present a representation of this polynomial using totally cyclic subdigraphs, which form a graded poset $\mathcal{P}$.
Furthermore we will prove that our polynomial equals the chromatic polynomial of the underlying undirected graph divided by the number of colors in the symmetric case using the structure of the face lattice of a class of polyhedra that correspond to $\mathcal{P}$.
This is joint work with W. Hochstättler, FernUniversität in Hagen.

7 — Section III — Room C — 10:55 - 11:15

Local orientation-preserving symmetry preserving operations on polyhedra

PIETER GOETSCHALCKX (Ghent)

We introduce a definition of local operations on polyhedra that preserve orientation-preserving symmetries, but not necessarily orientation-reversing symmetries. This includes among others the chiral Goldberg-Coxeter and Conway operations, and all local symmetry-preserving operations.
By replacing each double chamber of the barycentric subdivision of a polyhedron with the same patch cut out of a symmetric tiling, we can construct new polyhedra with the same orientation-preserving symmetries. These patches are not unique, sometimes different patches can give the same results on all polyhedra. In order to recognize equivalent operations, we introduce the *double chamber decoration* of an operation, and proof that two operations are equivalent if and only if the corresponding double chamber decorations are identical.

8 — Section IV — Room D — 10:55 - 11:15

Blockchain infrastructure: problems with cryptography and mining

ULRICH TAMM (Bielefeld)

Blockchains rely on two basic infrastructures: cryptography in order to protect the information and mining to validate transcactions and maintain the database. We shall take a closer look at the problems which may come into play, how they might be corrected and at some mathematical problems arising in this context.

Friday, 8 Nov. 2019 — Time: 11:20 - 11:40

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9 — Section I — Room A — 11:20 - 11:40

Induced arboricity

JONATHAN ROLLIN (Hagen)

The induced arboricity of a graph G is the smallest integer k such that there are k induced forests in G together covering all the edges of G. It turns out that this parameter depends on the structure of the graph and not only on its density. This is in contrast to the well known arboricity, where the forests are not necessarily induced.

We discuss some relations between induced arboricity and other graph parameters. This leads to a classification of families of graphs with bounded induced arboricity. In particular the induced arboricity is bounded for any family of graphs with bounded expansion. Specifically the largest induced arboricity among all planar graphs lies between 8 and 10.

From an algorithmic point of view we show that deciding whether a graph has induced arboricity at most k is NP-complete for each $k \geq 2$. The problem stays NP-complete for planar graphs in case $2 \leq k \leq 4$.

By varying the requirements on the forests many variants of induced arboricty can be defined. We consider two variants, one with weaker and one with stronger requirements.

This is joint work with Maria Axenovich, Philip Dörr, Daniel Gonçalves, and Torsten Ueckerdt.

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10 — Section II — Room B — 11:20 - 11:40

A semi-strong perfect digraph theorem

WINFRIED HOCHSTÄTTLER (Hagen)

Perfect digraphs have been introduced by Andres and Hochstättler as the class of digraphs where the clique number equals the dichromatic number for every induced subdigraph. Reed showed that, if two graphs are P_4-isomorphic, then either both are perfect or none of them is. We derive an analogous result for perfect digraphs.

Joint work with Dominique Andres, Helena Bergold and Johanna Wiehe.

11 — Section III — Room C — 11:20 - 11:40

4-connected polyhedra have at least a linear number of hamiltonian cycles

NICO VAN CLEEMPUT (Ghent)

Although polyhedra can have much fewer edges than triangulations, many results about hamiltonicity proven for triangulations also hold for polyhedra. The most famous of these results is surely Whitney's result from 1931 that 4-connected triangulations are hamiltonian, which was 25 years later generalised to 4-connected polyhedra by Tutte. For triangulations a lower bound of $|V|/(\log_2 |V|)$ was proven in 1979 and improved to a linear bound in 2018. Nevertheless the only known bounds for the number of hamiltonian cycles in 4-connected polyhedra are constant. In this talk we present the proof of a linear lower bound for 4-connected polyhedra.

This is joint work with Gunnar Brinkmann.

12 — Section IV — Room D — 11:20 - 11:40

Bounds for the capacity error function for unidirectional channels with feedback

CHRISTIAN DEPPE (Munich)

In digital systems such as fiber optical communications the ratio between probability of errors of type $1 \to 0$ and $0 \to 1$ can be large. Practically, one can assume that only one type of errors can occur. These errors are called asymmetric. Unidirectional errors differ from asymmetric type of errors, here both $1 \to 0$ and $0 \to 1$ type of errors are possible, but in any submitted codeword all the errors are of the same type.
We consider q-ary unidirectional channels with feedback and give bounds for the capacity error function. It turns out that the bounds depend on the parity of the alphabet q. Furthermore we show that for feedback the capacity error function for the binary asymetric channel is different from the symetric channel. This is in contrast to the behavior of that function without feedback.

Joint work with Vladimir Lebedev (Kharkevich Institute for Information Transmission Problems) and Georg Maringer (Technische Universität München)

Friday, 8 Nov. 2019 — Time: 11:45 - 12:05

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13 — Section I — Room A — 11:45 - 12:05

Resolution of the Oberwolfach problem

STEFAN GLOCK (ETH Zrich)

The Oberwolfach problem, posed by Ringel in 1967, asks for a decomposition of K_{2n+1} into edge-disjoint copies of a given 2-factor. We show that this can be achieved for all large n. This is joint work with Felix Joos, Jaehoon Kim, Daniela Kühn and Deryk Osthus.

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14 — Section II — Room B — 11:45 - 12:05

Nearly all trees are edge intersection hypergraphs of 3-uniform hypergraphs

MARTIN SONNTAG (Freiberg)
joint work with HANNS-MARTIN TEICHERT (Universität zu Lübeck)

If $\mathcal{H} = (V, \mathcal{E})$ is a hypergraph, its *edge intersection hypergraph* $EI(\mathcal{H}) = (V, \mathcal{E}^{EI})$ has the edge set $\mathcal{E}^{EI} = \{e_1 \cap e_2 \mid e_1, e_2 \in \mathcal{E} \ \wedge \ e_1 \neq e_2 \ \wedge \ |e_1 \cap e_2| \geq 2\}$.
We prove that all trees but seven exceptional ones are edge intersection hypergraphs of 3-uniform hypergraphs. Whereas this can be easily shown for stars $K_{1,n}$ $(n \geq 3)$ and paths P_n $(n \geq 7)$ (as well as for cycles C_n $(n \geq 5)$), the verification for trees $T = (V, E)$ uses an induction on the number of vertices $|V|$.

15 — Section III — Room C — 11:45 - 12:05

Edge-transitive polytopes

MARTIN WINTER (Chemnitz)

It has long been known that there are five regular polyhedra (the Platonic solids), six regular 4-polytopes and exactly three regular d-polytopes for all $d \geq 5$. Hence, the symmetry requirement of *regularity* (aka. flag-transitivity) seems to be quite restrictive for *convex* polytopes. In contrast, the class of *vertex-transitive* polytopes (all vertices are identical under the symmetries of the polytope) is almost as rich as the finite groups.
In this talk we ask about the class of *edge-transitive* (convex) polytopes, that is, polytopes in which all edges are identical under the symmetries of the polytope. Despite this restriction feeling more similar to vertex-transitivity than to regularity, we will see that quite the contrary seems to be the case: the class of edge-transitive polytopes appears to be quite restricted. We give, what we believe to be, a complete list of all edge-transitive polytopes, as well as a full classification for certain interesting sub-classes. Thereby, we show how edge-transitive polytopes can be studied with the tools of spectral graph theory.

16 — Section IV — Room D — 11:45 - 12:05

Almost optimal classical approximation algorithms for a quantum generalization of Max-Cut

SEVAG GHARIBIAN (Paderborn)

Approximation algorithms for constraint satisfaction problems (CSPs) are a central direction of study in theoretical computer science. In this work, we study classical product state approximation algorithms for a physically motivated quantum generalization of Max-Cut, known as the quantum Heisenberg model. This model is notoriously difficult to solve exactly, even on bipartite graphs, in stark contrast to the classical setting of Max-Cut. Here we show, for any interaction graph, how to classically and efficiently obtain approximation ratios 0.649 (anti-ferromagnetic XY model) and 0.498 (anti-ferromagnetic Heisenberg XYZ model). These are almost optimal; we show that the best possible ratios achievable by a product state for these models is 2/3 and 1/2, respectively.

No background in quantum computation is assumed for this talk. Based on joint work with Ojas Parekh (Sandia National Labs, USA).

Friday, 8 Nov. 2019 — Time: 13:15 - 13:35

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17 — Section I — Room A — 13:15 - 13:35

Restricted size ramsey number for graph of P_3 versus small trees

DENNY RIAMA SILABAN (Jakarta)

Let G and H be simple graphs. The Ramsey number for G and H is the smallest number $r(G, H)$ such that any red-blue coloring of edges of K_r contains a red subgraph G or a blue subgraph H. The size Ramsey number for G and H is the smallest number $\hat{r}(G, H)$ such that there exists a graph F with size $\hat{r}$ satisfying the property that any red-blue coloring of edges of F contains a red subgraph G or a blue subgraph H. Additionally, if the order of F is $r(G, H)$, then it is called the restricted size Ramsey number $r^*(G, H)$. In 1983, Harary and Miller started to find the (restricted) size Ramsey number for any pair of small graphs. They obtained the values for some pair of small graphs with order at most four. Faudree and Sheehan (1983) continued Harary and Miller's works and summarized the complete results on the (restricted) size Ramsey number for any pair of small graphs with order at most four. Moreover, Lortz and Mengenser (1998) gave both the size Ramsey number and the restricted size Ramsey number for any pair of small forests with order at most five.
In this talk we consider the restricted size Ramsey number for graph of size two versus connected graph H. We give a short survey of results concerning this topic. In addition, we also give the exact values of $r^*(P_3, T_n)$ where T_n is the set of trees of order n for small n.

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18 — Section II — Room B — 13:15 - 13:35

X-minors and X-spanning subgraphs

SAMUEL MOHR (Ilmenau)

Given a finite, undirected, and simple graph G and $X \subseteq V(G)$, let $\mathcal{H}$ be a partition of a subset of $V(G)$ into connected sets—called *bags*—such that each bag contains at most one vertex of X and X is a subset of the union of all bags. If M is a simple graph on the vertex set $\mathcal{H}$ such that there is an edge of G connecting two bags of $\mathcal{H}$ if these two bags are adjacent in M, then M is an X-*minor* of G.
We consider the problem whether G has a highly connected X-minor if X cannot be separated in G by removing a few vertices of G. As an application of the achieved results, statements on the existence of special X-spanning subgraphs of G are presented, where a subgraph H of G is X-*spanning* if $X \subseteq V(H)$.
This is joint work with Thomas Bhme, Jochen Harant, Matthias Kriesell, and Jens M. Schmidt.

19 — Section III — Room C — 13:15 - 13:35

Saturated vertex-to-vertex packings of integral triangles

HEIKO HARBORTH (Braunschweig)

In the plane a vertex-to-vertex packing of triangles is called saturated if each vertex of the triangles is the vertexpoint of exactly two of the triangles. For unit triangles it is an open problem whether 42 is the minimum number of tringles such that there exists a saturated packing.
Instead of unit triangles now integral triangles are considered. It will be asked for the minimum number $t(d)$ of triangles in a saturated packing of integral triangles with side lengths up to the length d (diameter).

20 — Section IV — Room D — 13:15 - 13:35

Connector-breaker games on random boards

YANNICK MOGGE (Hamburg)

A Maker-Breaker game is a two player positional game, in which both players alternatingly claim one or more elements of a given board. One player (Maker) tries to claim all elements of a winning set while the other player (Breaker) tries to prevent her from doing so. The connectivity game is a variant of a Maker-Breaker game in which the board is some graph G and the winning sets consist of all spanning trees of G.
By now, the Maker-Breaker connectivity game on a complete graph K_n or on a random graph $G \sim G_{n,p}$ is well studied. Recently though, London and Pluhár introduced a new version of this game, in which Maker had to choose her edges in such a way that her graph stays connected throughout the game. They proved, that if Maker is allowed to claim one edge in each round, the threshold biases for the connectivity game played on K_n and $G_{n,p}$ differ drastically from their respective values in the Maker-Breaker version, but if played on K_n and if Maker is allowed to claim two edges in each round, the threshold biases of both versions are of the same order. This led to the question if the threshold probability when playing on $G_{n,p}$ and if both players are allowed to claim two edges in each round is of the same order as in the usual Maker-Breaker version. We give an answer to this question and prove that this is in fact not the case and determine the threshold probability for winning this game to be of size $n^{-2/3+o(1)}$.
This is joint work with Dennis Clemens and Laurin Kirsch.

Friday, 8 Nov. 2019 — Time: 13:40 - 14:00

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21 — Section I — Room A — 13:40 - 14:00

On some new optimal χ-binding functions for (P_5, H)-free graphs

Maximilian Geisser (Freiberg)

A graph G with clique number $\omega(G)$ and chromatic number $\chi(G)$ is *perfect* if $\chi(H) = \omega(H)$ for every induced subgraph H of G. As a generalisation of this concept a family $\mathcal{G}$ of graphs is called χ-*bounded* with binding function f if for each $G \in \mathcal{G}$ and each induced subgraph G' of G the condition $\chi(G') \leq f(\omega(G'))$ holds.
It is still an open question whether there is a polynomial χ-binding function for the family of P_5-free graph. For several classes which occur by forbidding an additional small graph as an induced subgraph polynomial χ-binding functions have been shown.
In this talk we will report about some new upper bounds for the chromatic number of (P_5, H)-free graphs, where $H \in \{\text{banner, dart, gem, hammer}\}$. All these bounds are optimal χ-binding functions (joint work with Ingo Schiermeyer and Christoph Brause).

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22 — Section II — Room B — 13:40 - 14:00

Avoidable paths in graphs

Meike Hatzel (Berlin)

The results I present are joined work with Marthe Bonamy, Oscar Defrain and Jocelyn Thiebaut.
We prove a recent conjecture of Beisegel et al. that for every positive integer k, every graph containing an induced P_k also contains an avoidable P_k. Avoidability generalises the notion of simpliciality best known in the context of chordal graphs. The conjecture was only established for $k \in \{1, 2\}$ (Ohtsuki et al. 1976, and Beisegel et al. 2019, respectively). Our result also implies a result of Chvátal et al. 2002, which assumed cycle restrictions. We provide a constructive and elementary proof, relying on a single trick regarding the induction hypothesis. In the line of previous works, we discuss conditions for multiple avoidable paths to exist.

23 — Section III — Room C — 13:40 - 14:00

Decompositions of graphs

FELIX JOOS (Hamburg)

A few years ago Kim, Kühn, Osthus and Tyomkyn proved a blow-up lemma that allows almost decompositions of quasirandom graphs into bounded degree graphs. This tool has been utilized recently for several decomposition results including the resolution of the Oberwolfach Problem (which I also discuss briefly) and important special cases of conjectures of Ringle as well as Gyárfás and Lehel concerning decompositions of the complete graph into trees. I present an alternative proof for the blow-up lemma for approximate decompositions that is significantly shorter.

This is joint work with Stefan Ehard.

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24 — Section IV — Room D — 13:40 - 14:00

On integer programming and convolution

KLAUS JANSEN (Kiel)

Integer programs (IP) with a constant number m of constraints are solvable in pseudo-polynomial time. We give a new algorithm based on the Steinitz Lemma and dynamic programming with a better pseudo-polynomial running time than previous results. Vectors $v_1, ...v_n$ in R^m that sum up to 0 can be seen as a circle in R^m that walks from 0 to v_1 to $v_1 + v_2$, etc. until it reaches $v_1 + ... + v_n = 0$ again. The Steinitz Lemma says that if each of the vectors is small with respect to some norm, we can reorder the vectors in a way that each point in the circle is not far away from 0 w.r.t. the same norm. We show in the talk that a solution to the ILP $\max c^T x, Ax = b, x >= 0, x \in Z^n$ with m constraints in A can be found in time $O(m\Delta)^{2m} \log(||b||_\infty) + O(nm)$ where Δ is the biggest absolute value of any entry in A.
Moreover, we establish a strong connection to the problem $(\min, +)$-convolution. $(\min, +)$-convolution has a trivial quadratic time algorithm and it has been conjectured that this cannot be improved si-gni?cantly. We show that further improvements to our pseudo-polynomial algorithm for any ?xed number m of constraints are equivalent to improvements for $(\min, +)$-convolution. This is a strong evidence that our algorithm?s running time is best possible. We also present a faster specialized algorithm for testing feasibility of an integer program with few constraints. Our algorithm for the feasibility problem runs in $O(m\Delta)^m \log(\Delta) \log(\Delta + ||b||_\infty) + O(nm)$. Finally we show for the feasibility problem also a tight lower bound, which is based on the Strong Exponential Time Hypothesis (SETH).

This is joint work with Lars Rohwedder.

Friday, 8 Nov. 2019 — Time: 14:05 - 14:25

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25 — Section I — Room A — 14:05 - 14:25

Polynomial χ-binding functions for P_5-free graphs

INGO SCHIERMEYER (Freiberg)

A graph G with clique number $\omega(G)$ and chromatic number $\chi(G)$ is *perfect* if $\chi(H) = \omega(H)$ for every induced subgraph H of G. A family $\mathcal{G}$ of graphs is called χ-bounded with binding function f if $\chi(G') \leq f(\omega(G'))$ holds whenever $G \in \mathcal{G}$ and G' is an induced subgraph of G. In this talk we will present a survey on polynomial χ-binding functions. Especially we will address perfect graphs, hereditary graphs satisfying the Vizing bound ($\chi \leq \omega + 1$), graphs having linear χ-binding functions and graphs having non-linear polynomial χ-binding functions. Thereby we also survey polynomial χ-binding functions for several graph classes defined in terms of forbidden induced subgraphs, among them $2K_2$-free graphs, P_k-free graphs, $claw$-free graphs, and $diamond$-free graphs. Our main focus will be on recent results for P_5-free graphs.

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26 — Section II — Room B — 14:05 - 14:25

New p-centered colorings for sparse graphs

FELIX SCHRÖDER (Berlin)

A p-centered coloring is a vertex-coloring of a graph G such that for every connected subgraph H of G either H receives more than p colors or there is a color that appears exactly once in H. The concept was introduced by Nešetřil and Ossona de Mendez to provide a local condition suitable to measure sparsity of graphs.
In the talk, we will discuss new p-centered colorings of graphs from several widely studied graph classes:

1. planar graphs admit p-centered colorings with $\mathcal{O}(p^3 \log p)$ colors where the previous bound was $\mathcal{O}(p^{19})$;

2. bounded degree graphs admit p-centered colorings with $\mathcal{O}(p)$ colors while it was conjectured that they may require exponential number of colors in p;

3. graphs avoiding a fixed graph as a topological minor admit p-centered colorings with a polynomial in p number of colors.

All these upper bounds imply polynomial algorithms for computing the colorings.

27 — Section III — Room C — 14:05 - 14:25

The Ulam-Hammersley problem for finite partial orders.

GABRIEL ISTRATE (Timişoara)

The Ulam-Hammersley problem (e.g. Romik (2015)) concerns the scaling behavior of the longest increasing subsequence of a random permutation.
Heapability of integer sequences was introduced, as a generalization of the concept of increasing sequence, by Byers et al. (ANALCO'2011), and further studied by Istrate et al. (CPM'2015, DCFS'2016, MCU'2018), Porfilio (2015), Basdevant et al. (2018), etc.
In this work we extend the concept of heapability to partial orders, and investigate the Ulam-Hammersley problem for heapable sequences, i.e. the partitioning of partial orders into a minimal number of heapable subsets. We prove a characterization result reminiscent of the proof of Dilworth?s theorem, which yields as a byproduct a flow-based algorithm for computing such a minimal decomposition. On the other hand, in the particular case of sets and sequences of intervals we prove that this minimal decomposition can be computed by a simple greedy-type algorithm. We give a couple of open problems related to the Ulam-Hammersley problem for decompositions of sets and sequences of random intervals into heapable sets.

This is joint work with J. Balogh (Szeged), C. Bonchiş and D. Diniş (Timişoara) and I. Todinca (Orleans).

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28 — Section IV — Room D — 14:05 - 14:25

Online matching on the line with recourse

LUKAS NÖLKE (Bremen)

In the online matching problem on the line, n requests appear online and have to be matched, irrevocably and upon arrival, to a given set of servers, all on the real line. The goal is to minimize the sum of distances from the requests to their respective servers. Despite all research efforts, it remains as an intriguing open problem whether there exists a constant-competitive online algorithm. The best known online algorithm, due to Raghvendra (SOCG 2018), achieves a competitive factor of $O(\log n)$. There exists a matching a lower bound of $\Omega(\log n)$ (Antoniadis et al., LATIN 2018) that holds for a quite large class of online algorithms, including all known deterministic algorithms in the literature. The best known general lower bound is $9 + \varepsilon$ (Fuchs et al., TCS 2005).
In this work, we consider the increasingly popular online recourse model and show that a constant competitive factor is possible if we allow to revoke online decisions to some extent. More precisely, we derive an $O(1)$-competitive algorithm for online minimum matching on the line that rematches each of the n requests at most $O(\log n)$ times. For special instances, where no more than one request appears between two servers, we obtain a substantially better result. We give a $(1+\varepsilon)$-competitive algorithm with $O_\varepsilon(1)$ recourse actions per request. Incidentally, the construction of the aforementioned $\Omega(\log n)$ lower bound uses such instances.

This is joint work with Nicole Megow.

Friday, 8 Nov. 2019 — Time: 14:30 - 14:50

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29 — Section I — Room A — 14:30 - 14:50

The subdivision of Ramsey minimal graphs of matching versus path on five vertices

KRISTIANA WIJAYA (Jember)

For given graphs G and H, we write $F \to (G, H)$ to mean that every red-blue coloring of edges of F contains a red copy of G or a blue copy of H. A graph F (without isolated vertices) is called a *Ramsey* (G, H)*-minimal graph* if it satisfies the following two conditions: (i) $F \to (G, H)$ and (ii) $(F - e) \nrightarrow (G, H)$, for each $e \in E(F)$. The set of all Ramsey (G, H)-minimal graphs is called the *Ramsey set* $\mathcal{R}(G, H)$.
In this paper, we construct a new Ramsey (mK_2, P_5)-minimal graph $F(e, 5)$, by subdivision of a Ramsey $((m-1)K_2, P_5)$-minimal graph F as follows. Let $e = uv$ be a non-pendant edge of a Ramsey $((m-1)K_2, P_5)$-minimal graph F. We prove that if $F \in \mathcal{R}((m-1)K_2, P_5)$ then the graph $F(e, 5)$ is belonging to $\mathcal{R}(mK_2, P_5)$, where $F(e, 5)$ is a graph obtained by subdividing a non-pendant edge e of F, with 5 new vertices $w_1, w_2, \cdots, w_5$ (instead of the non-pendant edge $e = uv$ we put a path $(u, w_1, w_2, \ldots, w_5, v)$).

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30 — Section II — Room B — 14:30 - 14:50

Short cycle covers of graphs

ROBERT LUKOŤKA (Bratislava)

A cycle cover of a graph is a collection of cycles such that each edge of the graph is contained in at least one of the cycles. The length of a cycle cover is the sum of all cycle lengths in the cover. We present several results on short cycle covers of graphs. Let G be a bridgeless graph with m edges. If G is cubic, then it has a cycle cover of total length at most $1.570m$. If G is of minimal degree three, then it has cycle cover of length at most $1.589m$ Finally, if G has at most n_2 vertices of degree two, then it has cycle cover of length less than $1.6148m + 0.0741n_2$. The last result beats the current best general bound of $5/3 \cdot m$ whenever $n_2 < 0.7m$.

31 — Section III — Room C — 14:30 - 14:50

Bounded distance equivalence in substitution tilings

DIRK FRETTLÖH (Bielefeld)

Delone sets are discrete point sets in the plane where (1) points do not come arbitrarily close together, and (2) there are no arbitrarily large holes. Two Delone sets are called “bounded distance equivalent” (bde) if there is a perfect matching between them such that the distance between matched points is uniformly bounded. This talk presents uncountably many Delone sets of the same density that are pairwise not bde to each other.

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32 — Section IV — Room D — 14:30 - 14:50

EPTAS for machine-scheduling with bag-constraints

KILIAN GRAGE (Kiel)

Machine scheduling is a fundamental optimization problem in computer science. The task of scheduling a set of jobs on a given number of machines and minimizing the makespan is well studied and among other results, we know that EPTAS's for machine scheduling on identical machines exist. Das and Wiese initiated the research on a generalization of makespan minimization, that includes so called bag-constraints. In this variation of machine scheduling the given set of jobs is partitioned into subsets, so called bags. Given this partition a schedule is only considered feasible when on any machine there is at most one job from each bag.
Das and Wiese showed that this variant of machine scheduling admits a PTAS. We will improve on this result by giving the first EPTAS for the machine scheduling problem with bag-constraints. We achieve this result by using new insights on this problem and restrictions given by the bag-constraints. We show that, to gain an approximate solution, we can relax the bag-constraints and ignore some of the restrictions. Our EPTAS uses a new instance transformation that will allow us to schedule large and small jobs independently of each other for a majority of bags. We also show that it is sufficient to respect the bag-constraint only among a constant number of bags, when scheduling large jobs. With these observations our algorithm will allow for some conflicts when computing a schedule and we show how to repair the schedule in polynomial-time by swapping certain jobs around.

Saturday, 9 Nov. 2019 — Time: 08:45 - 09:05

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33 — Section I — Room A — 08:45 - 09:05

Snarks with small circular flow number

DAVIDE MATTIOLO (Modena)

Given a real number $r \geq 2$, a *circular nowhere-zero r-flow*, or r-CNZF, in a graph G is a pair (D, f) where D is an orientation of G and $f\colon E(G) \to [1, r-1]$ such that, for all $x \in V(G)$, the sum of all incoming flow values equals the sum of all outgoing ones in the chosen orientation D. The parameter $\Phi_c(G) = \inf\{r\colon G \text{ has an } r\text{-CNZF}\}$ is called *circular flow number* of G. The well known Tutte's 5-flow Conjecture claims that every bridgeless graph admits a nowhere-zero 5-flow and is equivalent to its restriction to snarks. In 2008 Lukot'ka and Škoviera proved that every non-3-edge-colorable connected bridgeless cubic graph G with $|V(G)| \leq 8k+4$ is such that $\Phi_c(G) \geq 4 + \frac{1}{k}$. Moreover they showed that Flower snarks J_{2k+1} are examples of cubic graphs of order $8k+4$ such that $\Phi_c(J_{2k+1}) = 4 + \frac{1}{k}$ and asked whether there are graphs of order $8k-2, 8k$ and $8k+2$ whose circular flow numbers meet this general lower bound. We present an infinite family of snarks of order $8k+2$ having such a property.

This is a joint work with Jan Goedgebeur (Ghent University) and Giuseppe Mazzuoccolo (University of Verona).

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34 — Section II — Room B — 08:45 - 09:05

Majority colorings of sparse digraphs

RAPHAEL STEINER (Berlin)

A *majority coloring* of a directed graph is a vertex-coloring in which every vertex has the same color as at most half of its out-neighbors. Kreutzer, Oum, Seymour, van der Zypen and Wood proved that every digraph has a majority 4-coloring and conjectured that every digraph admits a majority 3-coloring. We verify this conjecture for digraphs D which admit a vertex-partition X_1, X_2, X_3 such that $D[X_i]$ contains no odd directed cycles. Therefore every digraph with chromatic number at most 6 or dichromatic number at most 3 is majority 3-colorable. For digraphs of dichromatic number 2, we verify a more general conjecture by Girão, Kittipassorn and Popielarz.
We obtain analogous results for list coloring: Every digraph with list chromatic number at most 6 or list dichromatic number at most 3 is majority 3-choosable. We conclude that r-regular digraphs are majority 3-choosable for all $r \leq 4$. On the way to these results we investigate digraphs admitting a majority 2-coloring. We show that every digraph without odd directed cycles is majority 2-choosable.

We answer an open question by Kreutzer et al. negatively, by showing that deciding whether a given digraph is majority 2-colorable is NP-complete.
Finally we deal with a fractional relaxation of majority coloring proposed by Kreutzer et al. and show that every digraph has fractional majority chromatic number at most 3.973. We show that every digraph D with minimum out-degree at least $C(1/\varepsilon)^2 \ln(1/\varepsilon)$ has a fractional $(2+\varepsilon)$-majority-coloring.

Joint work with Michael Anastos, Ander Lamaison and Tibor Szabó.

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35 — Section III — Room C — 08:45 - 09:05

Node-shellings of Euclidean oriented matroids

MICHAEL WILHELMI (Hagen)

We prove that a lexicographical extension of a Euclidean oriented matroid remains Euclidean. Based on that result we show that in a Euclidean oriented matroid program there exists a topological sweep inducing a recursive atom-ordering (a shelling of the cocircuits) of the tope cell of the feasible region. We conjecture that sweep being also a node-shelling of the whole oriented matroid and finally describe some connections to the simplicial tope conjecture.

This is joint work with Winfried Hochstättler.

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36 — Section IV — Room D — 08:45 - 09:05

Mixed fault-tolerant metric generators

UZMA AHMAD (Lahore)

For a connected graph Q and $M = \{m_1, m_2, \cdots, m_k\}$ a subset of $V(Q)$, if for two distinct vertices $t_1, t_2 \in V(Q)$, there exists $z \in M$ such that $d(t_1, z) \neq d(t_1, z)$ then M is called metric resolving set for the graph Q. Among many variants of metric resolving set, one is mixed metric generator. For a graph Q, a subset $M \subseteq V(Q)$ is referred as mixed metric generator, if distance vectors of any two members of $V(Q) \cup E(Q)$ are distinct. The vertices of minimum metric generating set can be considered as censors. In this scenario, if one of the censors fails to work correctly then the remaining censors will not uniquely distinguish all places/stations and will not provide sufficient information to deal the problem. The concept of fault-tolerant metric dimension can be used to overcome this type of situation. Fault-tolerant generating set deliver accurate data in the case when some censors become inactivated for some reasons. Thus the fault-tolerant metric dimension has its impact and significance in all those disciplines where metric dimension plays important role. In this talk, the notion of mixed fault-tolerant metric generator is defined for mixed generator. The graphs having mixed fault-tolerant metric generator are characterized. The mixed fault-tolerant metric resolving set for a graph with girth at least 4 is also determined.

Saturday, 9 Nov. 2019 — Time: 09:10 - 09:30

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37 — Section I — Room A — 09:10 - 09:30

Planar hypohamiltonian oriented graphs

CAROL T. ZAMFIRESCU (Ghent)

Motivated by questions of Hahn and Zamfirescu, Schiermeyer, as well as Thomassen, we discuss new methods for constructing hypohamiltonian digraphs. Combining these with graph generation algorithms, we fully characterise the orders for which planar hypohamiltonian oriented graphs exist. We also present the planar hypohamiltonian oriented graph of smallest order and size, infinitely many hypohamiltonian orientations of maximal planar graphs, and a planar hypohamiltonian oriented graph whose underlying graph has minimum degree 5. Finally, we characterise all the orders for which planar hypotraceable oriented graphs exist.

The talk is based on joint work with Alewyn P. Burger, Marietjie Frick, Johan P. de Wet, and Nico Van Cleemput.

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38 — Section II — Room B — 09:10 - 09:30

Strong and weak perfect digraph theorems for perfect, α-perfect and strictly perfect digraphs

STEPHAN DOMINIQUE ANDRES (Hagen)

We consider *perfect digraphs* introduced by Andres and Hochstättler and the dual notion, *α-perfect digraphs*, which are the complements of perfect digraphs. We define a digraph to be *strictly perfect* if it is perfect and α-perfect.
In order to prove the Weak Perfect Graph Theorem, Lovász proved that a graph G is perfect if and only if for every induced subgraph H of G

$$\alpha(H)\omega(H) \geq |V(H)|, \tag{1}$$

where α denotes the stability number and ω the clique number of H. For perfect and α-perfect digraphs we define appropriate parameters and obtain conditions similar to (1) by applying the Strong Perfect Graph Theorem.
Using the Strong Perfect Graph Theorem, Andres and Hochstättler characterised perfect digraphs by forbidden induced subdigraphs. As another application of the Strong Perfect Graph Theorem we obtain such characterisations for α-perfect and strictly perfect digraphs.

39 — Section III — Room C — 09:10 - 09:30

Power sum polynomials in a discrete tomography perspective

SILVIA M.C. PAGANI (Brescia)

For a point $P = (p_1, \ldots, p_{n+1})$ of PG(n, q), the corresponding Rédei factor is defined as the linear polynomial $p_1X_1 + \ldots + p_{n+1}X_{n+1}$. Given a pointset $S \subseteq$ PG(n, q), its Rédei polynomial is set as the product of the Rédei factors corresponding to the points of S, while the power sum polynomial is the sum of the $(q-1)$-th powers of the Rédei factors. There is an one-to-one correspondence between Rédei polynomials and pointsets; on the contrary, many different pointsets may share the same power sum polynomial.
In the present talk I will link the problem of characterizing the pointsets of PG$(2, q)$ having the same power sum polynomial to the well-known uniqueness problem of discrete tomography, and will show how techniques of the latter research field may provide new insights into the first one. In particular, the structure of the counterpart of the switching components, which are responsible of the ambiguities in the tomographic reconstruction, will be described.

This is a joint work with Silvia Pianta (UniCatt).

40 — Section IV — Room D — 09:10 - 09:30

Near-linear approximation algorithms for scheduling problems with batch setup times

MAX A. DEPPERT (Kiel)

We investigate the scheduling of n jobs divided into c classes on m identical parallel machines. For every class there is a setup time which is required whenever a machine switches from the processing of one class to another class. The objective is to find a schedule that minimizes the makespan. We give near-linear approximation algorithms for the following problem variants: the non-preemptive context where jobs may not be preempted, the preemptive context where jobs may be preempted but not parallelized, as well as the splittable context where jobs may be preempted and parallelized.
We present the first algorithm improving the previously best approximation ratio of 2 to a better ratio of $3/2$ in the preemptive case. In more detail, for all three flavors we present an approximation ratio 2 with running time $\mathcal{O}(n)$, ratio $3/2 + \epsilon$ in time $\mathcal{O}(n \log 1/\epsilon)$ as well as a ratio of $3/2$. The $(3/2)$-approximate algorithms have different running times. In the non-preemptive case we get time $\mathcal{O}(n \log(n + \Delta))$ where Δ is the largest value of the input. The splittable approximation runs in time $\mathcal{O}(n + c \log(c + m))$ whereas the preemptive algorithm has a running time $\mathcal{O}(n \log(c + m)) \leq \mathcal{O}(n \log n)$. So far, no PTAS is known for the preemptive problem without restrictions, so we make progress towards that question. Recently Jansen et al. found an EPTAS for the splittable and non-preemptive case but with impractical running times exponential in $1/\epsilon$.

This is joint work with Klaus Jansen.

Saturday, 9 Nov. 2019 — Time: 09:35 - 09:55

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41 — Section I — Room A — 09:35 - 09:55

Reduction of the Berge-Fulkerson conjecture to cyclically 5-edge-connected snarks

GIUSEPPE MAZZUOCCOLO (Verona)

The Berge-Fulkerson conjecture, originally formulated in the language of mathematical programming, asserts that the edges of any bridgeless cubic graph can be covered with six perfect matchings in such a way that every edge is in exactly two of them. As with several other classical conjectures in graph theory, any counterexample to the Berge-Fulkerson conjecture must be a non 3-edge-colorable cubic graph. By contrast to Tutte's 5-flow conjecture and the cycle double cover conjecture, no additional condition other than trivial ones is known for the Berge-Fulkerson conjecture. In the present paper, we prove that a possible minimum counterexample to the conjecture must be cyclically 5-edge-connected.

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42 — Section II — Room B — 09:35 - 09:55

What is a 'Directed Tree'?

SEBASTIAN WIEDERRECHT (Berlin)

Treewidth is a graph invariant generalising acyclicity, or tree-likeness, of graphs in a way that can be used to obtain nice structural and algorithmic results. The great success of treewidth has inspired many generalisations of its base ideas to other combinatorial structures like hypergraphs, directed graphs and matroids. We explore the connection between directed treewidth and hypertree-width and give answers to the question in what way directed treewidth generalises acyclicity in digraphs. To do this we provide characterisations of strongly connected digraphs of directed treewidth one, a class that can be seen as the directed version of trees.

43 — Section III — Room C — 09:35 - 09:55

Graßmann meets Macaulay: apolarity for catalecticants

CORNELIUS BRAND (Prague)

Let n be a positive natural number. Let $R_n = \mathbb{C}[X_1, \ldots, X_n]$ be the complex polynomial algebra in n variables, and let Λ_n be the complex exterior algebra on n generators. For $i = 1, \ldots, n$, we define $\partial_i : R_n \to R_n, f \mapsto \frac{\partial f}{\partial X_i}$.
The *algebra of differential operators* D_n is the subalgebra of $\mathrm{End}(R_n)$ generated by $\{\partial_i\}_{i=1,\ldots,n}$. D_n is canonically isomorphic to R_n via $X_i \leftrightarrow \partial_i$.
Given $f \in R_n$, the set of differential operators that send f to zero is an ideal of D_n, called the *apolar* ideal of f. The quotient of D_n by this ideal is called the *apolar* algebra of f.
A *Hankel matrix* is an $n \times n$ matrix (h_{ij}) that is constant along the anti-diagonals, that is, $h_{ij} = x_{i+j-1}$ for some entries $x_1, \ldots, x_{2n-1}$. The determinant of a Hankel matrix is is called a *catalecticant*.
Motivated by algorithmic applications given by Pratt (FOCS'19) (e.g. the subgraph isomorphism problem), we study the apolar ideals of determinants of the Hankel matrices $H_n \in R_{2n-1}^{n\times n}$ with indeterminate entries $h_{ij} = X_{i+j-1} \in R_{2n-1}$. We write $\kappa_n = \det H_n \in R_{2n-1}$.
We exhibit an isomorphism of the quotient of D_{2n-1} by the apolar ideal of κ_n generated in degree two and a different algebra recently used algorithmically in work by B., Dell and Husfeldt and B. (STOC'18, ESA'19). This is the subalgebra G of $\Lambda_n \otimes \Lambda_n$ generated by the set of orthogonal projections onto the rational normal curve in $\mathbb{C}^n$, understood as rank one tensors. We construct a Grbner basis of the kernel of the corresponding epimorphism $R \to G$.

44 — Section IV — Room D — 09:35 - 09:55

Near-linear time algorithm for n-fold ILPs via color coding

ALEXANDRA LASSOTA (Kiel)

We study an important case of ILPs $\max\{c^T x \mid \mathcal{A}x = b, l \leq x \leq u,\, x \in \mathbb{Z}^{nt}\}$ with $n \cdot t$ variables and lower and upper bounds $\ell, u \in \mathbb{Z}^{nt}$. In n-fold ILPs non-zero entries only appear in the first r rows of the matrix $\mathcal{A}$ and in small blocks of size $s \times t$ along the diagonal underneath. Despite this restriction many optimization problems can be expressed in this form. It is known that n-fold ILPs can be solved in FPT time regarding the parameters s, r, and Δ, where Δ is the greatest absolute value of an entry in $\mathcal{A}$. The state-of-the-art technique is a local search algorithm that subsequently moves in an improving direction. Both, the number of iterations and the search for such an improving direction take time $\Omega(n)$, leading to a quadratic running time in n. We introduce a technique based on Color Coding, which allows us to compute these improving directions in logarithmic time after a single initialization step. This leads to the first algorithm for n-fold ILPs with a running time that is near-linear in the number $n \cdot t$ of variables, namely $(rs\Delta)^{O(r^2 s + s^2)} L^2 \cdot nt \log^{O(1)}(nt)$, where L is the encoding length of the largest integer in the input.

This is conjoint work with Klaus Jansen and Lars Rohwedder.

Saturday, 9 Nov. 2019 — Time: 10:00 - 10:20

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45 — Section I — Room A — 10:00 - 10:20

Some results and problems on unique-maximum colorings of plane graphs

RISTE ŠKREKOVSKI (Ljubljana)

A unique-maximum coloring of a plane graph G is a proper vertex coloring by natural numbers such that each face α of G satisfies the propety: the maximal color that appears on α, appears precisely on one vertex of α (or shortly, the maximal color on every face is unique on that face). Fabrici and Göring proved that six colors are enough for any plane graph and conjectured that four colors suffice. Thus, this conjecture is a strengthening of the Four Color Theorem. Wendland later decreased the upper bound from six to five.
We first show that the conjecture holds for various subclasses of planar graphs but then we disprove it for planar graphs in general. Thus, the facial unique-maximum chromatic number of the sphere is not four but five. In the second part of the talk, we will consider various new directions and open problems.

(Joint work with Vesna Andova, Bernard Lidický, Borut Lužar, and Kacy Messerschmidt)

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46 — Section II — Room B — 10:00 - 10:20

Vertex labeling of graphs with interval representations

MEHMET AKIF YETIM (Isparta)

For non-negative integers p and q, an $L(p, q)$-*labeling* of a graph G is a labeling of its vertices with non-negative integers such that adjacent vertices receive labels with difference at least p and the vertices at distance 2 from each other get labels with difference at least q. The *span* of an $L(p, q)$-labeling of G is the difference between the smallest and the largest label used. $L(p, q)$-*labeling number* $\lambda_{p,q}(G)$ of G is the least integer k such that G admits an $L(p, q)$-labeling with span k. In this talk, we provide upper bounds on the $L(p, q)$-labeling number of graphs which have interval (or circular-arc) representations via simple greedy algorithms. Our results yield first known upper bounds on the number $\lambda_{p,q}$ for interval k-graphs, permutation graphs and cointerval graphs, while they improve existing bounds on $L(p, q)$-labeling of interval and circular arc graphs and $L(2, 1)$-labeling of permutation graphs. As a by-product, we achieve upper bounds on the chromatic number of squares of graphs we consider.

Some combinatorial results for the partial transformation monoid

ABDULLAHI UMAR (Abu Dhabi)

ABSTRACT. It is now established that counting certain natural equivalence classes in various semigroups of partial transformations of an *n*-set, leads to very interesting enumeration problems. Many numbers and triangle of numbers regarded as combinatorial gems like the *Fibonacci number, Catalan number, Schröder number, Stirling numbers, Eulerian numbers, Narayana numbers, Lah numbers,* etc., have all featured in these enumeration problems.
These enumeration problems lead to many numbers and triangle of numbers in the Online encyclopaedia of integer sequences (OEIS) but there are also others that are not yet or have just been recently recorded in OEIS.
In this talk, we are going to focus on the combinatorial (enumerative) aspects of the *partial transformation monoid*, $\mathcal{P}_n$ and its set of *idempotents*, $E(\mathcal{P}_n)$ where we obtain expressions for the combinatorial functions: $F(n; k, m, p, r)$ and $F(n; k, m, q, r)$ in $\mathcal{P}_n$ and $E(\mathcal{P}_n)$, respectively. Some consequences of these results are further discussed.

Saturday, 9 Nov. 2019 — Time: 10:50 - 11:10

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49 — Section I — Room A — 10:50 - 11:10

Lower bound on the length of a cycle cover of a cubic graph

EDITA MÁČAJOVÁ (Bratislava)

The well-known shortest cycle cover conjecture suggests that every bridgeless cubic G can have its edges covered with a collection of cycles of total length not exceeding $\frac{7}{5}|E(G)|$. This conjecture is particularly interesting for cubic graphs, where the largest known values of the ratio between the length of a shortest cycle cover and the number of edges occur. The covering ratio $7/5$ is best possible, being reached by the Petersen graph whose shortest cycle cover has length 21. There exist infinitely many cubic graphs with cyclic connectivity 2, as well as those with cyclic connectivity 3, whose covering ratio equals $7/5$. By contrast, all cyclically 4-edge-connected cubic graphs, where the length of a shortest cycle cover is known, have covering ratio close to $4/3$, which is a natural lower bound. In line with this observation, Brinkmannn et al. [J. Combin. Theory Ser. B **103** (2013), 468–488] made a conjecture that every cyclically 4-edge-connected cubic graph has a cycle cover of length at most $\frac{4}{3}m + o(m)$, where m is the number of edges. We disprove this conjecture by exhibiting an infinite family of cyclically 4-edge-connected cubic graphs G_n, $n \geq 1$, such that the length of a shortest cycle cover of each G_n is at least $(\frac{4}{3} + \frac{1}{69})|E(G_n)|$.

This is a joint work with Martin Škoviera

Separators in geometric graphs

THOMAS BÖHME (Ilmenau)

Let $G = (V, E)$ be a finite connected graph. For $x, y \in V$ let $d_G(x, y)$ denote the least number of edges in connected subgraph H of G with $x, y \in V(H)$. Clearly, (V, d_G) is a metric space. Let $\mathbb{E}^n$ denote the euclidean n-dimensional space. A mapping $\varphi : V \to \mathbb{E}^n$ is said to have *distortion* c if for any two vertices $x, y \in V$

$$d_G(x, y) \geq \|\varphi(x) - \varphi(y)\| \geq \frac{1}{c} \cdot d_G(x, y).$$

In [1] it is proved that if a graph $G = (V, E)$ permits a mapping $\varphi : V \to \mathbb{E}^n$ with distortion c such that $c \cdot n = o(|V|^{\frac{1}{n}})$, then there is a set $S \subseteq V$ of at most $O(c \cdot n \cdot |V|^{1-\frac{1}{n}})$ vertices such that no component of $G - S$ has more than $(1 - \frac{1}{n+1} + o(1))|V|$ vertices. The proof is probabilistic and based on an idea from [2]. Our main result is the following modification of the above result.

Theorem. For every positive integer n and every $c \geq 1$ there is a number $f(n, c)$ such that every graph $G = (V, E)$ that permits a mapping $\varphi : V \to \mathbb{E}^n$ with distortion c contains a set S of at most $f(n, c) \cdot |V|^{1-\frac{1}{n}}$ vertices such that no component of $G - S$ has more than $\frac{1}{2} \cdot |V|$ vertices. The proof is deterministic and gives rise to a polynomial time algorithm. While the factor $f(n, c)$ is worse than in the result from [1], the upper bound for the size of a component of $G - S$ does not depend on the dimension n.

[1] Linial, Nathan; London, Eran; Rabinovich, Yuri, “The Geometry of Graphs and Some of its Algorithmic Applications”, Combinatorica 15(2): 215 – 245 (1995).

[2] Miller, Gary L.; Thurston, William, “Separators in two and three dimensions”, STOC 22: 200 – 209 (1990).

51 — Section III — Room C — 10:50 - 11:10

Design-theoretic aspects of vectorial bent functions

ALEXANDR A. POLUJAN (Magdeburg)

Let $\mathbb{F}_2 = \{0,1\}$ be a finite field and $\mathbb{F}_2^n$ be an n-dimensional vector space over $\mathbb{F}_2$. Boolean functions $f\colon \mathbb{F}_2^n \to \mathbb{F}_2$ (n is necessarily even), which lie at the maximum Hamming distance from the set of all affine functions, are called *Boolean bent functions*.
There are two construction methods of 2-$(2^n, 2^{n-1} \pm 2^{n/2-1}, 2^{n-2} \pm 2^{n/2-1})$ designs from Boolean bent functions $f\colon \mathbb{F}_2^n \to \mathbb{F}_2$, known in the literature as *translation designs* and *addition designs*. In this talk we discuss, how to construct translation and addition designs from *vectorial bent functions* $F : \mathbb{F}_2^n \to \mathbb{F}_2^m$, which are m-dimensional vector spaces of Boolean bent functions. We also explain why, similar to the Boolean case, isomorphism of addition designs and equivalence of vectorial bent functions, are the same concepts. Finally, we point out that translation designs of vectorial bent functions show slightly different behaviour than translation designs of Boolean bent functions.

This is joint work with Alexander Pott.

52 — Section IV — Room D — 10:50 - 11:10

Using SAT solvers in combinatorics and geometry

MANFRED SCHEUCHER (Berlin)

In this talk, we discuss how modern SAT solvers such as Minisat, Glucose, or Picosat can be used to tackle mathematical problems. We present some of our recent results on various problems to give the audience a better understanding, which problems might be tackled in this fashion, and which problems might not.
Besides the naive SAT formulation also further ideas might be required to tackle certain problems – additional constraints (such as statements which hold "without loss of generality") might need to be added to the SAT model so that is becomes solvable in reasonable time. In particular, to tackle universal point sets for planar graphs, we present a sophisticated approach which combines the following four powerful tools: complete enumeration of order types, complete enumeration of (planar) graphs, SAT solvers, and IP solvers.

Literature:

K. Däubel, S. Jäger, T. Mütze, and M. Scheucher. *On orthogonal symmetric chain decompositions.* In Proc. EuroComb 2019.
T. Mütze and M. Scheucher. *On L-shaped Point Set Embeddings of Trees: First Non-embeddable Examples.* In Proc. Graph Drawing 2018.
M. Scheucher. *On Disjoint Holes in Point Sets.* In Proc. EuroComb 2019.
M. Scheucher, H. Schrezenmaier, and R. Steiner. *A Note On Universal Point Sets for Planar Graphs.* In Proc. Graph Drawing 2019.

Saturday, 9 Nov. 2019 — Time: 11:15 - 11:35

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53 — Section I — Room A — 11:15 - 11:35

Regular 1-factorizations of complete graphs and decompositions into pairwise isomorphic rainbow spanning trees

GLORIA RINALDI (Modena)

The number of non-isomorphic $1-$factorizations of a complete graph explodes as the number of vertices increases, and a general classification seems impossible to achieve. An attempt can be done if one imposes additional conditions either on the $1-$factorization or on its automorphism group. For example, a precise description of the $1-$factorization and of its automorphism group is available when the group is assumed to act multiply transitively on the vertex set. Few years ago the following question was addressed: *"Does there exist a $1-$factorization of the complete graph K_{2n} admitting a prescribed group G as an automorphism group acting sharply transitively on the vertex–set of K_{2n}?* The $1-$factorization is said *G-regular* in this case. When n is odd G must be the semi-direct product of Z_2 with its normal complement and G always realizes a G-regular $1-$factorization. When n is even, the complete answer is still unknown. Several authors tested some classes of groups, and among these, the unique case in which the answer is negative is when G is cyclic and $2n$ is a power of 2 greater than 4 (Hartman and Rosa 1985). In this talk we consider the possibility of finding complete sets of rainbow spanning trees in G-regular $1-$factorizations. We see that for each group G of order twice an odd number, a G-regular $1-$factorization possessing a complete set of isomorphic rainbow spanning trees always exists. When G is either a cyclic or a dihedral group, a G-regular $1-$factorization with a complete set of rainbow spanning trees exists as well.

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54 — Section II — Room B — 11:15 - 11:35

On the deficiency of complete multipartite graphs

ARMEN R. DAVTYAN (Yerevan)

An edge-coloring of a graph G with colors $1,\ldots,t$ is an *interval t-coloring* if all colors are used, and the colors of edges incident to each vertex of G are distinct and form an integral interval. It is well-known that there are graphs that do not have interval colorings. The *deficiency* of a graph G, denoted by $\mathrm{def}(G)$, is the minimum number of pendant edges whose attachment to G leads to a graph admitting an interval coloring. In this talk we consider the problem of determining or bounding of the deficiency of complete multipartite graphs. In particular, we obtain a tight upper bound for deficiency of complete multipartite graphs. We also determine or bound the deficiency for some classes of complete multipartite graphs.
This is joint work with Gevorg Minasyan and Petros Petrosyan.

55 — Section III — Room C — 11:15 - 11:35

Some incidence structures within q-analogs

KRISTIJAN TABAK (Zagreb)

We define two incidence structures $\mathcal{B}_{min}$ and $\mathcal{B}_{max}$ within putative 2-analog of a Fano plane. The first containes blocks (of 2-analog of a Fano plane) that contain one point, while the second containes blocks (subgroups) of a maximal subgroup of E_{2^7}. Usinge a concept of group development we analyze their incidence matrices and prove some of their properties.

56 — Section IV — Room D — 11:15 - 11:35

Polynomial-time preprocessing for weighted problems beyond additive goal functions

TILL FLUSCHNIK (Berlin)

Kernelization is the fundamental notion for polynomial-time preprocessing with performance guarantees in parameterized algorithmics. When preprocessing weighted problems, the need of shrinking weights might arise. Marx and Végh [ACM Trans. Algorithms 2015] and Etscheid et al. [J. Comput. Syst. Sci. 2017] used a technique due to Frank and Tardos [Combinatorica 1987] that we refer to as *losing-weight technique* to obtain kernels of polynomial size for weighted problems. While the mentioned earlier works focus on problems with additive goal functions, we focus on a broader class of goal functions. We lift the losing-weight technique to what we call *linearizable* goal functions, which also contain non-additive functions. We apply the lifted technique to five exemplary problems, thereby improving two results from the literature by proving polynomial kernels.

This is joint work with Matthias Bentert, René van Bevern, André Nichterlein, and Rolf Niedermeier.

A full version of the paper is available at `https://arxiv.org/abs/1910.00277`.

Saturday, 9 Nov. 2019 — Time: 11:40 - 12:00

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57 — Section I — Room A — 11:40 - 12:00

Decompose a graph into two disjoint cycles

SHIN-SHIN KAO (Tao-Yuan City)

Consider a simple and undirected graph G. A set of subgraphs of G is disjoint if no two of them share a common vertex in G. Let $|G| = n$ be the total number of vertices in G. For $i \in \{1, 2\}$, let n_i be an integer with $n_i \geq 3$, and $n_1 + n_2 = n$. Let $\bar{e}(G)$ be the number of edges in the complement of G. We prove that if $\bar{e}(G) \leq n - 3$, then G contains two disjoint cycles with lengths n_1 and n_2. The bound $n - 3$ is sharp.

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58 — Section II — Room B — 11:40 - 12:00

On locally-balanced k-partitions of graphs

ARAM H. GHARIBYAN (Yerevan)

A *k-partition* of a graph G is a function $f : V(G) \to \{0, 1, \ldots, k-1\}$. A k-partition f of a graph G is *locally-balanced with an open neighborhood* if for every $v \in V(G)$ and for any $0 \leq i < j \leq k-1$,

$$||\{u \in N_G(v) \colon\ f(u) = i\}| - |\{u \in N_G(v) \colon\ f(u) = j\}|| \leq 1,$$

where $N_G(v) = \{u \in V(G) \colon\ uv \in E(G)\}$. The minimum number k for which G has a locally-balanced k-partition with an open neighborhood is called *lb-open chromatic number* of G and denoted by $\chi_{(lb)}(G)$. A k-partition f' of a graph G is *locally-balanced with a closed neighborhood* if for every $v \in V(G)$ and for any $0 \leq i < j \leq k-1$,

$$||\{u \in N_G[v] \colon\ f'(u) = i\}| - |\{u \in N_G[v] \colon\ f'(u) = j\}|| \leq 1,$$

where $N_G[v] = N_G(v) \cup \{v\}$. The minimum number k for which G has a locally-balanced k-partition with a closed neighborhood is called *lb-closed chromatic number* of G and denoted by $\chi_{[lb]}(G)$. In this talk we present some upper bounds on lb-open and lb-closed chromatic numbers of graphs. Next we give some necessary conditions for the existence of locally-balanced k-partitions of regular graphs. We also consider the connections between lb-open and lb-closed chromatic numbers and other graph parameters.
This is joint work with Petros Petrosyan.

59 — Section III — Room C — 11:40 - 12:00

A lower bound on the number of CCZ-inequivalent APN functions

CHRISTIAN KASPERS (Magdeburg)

A function f on $\mathbb{F}_{2^n}$ is called *almost perfect nonlinear* (APN) if for all $a, b \in \mathbb{F}_{2^n}$, where $a \neq 0$, the equation $f(x+a) + f(x) = b$ has at most two solutions. Two functions f, g on $\mathbb{F}_{2^n}$ are called *CCZ-equivalent* if there exists an affine permutation on $\mathbb{F}_{2^n} \times \mathbb{F}_{2^n}$ that maps the graph of f onto the graph of g. CCZ-equivalence preserves the APN property. Multiple infinite families of APN functions are known, however, most of them depend on only one parameter and thus, lead to a very limited number of CCZ-inequivalent functions. In 2013, Pott and Zhou presented an infinite family of APN functions $f_{k,s}$ on $\mathbb{F}_{2^{2m}}$, where m is even, depending on two parameters k and s. It has not been known, however, which of these functions within the family are CCZ-inequivalent.
In this talk, we show that two Pott-Zhou APN functions $f_{k,s}$ and $f_{\ell,t}$ are CCZ-inequivalent if $k \neq \ell$ and $s \neq t$, where $0 \leq k, s \leq \frac{m}{2}$. We use this result to establish a lower bound on the total number of CCZ-inequivalent APN functions on $\mathbb{F}_{2^{2m}}$, where m is even. Moreover, we present the order of the automorphism group of the Pott-Zhou APN function.

This is joint work with Yue Zhou.

60 — Section IV — Room D — 11:40 - 12:00

Simple, distributed, and powerful - improving local search for distributed resource allocation and equilibrium computation

ALEXANDER SKOPALIK (Enschede)

We study variant of simple local search algorithms for general resource allocation problems with a diseconomy of scale or congestion games. Here, we are given a finite set of commodities or players that request certain resources. The cost of each resource grows super-linearly with the demand for it and our goal is to minimize the total costs of the resources. We show that for mildly growing cost functions a simple modification of a local search algorithm guarantees a approximation factor that is close to the best known centralized algorithm [Makarychev, Srividenko FOCS14]. Moreover, our technique has interesting game theoretic implications: On the one hand, the algorithmic technique can be used for a significant improvement in the computation of approximate pure Nash equilibria. For example for linear cost functions it improves the factor from $2 + \epsilon$ [Caragiannis et al. FOCS11] to $1.54 + \epsilon$. On the other hand, it exhibits a method to influence the strategic behavior of selfish agents to increase efficiency by pricing or taxing.

Saturday, 9 Nov. 2019 — Time: 12:05 - 12:25

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61 — Section I — Room A — 12:05 - 12:25

On super edge-magic deficiency of graphs

ANAK AGUNG GEDE NGURAH (Malang)

A graph G of order p and size q is called *super edge-magic* if there exists a bijection $f : V(G) \cup E(G) \longrightarrow \{1, 2, 3, \ldots, p + q\}$ such that $f(V(G)) = \{1, 2, 3, \ldots, p\}$ and $f(x) + f(xy) + f(y)$ is a constant for every edge $xy \in E(G)$. Furthermore, the *super edge-magic deficiency* of G is either the smallest nonnegative integer n such that $G \cup nK_1$ is super edge-magic or $+\infty$ if there exists no such integer n. In this talk, we present some results on the super edge-magic deficiency of join product and 2-regular graphs.

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62 — Section II — Room B — 12:05 - 12:25

Characterising k-connected sets in infinite graphs

KARL HEUER (Berlin)

While the connectivity of a graph is a global invariant, even graphs of low connectivity might contain objects that are highly connected in a certain way. One such type of highly connected objects are k-connected sets:
Given a graph G we define a *k-connected set*, where $k > 0$ is an integer, to be a vertex set $X \subseteq V(G)$ such that any two of its subsets of the same size $\ell \leq k$ can be connected by ℓ disjoint paths in G.
For finite graphs the existence of k-connected sets has already been characterised in terms of unavoidable minors and via certain tree-decompositions, but for infinite graphs similar characterisations were not completely known. In this talk I will discuss our results and the involved proof ideas. This includes a characterisation for the existence of k-connected sets of arbitrary but fixed infinite cardinality via the existence of certain minors and topological minors. In particular, I will address the difficulties occurring when dealing with singular instead of regular infinite cardinals. Moreover, we proved a duality theorem for the existence of such k-connected sets: if a graph contains no such k-connected set, then it has a tree structure which, whenever it exists, precludes the existence of such a k-connected set.
This talk is based on joint work with J. Pascal Gollin.

63 — Section III — Room C — 12:05 - 12:25

The early Lothar Collatz and his $3n + 1$ problem

INGO ALTHÖFER (Jena)

We look at three related topics.

a) The Life of Lothar Collatz between 1933 and 1950, including his contributions to the Rocket Program at Peenemünde.

   Reference: I. Althöfer. Lothar Collatz zwischen 1933 und 1950, eine Teilbiographie. 3-Hirn-Verlag, 2019.

b) The $3n + 1$ Problem in Steps: 1932, 1937, 1952, 1986, 1988, and 2010 (the Lagarias book).

c) New Variants of the $3n + 1$ Problem.

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64 — Section IV — Room D — 12:05 - 12:25

Decompositions of flows on signed graphs without long barbells

MICHAEL SCHUBERT (Paderborn)

For unsigned graphs, Little, Tutte and Younger proved that any positive k-flow can be expressed as the sum of $k - 1$ non-negative 2-flows preserving the orientation. For signed graphs this theorem does not hold in general. However, in this talk we will extend this theorem to the class of signed graphs without long barbells. Furthermore, we will discuss some other kinds of flow decompositions on signed graphs.

This is joint work with You Lu, Rong Luo, Eckhard Steffen, and Cun-Quan Zhang.

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Speakers