COLLOQUIUM

ON

COMBINATORICS

KOLLOQUIUM ÜBER KOMBINATORIK

11/12 October 2024

UNIVERSITÄT
HEIDELBERG
ZUKUNFT
SEIT 1386

Dear combinatorialists,

It is my great pleasure to welcome you at Heidelberg University for the 41st Colloquium on Combinatorics – the second conference of this edition in Heidelberg! The Colloquium on Combinatorics was established in 1981 and has since been held annually (with the exceptions in 2005, 2020, and 2021) in eight cities throughout Germany. This conference is today an established conference in Germany covering all areas of Combinatorics and Discrete Mathematics in a broad sense, including combinatorial aspects in Algebra, Geometry, Optimization and Computer Science.

This year there are 60 participants. The program includes 38 contributed talks, organised in up to four parallel sessions, and four invited talks on a broad range of combinatorial topics.

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

Enjoy the conference!

Felix Joos

All **talks** will be in the Mathematikon (Im Neuenheimer Feld 205, 69120 Heidelberg)

Invited talks	:	Hörsaal
Contributed talks	:	Hörsaal, Seminar Rooms A, B, C
Coffee and snacks	:	Foyer (downstairs)
Registration desk	:	Foyer (ground floor)

The **registration desk** is open on Friday from 8:20 to 9:00 and on Saturday from 8:40 to 9:00.

The **dinner** will take place at the restaurant *Kulturbrauerei* (Leyergasse 6) on Friday at 19:00.

The restaurant can be reached by a 50-minute-walk or by bus and 9 minutes walk.

To go by bus, take line 31 (bound to Universitätsplatz) until Marstallstraße followed by a walk through the old town.

The closest bus and tram stop is *Bunsengymnasium* south of the Mathematikon.

There will be an **informal dinner** on Thursday evening at *Café Merlin* (Bergheimer Str. 85) starting at 18:30. Feel also free to join later once you arrive in Heidelberg.

A visit to the **Schloss Heidelberg** outside of the conference program is highly recommended.

Thursday, 10 October 2024

18:30 and later	*Informal dinner* at **Café Merlin** (Bergheimer Str. 85, Heidelberg)

Friday, 11 October 2024

08:20 - 09:00	*Registration*
08:50 - 09:00	*Opening*
09:00 - 10:00	**Julia Böttcher** “Graph Universality”
10:00 - 10:30	*Coffee break*
10:30 - 12:10	**Parallel sessions**
12:15 - 13:30	*Lunch*
14:00 - 15:00	**Torsten Mütze** “On Hamilton cycles in highly symmetric graphs”
15:00 - 15:30	*Coffee break*
15:30 - 17:10	**Parallel sessions**
19:00	*Dinner* at **Kulturbrauerei** (Leyergasse 6, Heidelberg)

Saturday, 12 October 2024

09:00 - 10:00	**Konstantinos Panagiotou** “Dispersion on the complete graph”
10:00 - 10:30	*Coffee break*
10:30 - 11:20	**Parallel sessions**
11:30 - 12:30	**Zdeněk Dvořák** “On density of flow-critical graphs ”
12:30 - 13:30	*Lunch and Farewell*

Detailed program on Friday, 11 October 2024

Time	Section I Hörsaal	Section II Seminar Room: A	Section III Seminar Room: B	Section IV Seminar Room: C
08:50 - 09:00	*Opening* **Hörsaal**			
09:00 - 10:00	**Julia Böttcher** Graph Universality **Hörsaal**			
10:00 - 10:30	*Coffee break*			
10:30 - 10:50	**S. Glock** **1** Tight Hamilton cycles with high discrepancy	**M. Kiermaier** **2** The paired construction for Boolean functions	**T. Hofmann** **3** The connectivity dimension of a graph	**A. Sagdeev** **4** General penny graphs are at most $43/18$-dense
10:55 - 11:15	**M. Kühn** **5** The H-removal process	**R. Lauff** **6** Facet-Hamiltonian cycles and rhombic strips	**L. Penso** **7** On the Dissociation Number	**C. Spiegel** **8** Extending the Continuum of Six-Colorings
11:20 - 11:40	**A. Strupp** **9** Generalizations of the diamond-free process	**A. Oertel** **10** 2-to-1 binomials from ovals and hyperovals	**O. Minevich** **11** Inverse Shortest Paths Problem on a Cycle	**Meike Weiß** **12** Strong graph embeddings of cubic 3-connected planar graphs and their relation to simplicial surfaces
11:45 - 12:05	**F. Kučerák** **13** Uniform Turán Densities and Coloring Palettes	**J. C. Dahlke** **14** Relating Smallest Separators	**S. de Vries** **15** On Inner Independence Systems	**X. Shu** **16** Four-coloring Eulerian triangulations of the torus
12:15 - 13:30	*Lunch*			

Detailed program on Friday, 11 October 2024

Time	Section I Hörsaal	Section II Seminar Room: A	Section III Seminar Room: B	Section IV Seminar Room: C
14:00 - 15:00	**Torsten Mütze** On Hamilton cycles in highly symmetric graphs **Hörsaal**			
15:00 - 15:30	*Coffee break*			
15:30 - 15:50	**M. Krone 17** Cut covers of acyclic digraphs	**Ö. Diner 18** Rainbow connectivity of multilayered random geometric graphs	**S. Brenner 19** The complexity of symmetry breaking in SAT	**K. Heuer 20** Infinite grids in digraphs
15:55 - 16:15	**M. Yıldız 21** Path decompositions of oriented graphs	**A. Espuny Díaz 22** Local resilience of random geometric graphs	**M. Lichter 23** Limitations of Affine Integer Relaxations for Solving Constraint Satisfaction Problems	**M. Pitz 24** Linked tree-decompositions of infinite graphs
16:20 - 16:40	**G. Santos 25** Spanning trees in dense oriented graphs	**J. Schrodt 26** Hitting times in the binomial random graph	**A. Lindermayr 27** The Power of Proportional Fairness for Non-Clairvoyant Scheduling under Polyhedral Constraints	**J. Kurkofka 28** Canonical graph decompositions and local separators: From coverings to a combinatorial theory
16:45 - 17:05	**M. Hamann 29** Hyperbolic digraphs	**Z. Smith 30** Factors and covers in the budget-constrained random graph process	**D. Rutschmann 31** Tight Bounds for Sorting Under Partial Information	**A. M. Limbach 32** Clique Dynamics and Triangular Covers
19:00	*Conference Dinner*			

Detailed program on Saturday, 12 October 2024

Time	Section I Hörsaal	Section II Seminar Room: A	Section III Seminar Room: B
09:00 - 10:00	**Konstantinos Panagiotou** Dispersion on the complete graph **Hörsaal**		
10:00 - 10:30	*Coffee break*		
10:30 - 10:50	**D. Rautenbach** **33** Degree Deviation and Spectral Radius	**F. Verciani** **34** Flips in colourful triangulations	**R. Akpanya** **35** Constructing face-transitive surfaces via cycle double covers induced by automorphism groups
10:55 - 11:15	**D. Stevanović** **36** Polynomial indicator of flat bands in crystal lattices	**A. Sgueglia** **37** Spanning spheres in Dirac hypergraphs	**J. van der Pol** **38** Triangles in graphs and geometries
11:30 - 12:30	**Zdeněk Dvořák** On density of flow-critical graphs **Hörsaal**		
12:30 - 13:30	*Lunch and Farewell*		

Invited talks

Zdeněk Dvořák	: On density of flow-critical graphs
Julia Böttcher	: Graph Universality
Torsten Mütze	: On Hamilton cycles in highly symmetric graphs
Konstantinos Panagiotou	: Dispersion on the complete graph

Contributed talks

Reymond Akpanya	: Constructing face-transitive surfaces via cycle double covers induced by automorphism groups
Sofia Brenner	: The complexity of symmetry breaking in SAT
Jonathan Christoph Dahlke	: Relating Smallest Separators
Öznur Yaşar Diner	: Rainbow connectivity of multilayered random geometric graphs
Alberto Espuny Díaz	: Local resilience of random geometric graphs
Stefan Glock	: Tight Hamilton cycles with high discrepancy
Matthias Hamann	: Hyperbolic digraphs
Karl Heuer	: Infinite grids in digraphs
Tobias Hofmann	: The connectivity dimension of a graph
Michael Kiermaier	: The paired construction for Boolean functions
Filip Kučerák	: Uniform Turán Densities and Coloring Palettes
Marcus Kühn	: The H-removal process
Jan Kurkofka	: Canonical graph decompositions and local separators: From coverings to a combinatorial theory
Maximilian Krone	: Cut covers of acyclic digraphs
Robert Lauff	: Facet-Hamiltonian cycles and rhombic strips
Moritz Lichter	: Limitations of Affine Integer Relaxations for Solving Constraint Satisfaction Problems
Anna Margarethe Limbach	: Clique Dynamics and Triangular Covers
Alexander Lindermayr	: The Power of Proportional Fairness for Non-Clairvoyant Scheduling under Polyhedral Constraints
Olga Minevich	: Inverse Shortest Paths Problem on a Cycle
Alexander Oertel	: 2-to-1 binomials from ovals and hyperovals
Lucia Draque Penso	: On the Dissociation Number
Max Pitz	: Linked tree-decompositions of infinite graphs
Jorn van der Pol	: Triangles in graphs and geometries
Daniel Rutschmann	: Tight Bounds for Sorting Under Partial Information
Dieter Rautenbach	: Degree Deviation and Spectral Radius

Arsenii Sagdeev	: General penny graphs are at most $43/18$-dense
Giovanne Santos	: Spanning trees in dense oriented graphs
Jonathan Schrodt	: Hitting times in the binomial random graph
Amedeo Sgueglia	: Spanning spheres in Dirac hypergraphs
Xichao Shu	: Four-coloring Eulerian triangulations of the torus
Zak Smith	: Factors and covers in the budget-constrained random graph process
Christoph Spiegel	: Extending the Continuum of Six-Colorings
Dragan Stevanović	: Polynomial indicator of flat bands in crystal lattices
Amelie Strupp	: Generalizations of the diamond-free process
Francesco Verciani	: Flips in colourful triangulations
Sven de Vries	: On Inner Independence Systems
Meike Weiß	: Strong graph embeddings of cubic 3-connected planar graphs and their relation to simplicial surfaces
Mehmet Akif Yıldız	: Path decompositions of oriented graphs

Friday, 11 Oct. 2024 — Time: 09:00 - 10:00 — Hörsaal

Graph Universality

JULIA BÖTTCHER (LSE)

Given a class G of n-vertex graphs, how can we construct a host graph H that contains them all as subgraphs? Graphs H with this property are called universal for G, and the question gets interesting when we put certain restrictions on H. For example, we might be interested in a graph H with as few edges as possible, or a graph H which has only n vertices itself and still only few edges. Or we might ask when certain random graphs are universal for G. This all leads to a variety of interesting and challenging problems. In the talk, I will explain what is known and what is open for some classes of graphs G. I will also detail some techniques that I recently used with my coauthors Peter Allen and Anita Liebenau for progress when G consists of all D-degenerate graphs for a fixed D.

Friday, 11 Oct. 2024 — Time: 14:00 - 15:00 — Hörsaal

On Hamilton cycles in highly symmetric graphs

TORSTEN MÜTZE (Universität Kassel)

In 1970 Lovász conjectured that every connected vertex-transitive graph has a Hamilton cycle, apart from five exceptional graphs, one of them being the infamous Petersen graph. This problem received a lot of attention, and it has far-ranging connections to algebra, algorithms, geometry, etc. The question turns out to be surprisingly difficult even for vertex-transitive graphs defined by explicit constructions, e.g., Cayley graphs for various groups and generators. Another plentiful source of vertex-transitive graphs are intersecting set systems. One example for this are Kneser graphs $K(n, k)$, whose vertices are all k-element subsets of an n-element set, and the edges connect disjoint sets. In this talk I present our line of work that settles Lovász' conjecture for all natural known graphs defined by intersecting set systems. In particular, we show that all Kneser graphs $K(n, k)$ admit a Hamilton cycle, except the Petersen graph $K(5, 2)$.

Saturday, 12 Oct. 2024 — Time: 09:00 - 10:00 — Hörsaal

Dispersion on the complete graph

KONSTANTINOS PANAGIOTOU (LMU München)

We consider a synchronous process of particles moving on the vertices of a graph G. Initially, M particles are placed on a vertex of G. In subsequent time steps, all particles that are located on a vertex inhabited by at least two particles jump independently to a neighbour chosen uniformly at random. The process ends at the first step when no vertex is inhabited by more than one particle; we call this (random) time step the dispersion time.

In this talk we consider the case where G is a complete graph on n vertices and $M = cn$. In that case, the dispresion time undergoes a phase transition from logarithmic to exponential time when c crosses the value $1/2$. We will investigate the fine details of this transition, and we will establish that there is a critical window of order $n^{1/2}$, where the dispersion time is also of that order. Moreover, we will derive very explicit descriptions of the distributions of various quantities, like the dispersion time and the total number of jumps. Within the proof we develop an explicit strategy that is based on *diffusion approximation*, a powerful tool from stochastic analysis, that allow us to describe the behavior of processes that do not concentrate around a deterministic trajectory, and that is very likely to be of great use in other problems.

This is joint work with U. De Ambroggio, T. Makai and A. Steibel.

Saturday, 12 Oct. 2024 — Time: 11:30 - 12:30 — Hörsaal

On density of flow-critical graphs

ZDENĚK DVOŘÁK (Charles University)

For a (finite) abelian group A, a connected graph is A-flow-critical if it does not have a nowhere-zero A-flow, but all proper contractions of A do. We survey results and open questions on the density A-flow-critical graphs, motivated by analogous dual problems concerning critical graphs for graph coloring.

Friday, 11 Oct. 2024 — Time: 10:30 - 10:50

1 — Section I — HS — 10:30 - 10:50

Tight Hamilton cycles with high discrepancy

STEFAN GLOCK (Universität Passau)

In discrepancy theory, the basic question is whether a structure can be partitioned in a balanced way, or if there is always some “discrepancy” no matter how the partition is made. In the context of graph theory, a well-studied question is whether for a given host graph, any 2-colouring of its edges must contain a specified subgraph “with high discrepancy”, meaning that within this subgraph one of the colour classes is signficantly larger than the other. We initiate the study of such questions for hypergraphs. Our main result is a discrepancy version of the celebrated theorem of Rödl, Ruciński and Szemerédi on tight Hamilton cycles in Dirac hypergraphs.

Joint work with Lior Gishboliner and Amedeo Sgueglia.

2 — Section II — SR A — 10:30 - 10:50

The paired construction for Boolean functions

MICHAEL KIERMAIER (Universität Bayreuth)

We consider Boolean functions $f : \{0,1\}^n \to \{0,1\}$ in n Boolean variables whose domain is restricted to the *slice* consisting of all words in $\{0,1\}^n$ of fixed Hamming weight k. Such Boolean functions play a role in complexity theory and cryptography. An important parameter is the *degree* of f, which is the minimum degree of a representation of f as a real multivariate polynomial. Functions of degree at most t are the same as t-antidesigns in the Johnson scheme $J(n,k)$. Moreover, this kind of Boolean functions is related to the notion of Cameron-Liebler sets in finite geometries, which is the q-analog notion in the case $t = 1$.

This talk discusses a new construction for Boolean functions on the slice. The resulting functions f are of low degree t and of small support size $\#f > 0$, which in the case $n = 2k$ might even be the smallest possible.

3 — Section III — SR B — 10:30 - 10:50

The connectivity dimension of a graph

TOBIAS HOFMANN (TU Berlin)

In this talk, we introduce a new graph parameter, called the connectivity dimension of a graph. This parameter is inspired by the notion of the metric dimension of a graph and can be seen as a measure of heterogeneity of a graph. Among other fundamental properties, we study how to construct graphs on n vertices having connectivity dimension k, for given n and k. We also show that deciding whether the connectivity dimension of a graph is bounded by a given constant is NP-complete. We conclude by raising a couple of open questions.

4 — Section IV — SR C — 10:30 - 10:50

General penny graphs are at most $43/18$-dense

ARSENII SAGDEEV (Karlsruhe Institute of Technology)

We use the discharging method to prove that among n points in the plane in general position, the shortest distance occurs at most $43n/18$ times, improving upon the upper bound of $17n/7$ obtained by Tóth in 1997.

Friday, 11 Oct. 2024 — Time: 10:55 - 11:15

5 — Section I — HS — 10:55 - 11:15

The H-removal process

MARCUS KÜHN (Heidelberg University)

For a graph H, the *H-removal process* on n vertices is the random process that runs as follows. Starting with a complete graph on n vertices, the process iteratively removes all edges of a copy of H chosen uniformly at random among all remaining copies of H. When no copies of H remain, the process terminates. For large values of n, how many edges typically remain when the process terminates?

Proving asymptotically tight estimates, even for the order of magnitude of this random number of edges, that hold with high probability turns out to be challenging. Bohman, Frieze and Lubetzky obtained such an estimate for the case where H is a triangle, however, so far the analogous question remained open for all other choices of H.

We discuss the history of the analysis of the H-removal process and draw comparisons with another random process that generates graphs containing no copies of H, the *H-free process*. Furthermore, we present new results that generalize the estimate for the triangle case to a large class of sensible graphs and hypergraphs, thereby confirming a folklore conjecture in the area.

This is joint work with Felix Joos.

6 — Section II — SR A — 10:55 - 11:15

Facet-Hamiltonian cycles and rhombic strips

ROBERT LAUFF (Technische Universität Berlin)

A facet-Hamiltoniancycle C on a polytope P is a cycle on its skeleton such that for every facet f of P it holds that $C \cap P$ is connected and not empty. For an example, see Figure 1. These cycles have nice combinatorial interpretations on many well known polytopes. As an example, the facets of the permutahedron on n elements are in bijection to the subsets of $[n]$. A permutation is incident to a facet if it has the given subset as a prefix. Hence a facet-Hamiltoniancycle on the permutahedron is a cyclic list of permutations with neighboring permutations differing in an adjacent transposition, such that every prefix appears in an interval along this cycle.

Another interesting class of polytopes for the study of facet-Hamiltoniancycles are the graph associahedra. This class includes many well known polytopes such as the permutahedron, the classical associahedron, the cyclohedron, and many more. For these polytopes, as well as many others, all or at least many vertices can be identified as maximal chains in a certain face lattice, so called flags. This then yields a nice visualization of facet-Hamiltoniancycles called rhombic strips. A nice example is

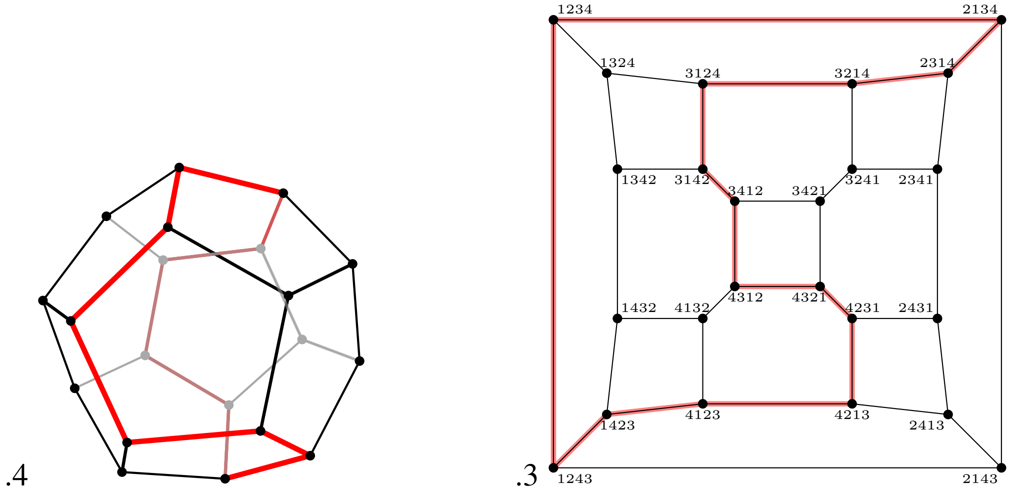

Abbildung 1: The dodecahedron (a) and the permutahedron (b), each with a facet-Hamiltoniancycle.

the B-permutahedron. It is obtained from the cube by truncating every proper face, see Figure 2. Its vertices are clearly associated to flags of the cube and hence a cycle on the B-permutahedron is a cyclicly closed sequence of such flags. The facets of the B-permutahedron are associated to the faces of the cube, and hence we want every face of the cube to appear in such a sequence in an interval. Drawing this sequence of flags without repeating faces yields a rhombic strip, see Figures Figure 3 and Figure 4.

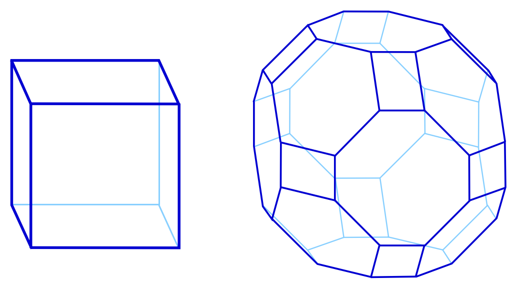

Abbildung 2: The 3-cube and the 3-dimensional B-permutahedron.

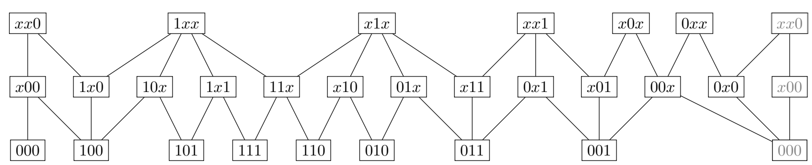

Abbildung 3: The facet-Hamiltoniancycle on the type B permutahedron of dimension 3 represented by its rhombic strip. There is a unique strip up to graph isomorphisms. The two cut vertices in the middle rank show that this strip encodes four facet-Hamiltoniancycles.

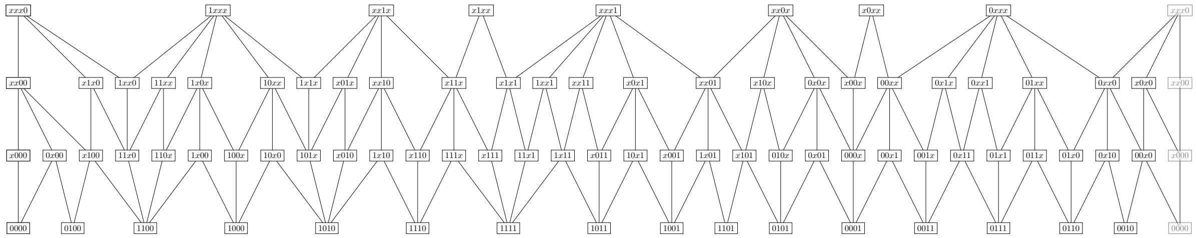

Abbildung 4: A rhombic strip on the type B permutahedron of dimension 4.

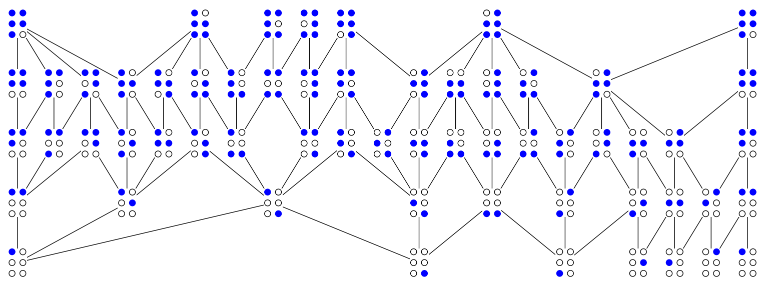

Abbildung 5: A rhombic strip on the graph associahedron of $K_{3,3}$.

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7 — Section III — SR B — 10:55 - 11:15

On the Dissociation Number

LUCIA DRAQUE PENSO (Ulm University)

The dissociation number of a graph is the maximum order of a set of vertices of G inducing a subgraph that is of maximum degree at most 1. Computing the dissociation number of a given graph is algorithmically hard even when restricted to subcubic bipartite graphs, though a quite simple $4/3$-approximation algorithm for the dissociation number problem can be found for bipartite graphs. In this talk, we show bounds for the dissociation number with extremal graph characterizations, and provide related open questions.

Extending the Continuum of Six-Colorings

CHRISTOPH SPIEGEL (Technische Universität Berlin, Institute of Mathematics and Zuse Institute Berlin)

We present two novel six-colorings of the Euclidean plane that avoid monochromatic pairs of points at unit distance in five colors and monochromatic pairs at another specified distance d in the sixth color. Such colorings have previously been known to exist for $0.41 < \sqrt{2} - 1 \leq d \leq 1/\sqrt{5} < 0.45$. Our results significantly expand that range to $0.354 \leq d \leq 0.657$, the first improvement in 30 years. The constructions underlying this notably were derived by formalizing colorings suggested by a custom machine learning approach.

This represents joint work with Konrad Mundinger, Sebastian Pokutta, and Max Zimmer and has partially funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany's Excellence Strategy – The Berlin Mathematics Research Center MATH+ (EXC-2046/1, project ID: 390685689).

Friday, 11 Oct. 2024 — Time: 11:20 - 11:40

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9 — Section I — HS — 11:20 - 11:40

Generalizations of the diamond-free process

AMELIE STRUPP (Heidelberg University)

For a graph H, the H-free process is the random process that, starting from an empty graph on n vertices, iteratively adds an edge chosen uniformly at random among all edges that can be added without creating a copy of H. The process terminates once no such edges remain.

For large n and graphs H satisfying a suitable density condition, Bohman and Keevash proved lower bounds for the number of iterations of this process that hold with high probability and conjecture that, for such H, those bounds are asymptotically tight. Complementing this, work of Picollelli on the diamond-free process suggests that the runtime of the process behaves differently for other choices of H. We generalize this result of Picollelli to an infinite family of graphs.

This is joint work with Felix Joos and Marcus Kühn.

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10 — Section II — SR A — 11:20 - 11:40

2-to-1 binomials from ovals and hyperovals

ALEXANDER OERTEL (Universität Rostock)

Hyperovals in finite Desarguesian planes of even order q are sets of $q+2$ points, of which no three are collinear. Although their investigation started over 60 years ago, a complete classification still remains open. Hyperovals can be studied combinatorially and geometrically, as well as algebraically using a specific class of permutation polynomials over binary finite fields called o-polynomials. This class of polynomials can be linked to 2-to-1 polynomials. It was recently shown by Kölsch and Kyureghyan (2024) that o-monomials and 2-to-1 binomials are indeed equivalent. These binomials are interesting for their occurrences in the study of finite fields and for their applications in cryptography. Using a (geometrically motivated) equivalence relation called o-equivalence, one can thus construct many different 2-to-1 binomials from the known families of o-monomials. In this talk we survey these results and generalize them to odd characteristic and show that a specific class of 2-to-1 binomials can be fully classified using Segre's Theorem about ovals in odd characteristic.

Inverse Shortest Paths Problem on a Cycle

OLGA MINEVICH (FernUniversität in Hagen)

Inverse Shortest Paths (ISP) problem as introduced by Moll [1] can be formulated as follows: Given a graph $G = (V, E)$ and a weighted distance graph $D = (U, F)$, $U \subseteq V$, with a non-negative weight function $w : F \to \mathbb{N}_0$, one needs to find the weights of the edges E, such that the given weights of the distance edges $w(F)$ provide the shortest paths between corresponding vertices in the graph.

It is known that ISP problems are generally $\mathcal{NP}$-complete. We consider the easiest subclass, for which the complexity is unknown, namely the ISP on a cycle graph, where each distance edge defines precisely two possible paths on the graph. In this talk, I will present our current work on algorithmic approaches from the perspectives of linear programming and linear complementarity theory.

The talk is based on joint work with Saskia Grabinat, Prof. Winfried Hochstättler, and Adrian Sauer.

Literature

[1] C. Moll, Das inverse Kürzeste-Wege-Problem, Doctoral dissertation, Universität zu Köln, 1995.

Strong graph embeddings of cubic 3-connected planar graphs and their relation to simplicial surfaces

MEIKE WEISS (RWTH Aachen University)

We study simplicial surfaces, which describe the incidence relations of triangulated surfaces. By considering only the incidences between faces and edges of a simplicial surface, we can associate a cubic graph to the simplicial surface, called the *face graph*. Several properties of simplicial surfaces can be transferred to properties of their face graphs, where e.g. 3-connectivity plays a particular role. An interesting and challenging question is whether a given cubic graph can be the face graph of a simplicial surface. Constructing such a simplicial surface is equivalent to constructing a strong graph embedding of the given graph.

We therefore investigate strong graph embeddings of 3-connected cubic planar graphs in this talk. It is well known from Whitney's embedding theorem that 3-connected cubic planar graphs are uniquely (strongly) embeddable on the sphere. However, these graphs can have several strong embeddings on surfaces of higher genus. We give a combinatorial characterisation and a construction of strong embeddings of 3-connected cubic planar graphs on surfaces of non-negative Euler characteristic. Futhermore, we present a class of 3-connected cubic planar graphs that have no strong embeddings on orientable surfaces of positive genus.

Friday, 11 Oct. 2024 — Time: 11:45 - 12:05

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13 — Section I — HS — 11:45 - 12:05

Uniform Turán Densities and Coloring Palettes

FILIP KUČERÁK (Masaryk University)

In the 1980s, Erdős and Sós introduced the notion of uniform Turán density of a hypergraph which constrains the host hypergraphs in the standard study of Turán densities to have uniformly distributed edges. For nearly 20 years, the area remained stagnant, with no non-zero densities determined exactly. Lately, a series of results established a number of densities, namely, 1/4, 1/27, 4/27, and 8/27 as achievable for 3-uniform hypergraphs. Throughout these works, a technique of coloring palettes started to emerge as a recurring tool. The significance of the notion was recently established by Lamaison, who showed that determining the uniform Turán density of a hypergraph reduces to finding the supremum of densities of coloring palettes by which the hypergraph cannot be colored. In the talk, we will present a new set of coloring palette tools that enable us to study uniform Turán density solely by analyzing relationships between different palette sets. As an example, we illustrate the use of the tools by showing existance of a hypergraph with uniform Turán density equal to 4/81.

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14 — Section II — SR A — 11:45 - 12:05

Relating Smallest Separators

JONATHAN CHRISTOPH DAHLKE (Technische Universität Ilmenau)

A *separator* in a graph G is a smallest set of vertices whose removal disconnects the graph and the size of such a set is defined as the *connectivity number*, denoted $k = \kappa(G)$. Let $\mathcal{T}(G)$ be the set of all separators in G. We introduce a novel relation on $\mathcal{T}(G)$, capturing when two separators divide the graph in a similar manner. This generalizes the observation that an edge cut of size k formed by a matching leads to up to 2^k separators by selecting one endpoint from each edge.

We show that any subset $\mathcal{S} \subseteq \mathcal{T}(G)$ of pairwise related separators satisfies $|\bigcup \mathcal{S}| \leq 2k$ and $|\mathcal{S}| \leq 2^k$. Furthermore, leveraging this relation, we provide an upper bound on $|\mathcal{T}(G)|$. While previous work suggests a bound of $\mathcal{O}\left(\frac{2^k}{k}n^2\right)$ and our approach yields a preliminary bound of $4^k n^2$, we offer a significantly more accessible and concise argument. Ongoing work suggests this bound may be further refined.

15 — Section III — SR B — 11:45 - 12:05

On Inner Independence Systems

SVEN DE VRIES (Trier University)

A classic result of Korte and Hausmann [1978] and Jenkyns [1976] bounds the quality of the greedy solution to the problem of finding a maximum value basis of an independence system $(E, \mathcal{I})$ in terms of the rank-quotient. We extend this result in two ways.

First, we apply the greedy algorithm to an inner independence system contained in $\mathcal{I}$. Additionally, following an idea of Milgrom [2017], we incorporate exogenously given prior information about the set of likely candidates for an optimal basis in terms of a set $\mathcal{O} \subseteq \mathcal{I}$. We provide a generalization of the rank-quotient that yields a tight bound on the worst-case performance of the greedy algorithm applied to the inner independence system relative to the optimal solution in $\mathcal{O}$. Furthermore, we show that for a worst-case objective, the inner independence system approximation may outperform not only the standard greedy algorithm but also the inner matroid approximation proposed by Milgrom [2017].

Second, we generalize the inner approximation framework of independence systems to inner approximations of packing instances in $\mathbf{Z}^n_{\geq 0}$ by inner polymatroids and inner packing instances in $\mathbf{Z}^n_{\geq 0}$. We consider the problem of maximizing a separable discrete concave function and show that our inner approximation can be better than the greedy algorithm applied to the original packing instance. Our result provides a lower bound to the generalized rank-quotient of a greedy algorithm to the optimal solution in this more general setting and subsumes Malinov and Kovalyov [1980].

Joint work with: Stephen Raach (Trier University) and Rakesh V. Vohra (University of Pennsylvania)

16 — Section IV — SR C — 11:45 - 12:05

Four-coloring Eulerian triangulations of the torus

XICHAO SHU (Masaryk University)

Hutchinson, Richter and Seymour [J. Combin. Theory Ser. B 84 (2002), 225-239] showed that every Eulerian triangulation of an orientable surface that has a sufficiently high representativity is 4-colorable. We give an explicit bound on the representativity in the case of the torus by proving that every Eulerian triangulation of the torus with representativity at least 10 is 4-colorable. We also observe that the bound on the representativity cannot be decreased to less than 8 as there exists a non-4-colorable Eulerian triangulation of the torus with representativity 7.

Friday, 11 Oct. 2024 — Time: 15:30 - 15:50

17 — Section I — HS — 15:30 - 15:50

Cut covers of acyclic digraphs

MAXIMILIAN KRONE (Technische Universität Ilmenau)

A *cut* in a digraph $D = (V, A)$ is a set of arcs $\{uv \in A : u \in U, v \notin U\}$, for some $U \subseteq V$. It is known that the arc set A is covered by k cuts if and only if it admits a k-coloring such that no two consecutive arcs uv, vw receive the same color. Alon, Bollobás, Gyárfás, Lehel and Scott (2007) observed that every acyclic digraph of maximum indegree at most $\binom{k}{\lfloor k/2 \rfloor} - 1$ is covered by k cuts. We prove that this degree condition is best possible (if an enormous outdegree is allowed). Unfortunately, for $k \geq 5$, powers of directed paths do not suffice for the proof. Instead, the maximum d such that the d-th power of an arbitrarily long directed path is covered by k cuts is located between $(1 - o(1))\frac{1}{e}2^k$ and $\frac{1}{2}2^k - 2$.

Let $k \geq 3$ and D be an acyclic digraph that is not covered by k cuts. We prove that the decision whether a digraph that admits a homomorphism to D is covered by k cuts is NP-complete. If $k = 3$ and D is the third power of the directed path on 12 vertices, then the NP-completeness even holds on planar digraphs of maximum indegree and outdegree 3.

18 — Section II — SR A — 15:30 - 15:50

Rainbow connectivity of multilayered random geometric graphs

ÖZNUR YAŞAR DINER (Kadir Has University)

An edge-colored multigraph G is rainbow connected if every pair of vertices is joined by at least one rainbow path, i.e., a path where no two edges are of the same color. In the context of multilayered networks we introduce the notion of multilayered random geometric graphs, from $h \geq 2$ independent random geometric graphs $G(n, r)$ on the unit square. We define an edge-coloring by coloring the edges according to the copy of $G(n, r)$ they belong to and study the rainbow connectivity of the resulting edge-colored multigraph. We show that $r(n) = (\frac{\log(n)}{n})^{\frac{h-1}{2h}}$ is a threshold of the radius for the property of being rainbow connected. This complements the known analogous results for the multilayered graphs defined on the Erdős-Rényi random model. This is joint work with Josep Díaz, Maria Serna, and Oriol Serra.

19 — Section III — SR B — 15:30 - 15:50

The complexity of symmetry breaking in SAT

SOFIA BRENNER (Universität Kassel)

Symmetry breaking is a widely popular approach to enhance solvers in constraint programming. Symmetry breaking predicates (SBPs) typically impose an order on variables and single out the lexicographic leader in each orbit of assignments. In this talk, we discuss the complexity of computing SBPs, lex-leader or otherwise, for SAT. We prove a natural barrier for efficiently computing SBPs: efficient certification of graph non-isomorphism. Our results explain the difficulty of obtaining short SBPs for important classes of symmetries such as matrix models with row-column symmetries and graph generation problems. This is joint work with Markus Anders and Gaurav Rattan.

20 — Section IV — SR C — 15:30 - 15:50

Infinite grids in digraphs

KARL HEUER (Technical University of Denmark)

In this talk I will present a recent result which yields a version of Halin's Grid Theorem for infinite digraphs. More precisely, the result shows that every digraph with an end which contains infinitely many disjoint forward directed one-way infinite paths, contains a subdivision of a certain infinite grid-like digraph. This statement utilises an end concept for digraphs which was introduced by Zuther and mimics the corresponding definition for undirected graphs. Crucial for the proof of the main result is another new result for finite digraphs showing that every large enough strongly connected digraph contains an arbitrarily large strongly connected subdigraph which belongs to one of three simply structured digraph classes.

This talk is based on joint work with Matthias Hamann.

Friday, 11 Oct. 2024 — Time: 15:55 - 16:15

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21 — Section I — HS — 15:55 - 16:15

Path decompositions of oriented graphs

MEHMET AKIF YILDIZ (University of Amsterdam)

We consider the problem of decomposing the edges of a digraph into as few paths as possible. There is a natural lower bound for the number of paths in any path decomposition, based on vertex degree imbalances. Any digraph that achieves this bound is called consistent. We say that an undirected graph is strongly consistent if every orientation of it is consistent. As a generalization of Kelly's conjecture on Hamilton decompositions of regular tournaments, Alspach, Mason, and Pullman conjectured in 1976 that every complete graph of even order is strongly consistent. This was recently verified for large graphs by Girão, Granet, Kühn, Lo, and Osthus. A more general conjecture by Pullman from 1980 states that every regular graph of odd degree is strongly consistent. In this work, we prove that for odd d:

- A random d-regular graph is strongly consistent with high probability.
- Every d-regular graph with no short cycles is strongly consistent.

In this talk, I will explain parts of the proof. This is joint work with Viresh Patel (Queen Mary University of London).

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22 — Section II — SR A — 15:55 - 16:15

Local resilience of random geometric graphs

ALBERTO ESPUNY DÍAZ (Universität Heidelberg)

The theory of "local resilience" aims to understand under what minimum degree conditions (or, in more generality, degree sequence conditions) the subgraphs of some given graph satisfy a desired property. The local resilience of random graphs has been studied particularly intensively. In this talk, I will discuss new results about the local resilience of random geometric graphs with respect to different properties, and propose several open problems.

This is based on joint work with Lyuben Lichev and Alexandra Wesolek.

23 — Section III — SR B — 15:55 - 16:15

Limitations of Affine Integer Relaxations for Solving Constraint Satisfaction Problems

MORITZ LICHTER (RWTH Aachen University)

Constraint satisfaction problems (CSPs) provide a universal framework that covers many different computational problems, e.g., solving system of equations, graph coloring problems, or homomorphism problems. Finite-domain CSPs are polynomial-time solvable or NP-complete. While the known algorithms for the tractable case are sophisticated, different rather simple algorithms that combine combinatorial techniques with solving system of linear equations over the integers were proposed for the tractable case. This talks shows that many of them fail to solve all tractable CSPs correctly. These algorithms include $\mathbb{Z}$-affine k-consistency, BLP+AIP, every fixed level of the BA^k-hierarchy, and the CLAP algorithm. In particular, this refutes the conjecture by Dalmau and Opršal that there is a fixed constant k such that the $\mathbb{Z}$-affine-affine k-consistency algorithm solves all tractable finite domain CSPs.

24 — Section IV — SR C — 15:55 - 16:15

Linked tree-decompositions of infinite graphs

MAX PITZ (Universität Hamburg)

Linked and lean tree-decompositions of finite graphs play an important role in graph-minor theory. I will discuss to which degree these results extend to infinite graphs. After giving some examples and counterexamples, I explain our main affirmative result that every graph which admits a tree-decomposition into finite parts has a rooted tree-decomposition into finite parts that is linked, tight and componental.

As an application, we obtain that every graph without half-grid minor has a lean tree-decomposition into finite parts, strengthening the corresponding result by Kříž and Thomas for graphs of finitely bounded tree-width. As a second application of our main result, it follows that every graph which admits a tree-decomposition into finite parts has a tree-decomposition into finite parts that displays all the ends of G and their combined degrees, resolving a question of Halin from 1977. This latter tree-decomposition yields short, unified proofs of the characterisations due to Robertson, Seymour and Thomas of graphs without half-grid minor, and of graphs without binary tree subdivision.

This is joint work with S. Albrechtsen, R. W. Jacobs and P. Knappe. The arXiv identifier is 2405.06753.

Friday, 11 Oct. 2024 — Time: 16:20 - 16:40

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25 — Section I — HS — 16:20 - 16:40

Spanning trees in dense oriented graphs

GIOVANNE SANTOS (Universidad de Chile)

We prove that, for any $\gamma > 0$, there exists n_0 such that, if $n \geq n_0$, then every oriented graph on n vertices with minimum semidegree at least $(3/8 + \gamma)n$ contains every bounded-degree tree on n vertices in any orientation. This corresponds to the minimum semidegree bound for oriented Hamilton cycles in oriented graphs due to Kelly. In this talk we will focus on how mixing properties of random walks, combined with Szemerédi's regularity lemma, are used to embed oriented trees.

This is joint work with Pedro Araújo and Maya Stein.

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26 — Section II — SR A — 16:20 - 16:40

Hitting times in the binomial random graph

JONATHAN SCHRODT (Heidelberg University)

Fix $k \geq 2$, choose $\frac{\log n}{n^{(k-1)/k}} \leq p \leq 1 - \Omega(\frac{\log^4 n}{n})$, and consider $G \sim G(n,p)$. For any pair of vertices $v, w \in V(G)$, we give a simple and precise formula for the expected number of steps that a random walk on G starting at w needs to first arrive at v. The formula only depends on basic structural properties of G. This improves and extends recent results of Ottolini and Steinerberger, as well as Ottolini, who considered this problem for constant as well as for mildly vanishing p.

This is joint work with Bertille Granet and Felix Joos.

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27 — Section III — SR B — 16:20 - 16:40

The Power of Proportional Fairness for Non-Clairvoyant Scheduling under Polyhedral Constraints

ALEXANDER LINDERMAYR (University of Bremen)

The Polytope Scheduling Problem (PSP) was introduced by Im, Kulkarni, and Munagala (JACM 2018) as a very general abstraction of resource allocation over time and captures many well-studied problems including classical unrelated machine scheduling, multidimensional scheduling, and broadcast scheduling. In PSP, jobs with different arrival times receive processing rates that are subject to arbitrary packing constraints. An elegant and well-known algorithm for instantaneous rate allocation

with good fairness and efficiency properties is the Proportional Fairness algorithm (PF), which was analyzed for PSP by Im et al.

We drastically improve the analysis of the PF algorithm for both the general PSP and several of its important special cases subject to the objective of minimizing the sum of weighted completion times. We reduce the upper bound on the competitive ratio from 128 to 27 for general PSP and to 4 for the prominent class of monotone PSP. For certain heterogeneous machine environments we even close the substantial gap to the lower bound of 2 for non-clairvoyant scheduling. Our analysis also gives the first polynomial-time improvements over the nearly 30-year-old bounds on the competitive ratio of the doubling framework by Hall, Shmoys, and Wein (SODA 1996) for clairvoyant online preemptive scheduling on unrelated machines. Somewhat surprisingly, we achieve this improvement by a non-clairvoyant algorithm, thereby demonstrating that non-clairvoyance is not a (significant) hurdle.

Our improvements are based on exploiting monotonicity properties of PSP, providing tight dual fitting arguments on structured instances, and showing new additivity properties on the optimal objective value for scheduling on unrelated machines. Finally, we establish new connections of PF to matching markets, and thereby provide new insights on equilibria and their computational complexity.

This is joint work with Sven Jäger and Nicole Megow.

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28 — Section IV — SR C — 16:20 - 16:40

Canonical graph decompositions and local separators: From coverings to a combinatorial theory

JAN KURKOFKA (TU Bergakademie Freiberg)

Tree-decompositions are the go-to concept in Graph Minor Theory to display the global structure of graphs when this resembles that of a tree. But there are plenty of graphs whose global structure is arbitrarily far away from tree-like. Examples include sparse networks, coming from applications such as social networks, biological networks or infrastructure networks, and Cayley graphs of finite groups.

A recent development in Graph Minor Theory is the study of graph-decompositions, which generalise tree-decompositions in that the decomposition tree may take the form of an arbitrary graph. In previous work with Diestel, we introduced a systematic way to construct graph-decompositions which display the global structure of the underlying graphs. For this, we combined tree-decomposition methods with coverings from Topology. But coverings usually are infinite, and hence obstruct algorithmic applications.

We present a purely combinatorial (finite) construction of these graph-decompositions that, instead of referring to coverings, uses a new theory of local separators in the original graph, which we introduce as well.

Joint work with Raphael W. Jacobs and Paul Knappe (Hamburg).

Friday, 11 Oct. 2024 — Time: 16:45 - 17:05

29 — Section I — HS — 16:45 - 17:05

Hyperbolic digraphs

MATTHIAS HAMANN (University of Hamburg)

Ever since Gromov's semial paper on hyperbolic groups, the notion of hyperbolicity received lots of attention in graphs, groups and metric spaces. For digraphs, notions of hyperbolicity relied for a long time on that of the underlying undirected graph. Gray and Kambites were the first who offered a geometric notion of hyperbolic digraphs based on thin geodesic triangles that took the directions of the edges into account. We will pick up their notion of hyperbolic digraphs, define hyperbolic boundaries for them and discuss the interaction of hyperbolic digraphs and their hyperbolic boundaries with quasi-isometries.

30 — Section II — SR A — 16:45 - 17:05

Factors and covers in the budget-constrained random graph process

ZAK SMITH (Heidelberg University)

A classic problem in random graphs is to determine the threshold probability for a property $\mathcal{P}$, or analogously its hitting time in the random graph process. We consider the 'budget-constrained' model introduced recently by Frieze, Krivelevich and Michaeli, in which possible edges are presented in a random order, and a player must decide (immediately and irrevocably) whether or not to buy each edge. Their goal is to construct a graph satisfying $\mathcal{P}$ (with high probability) as close as possible to the hitting time for $\mathcal{P}$, while buying as few edges as possible. Frieze, Krivelevich and Michaeli provided a strategy to construct a Hamilton cycle at a constant multiple of the hitting time $Cn \log n$ buying only linearly many edges, and asked whether this is possible for other structures; in particular the square of a Hamilton cycle. We answer this question in the negative, and more generally provide a lower bound for the budget required to construct an F-factor (that is, a covering by disjoint copies of F) for a large class of graphs F, which is tight up to a logarithmic factor. We further expand this line of research to consider the budget required to construct K_r-covers, and prove several tight results which exhibit varying and unexpected behaviour.

This talk is based on joint work with Alberto Espuny Díaz, Frederik Garbe, and Tássio Naia.

Tight Bounds for Sorting Under Partial Information

DANIEL RUTSCHMANN (Technical University of Denmark (DTU))

Sorting is one of the fundamental algorithmic problems in theoretical computer science. It has a natural generalization, introduced by Fredman in 1976, called *sorting under partial information*. The input consists of:

- a ground set X of size n,

- a partial oracle O_P (where partial oracle queries for any (x_i, x_j) output whether $x_i \prec_P x_j$, for some fixed *partial order* P),

- a linear oracle O_L (where linear oracle queries for any (x_i, x_j) output whether $x_i <_L x_j$, where the *linear order* L extends P)

The goal is to recover the linear order L on X using the fewest number of linear oracle queries. Let $e(P)$ denote the number of linear extensions of P. Any algorithm has to perform worst-case $\log_2 e(P)$ linear oracle queries to recover L.

By using the concept of graph entropy, introduced by Körner in 1973, we show that P can be approximated by a poset of small width without increasing $\log e(P)$ too much. Moreover, this approximation can be found efficiently via partial oracle queries.

We present the first algorithm that uses a subquadratic number of partial oracle queries. For any constant $c \geq 1$, our algorithm can preprocess O_P using $O(n^{1+\frac{1}{c}})$ partial oracle queries and time. Given O_L, we uncover the linear order on X using $\Theta(c \log e(P))$ linear oracle queries and time. We show a matching lower bound, proving that our algorithm is asymtpotically optimal.

Clique Dynamics and Triangular Covers

ANNA MARGARETHE LIMBACH (Czech Academy of Sciences)

Given a potentially infinite (but locally finite) graph G, its clique graph kG has as its vertices the cliques of G (i.e. the maximal complete subgraphs), two of which are adjacent in kG if they have non-empty intersection in G. A graph G is *clique divergent* if all iterated clique graphs $kG, k(kG), k^3G, ...$ are pairwise non-isomorphic, or *clique convergent* otherwise.

It turns out that the study of this so-called *clique dynamics* for infinite graphs is qualitatively different from the one for finite graphs. For example, clique convergence and clique divergence of finite graphs is *cover stable*, i.e. preserved under (triangular) graph covers. The classic proof by Larrión and Neumann-Lara is however based on a pigeon hole argument that does not transfer to the infinite case. In previous work we established that a clique convergent graph, finite or infinite, has a clique convergent universal cover. Beyond this, very little is known about the interactions between clique dynamics and the graph cover operation.

We present an instructive counterexample that shows that clique convergence is in fact not necessarily preserved by graph covers on infinite graphs. We then focus on *local conditions* (i.e. conditions on the neighborhoods of vertices) and show that the following are sufficient to imply cover stability: local girth ≥ 7 and local minimum degree ≥ 2; being locally cyclic and of minimum degree ≥ 6. Despite being semantically similar, the respective arguments turn out very different.

This also raises the following question: is the clique dynamics of graphs of local girth ≥ 6 and local minimum degree ≥ 2 cover stable? We discuss this question briefly.

This is joint work with Martin Winter.

Saturday, 12 Oct. 2024 — Time: 10:30 - 10:50

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33 — Section I — HS — 10:30 - 10:50

Degree Deviation and Spectral Radius

DIETER RAUTENBACH (Ulm University)

For a finite, simple, and undirected graph G with n vertices, m edges, and largest eigenvalue λ, Nikiforov introduced the degree deviation of G as

$$s = \sum_{u \in V(G)} \left| d_G(u) - \frac{2m}{n} \right|.$$

Contributing to a conjecture of Nikiforov, we show

$$\lambda - \frac{2m}{n} \leq \sqrt{\frac{2s}{3}}.$$

For our result, we show that the largest eigenvalue of a graph that arises from a bipartite graph with $m_{A,B}$ edges by adding m_A edges within one of the two partite sets is at most

$$\sqrt{m_A + m_{A,B} + \sqrt{m_A^2 + 2m_A m_{A,B}}},$$

which is a common generalization of results due to Stanley and Bhattacharya, Friedland, and Peled.

The presented results are joint work with Florian Werner (Ulm University).

34 — Section II — SR A — 10:30 - 10:50

Flips in colourful triangulations

FRANCESCO VERCIANI (Universität Kassel)

The *associahedron* is the graph $\mathcal{G}_N$ that has as nodes all triangulations of a convex N-gon, and an edge between any two triangulations that differ in a flip operation. A *flip* removes an edge shared by two triangles and replaces it by the other diagonal of the resulting 4-gon. We consider a large collection of induced subgraphs of $\mathcal{G}_N$ obtained by Ramsey-type colorability properties. Specifically, coloring the points of the N-gon red and blue alternatingly, we consider only *colorful* triangulations, namely triangulations in which every triangle has points in both colors, i.e., monochromatic triangles are forbidden. We prove that the resulting induced subgraph $\mathcal{F}_N$ has a Hamilton cycle for all $N \geq 8$, resolving a problem raised by Sagan, i.e., all colorful triangulations on N points can be listed so that any two cyclically consecutive triangulations differ in a flip. In fact, we prove that for an arbitrary fixed coloring pattern of the N points with at least 10 changes of color, the resulting subgraph of $\mathcal{G}_N$ on colorful triangulations (for that coloring pattern) admits a Hamilton cycle.

This is joint work with Rohan Acharya (University of Warwick) and Torsten Mütze (Universität Kassel).

35 — Section III — SR B — 10:30 - 10:50

Constructing face-transitive surfaces via cycle double covers induced by automorphism groups

REYMOND AKPANYA (RWTH Aachen University)

A (simplicial) surface can be seen as the incidence geometry of the vertices, edges and faces of a triangulated 2-manifold. We call such a surface face-transitive if its automorphism group acts transitively on the faces of the given surface. Linking a given simplicial surface to a cubic graph is achieved by recording the incidences between the corresponding faces and edges. Note that the resulting cubic graph does not directly contain any information on the vertices of the corresponding surface. This missing information is obtained by constructing a cycle double cover (CDC) of the corresponding cubic graph, i.e. a collection of cycles of the graph such that every edge of the graph is contained in exactly two cycles. In this talk, we discuss the construction of face-transitive surfaces by providing suitable CDCs of vertex-transitive cubic graphs. We demonstrate that the CDC of a given cubic graph corresponding to a face-transitive surface can be constructed by exploiting suitable subgroups of the automorphism group of the given cubic graph. This is a joint work with Jonathan Spreer (Usyd).

Saturday, 12 Oct. 2024 — Time: 10:55 - 11:15

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36 — Section I — HS — 10:55 - 11:15

Polynomial indicator of flat bands in crystal lattices

DRAGAN STEVANOVIĆ (Abdullah Al Salem University, Kuwait)

A translattionaly invariant, d-dimensional, discrete crystal lattice with a tight-binding Hamiltonian has a flat band if the eigenvalue equation of its Bloch Hamiltonian

$$H_B(k)\Psi(k) = E(k)\Psi(k),$$

has an energy level/eigenvalue $E(k)$ which is independent of the wave vector k as it scans the Brillouin zone. The Bloch Hamiltonian $H_B(k)$ is a hermitian matrix that depends on adjacencies between the sites in the unit cell of the lattice and d new complex variables that are used to describe adjacencies between distinct unit cells in different dimensions.

While the recognition of a flat band in the literature is usually reduced to the search for a compact localized eigenstate, i.e., an eigenvector that is zero everywhere outside of a finite region of the lattice, we show here that the flat band can also be recognized by simply checking whether the coefficients of the characteristic polynomial of $H_B(k)$, after suitable rewriting of terms, have a non-trivial greatest common divisor.

This is a joint work with Milan Damnjanović, Ivanka Milošević and Ivan Damnjanović.

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37 — Section II — SR A — 10:55 - 11:15

Spanning spheres in Dirac hypergraphs

AMEDEO SGUEGLIA (Universität Passau)

We provide a topological extension of Dirac's theorem and show that a k-uniform hypergraph on n vertices has a spanning triangulation of the $(k-1)$-dimensional sphere, provided that H has no isolated vertices and each set of $k-1$ vertices supported by an edge is contained in at least $(1/2 + o(1))n$ edges. This asymptotically confirms a conjecture of Georgakopoulos, Haslegrave, Montgomery and Narayanan.

This is joint work with Freddie Illingworth, Richard Lang, Alp Müyesser and Olaf Parczyk.

Triangles in graphs and geometries

JORN VAN DER POL (University of Twente)

Matroids are geometric objects that generalise aspects of independence in graphs and therefore allow us to study graphs using geometric tools. We explore how this connection may shed light on a conjecture of Tuza's (1981) on packings and coverings of triangles in graphs.

This talk is based on joint work with Kazuhiro Nomoto.