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Invited speakers

Total weight choosability of graphs

by Xuding Zhu with Tsai-Lien Wong, Daqing Yang and Gerard Chang

Abstract: Suppose $G = (V, E)$ is a graph. An edge weighting of G is a mapping f which assigns to each edge e a real number $f(e)$ as its weight. An edge weighting f of G is proper if the colouring ϕ_f of the vertices of G defined as $\phi_f(v) = \sum_{e \in E(v)} f(e)$ is a proper colouring of G . A total weighting of a graph $G = (V, E)$ is a mapping f which assigns to each element $y \in V \cup E$ a real number $f(y)$ as the weight of y . A total weighting f of G is proper if the colouring ϕ_f of the vertices of G defined as $\phi_f(v) = \sum_{e \in E(v)} f(e) + f(v)$ is a proper colouring of G . For positive integers k, k' , a graph G is called total (k, k') -weight choosable if whenever each vertex v is given k permissible weights and each edge e is given k' permissible weights, there is a proper total weighting f of G which uses only permissible weights on each element $y \in V \cup E$. Karoński, Łuczak and Thomason conjectured in 2004 that every connected graphs $G \neq K_2$ has a proper edge weighting f such that $f(e) \in \{1, 2, 3\}$ for every edge e . This conjecture is still open, however, it is recently shown by M. Kalkowski, M. Karonski and F. Pfender that the conjecture would be true if the set $\{1, 2, 3\}$ is replaced by $\{1, 2, 3, 4, 5\}$. In 2008, J. Przybyło and M. Woźniak conjectured that every graph has a proper total weighting f with $f(y) \in \{1, 2\}$ for all $y \in V \cup E$. Again the conjecture is open, but it is shown by M. Kalkowski, M. Karonski and F. Pfender that the conjecture would be true if the edges are allowed to have weights in $\{1, 2, 3\}$ and vertices are allowed to have weights in $\{1, 2\}$. It was conjectured by T. Bartnicki, J. Grytczuk and S. Niwczyk that every connected graph with more than one edge is 3-edge weight choosable, and the conjecture is confirmed for some special graphs. We conjecture that every graph is total $(2, 2)$ -weight choosable, and every connected graph on more than one edge is total $(1, 3)$ -choosable. We show that complete multipartite graphs of the form $K_{n, m, 1, 1, \dots, 1}$, trees, cycles, generalized theta graphs are $(2, 2)$ -choosable, and complete bipartite graphs other than K_2 are $(1, 2)$ -choosable. A characterization of $(1, 2)$ -weight choosable trees is given and there is a linear time algorithm that determines

whether a tree is $(1, 2)$ -weight choosable.

Kernelization via combinatorial optimization

by *Stéphan Thomassé*

Abstract: A graph parameter π has *polynomial kernelization* if there exists an algorithm which has input a pair (G, k) where G is a graph of size n and k is an integer and outputs (G', k') where $\pi(G) \leq k$ iff $\pi(G') \leq k'$, and G' has size polynomial in k . Moreover the running time of the algorithm is $O(n^c)$ for some constant c .

Roughly speaking, there exists an efficient preprocess of the instance (G, k) which compress it into a instance of size polynomial in k .

For example Vertex Cover in graphs can be kernelized to size $2k$, Feedback Vertex Set to size $4k^2$, etc. The goal is to find a minimum size kernel.

The design of kernelization algorithms heavily relies on combinatorial optimization tools applied to a substructure called *crown decomposition*. I will present some algorithms based on matchings, convex embeddings, hyper-graphic matroids, A -disjoint paths, ...

A q -analogue of the FKG inequality and some applications

by *Anders Björner*

Abstract: Let L be a finite distributive lattice and $\mu : L \rightarrow \mathbb{R}^+$ a log-supermodular function. For functions $f : L \rightarrow \mathbb{R}^+$ let

$$E_\mu(f; q) := \sum_{x \in L} f(x) \mu(x) q^{\text{rank}(x)} \in \mathbb{R}^+(q).$$

We prove for any pair $f, g : L \rightarrow \mathbb{R}^+$ of monotonely increasing functions, that

$$E_\mu(g; q) \cdot E_\mu(h; q) \ll E_\mu(1; q) \cdot E_\mu(gh; q),$$

where “ \ll ” denotes coefficientwise inequality of real polynomials. The FKG inequality of Fortuin, Kasteleyn and Ginibre (1971) is obtained by specializing to $q = 1$.

The polynomial FKG inequality has applications to f -vectors of joins of simplicial complexes, to Betti numbers of intersection of certain Schubert varieties, and to power series weighted by Young tableaux.

The talk will be quite elementary and no previous familiarity with these topics will be assumed.

Hamiltonicity problems in random graphs

by Michael Krivelevich

Abstract: Problems about Hamilton cycles have always been one of the most central and attractive areas of research in random graphs, with a variety of impressive results proven and ingenious arguments developed. Recent years brought a surge of renewed interest in the subject, and quite a few interesting results and approaches appeared. I will survey some of them.

The talk is intended for a general combinatorial audience.

Packing and covering in hypergraphs

by Penny Haxell

Abstract: For a hypergraph H , we denote by $\nu(H)$ the maximum size of a set of disjoint edges in H . The parameter $\tau(H)$ is defined to be the minimum size of cover in H , that is, a set C of vertices that intersects every edge of H . We discuss a class of combinatorial problems (some notoriously old and difficult) that seeks to establish upper bounds for $\tau(H)$ in terms of $\nu(H)$ for certain classes of hypergraphs H .

Optimization by enumeration

by *Martin Loeb*

Abstract: I plan to show recently discovered connections of enumeration and some well-known optimization problems, like: Is there a natural observation that distinguishes non-isomorphic graphs? Has permanent an exponential complexity? How to conceal information to hide content but preserve local features? The links with the Tutte polynomial, structure and geometric representation of binary linear codes, statistical physics and biology will be stressed.

Is there a structural graph theory based on the spectral radius?

by *Bojan Mohar*

Abstract: The *spectral radius* $\rho(G)$ of a finite graph G is defined as the largest eigenvalue of the adjacency matrix of the graph. It can also be defined for infinite graphs as the supremum of spectral radii of all finite subgraphs. In this talk, we shall survey what is known about this simple algebraic parameter of graphs. Special emphasis will be made to uncover properties related to the structural graph theory. Among others, the following topics will be discussed:

- Spectral radius of finite and infinite trees, planar graphs, tessellations.
 - Minor-closed families of graphs and beyond.
 - Spectral degeneracy with respect to hereditary, induced hereditary and graph minors orderings.
 - Spectral radius of digraphs.
-

Logical characterizations of graph hierarchies

by Bruno Courcelle

Abstract: Structural Graph Theory relates several types of graph notions : decompositions, excluded configurations, embeddings on surfaces, homomorphisms to and from fixed graphs, colorings. Many of these properties can be expressed in Monadic Second-Order Logic, which has interesting algorithmic consequences for graph classes of bounded tree-width and clique-width.

This logical language is also able to express graph transformations, called Monadic Second-Order Transductions. These graph transformations interact nicely with graph decompositions and excluded configurations. In particular, a set of graphs has bounded clique-width (resp. tree-width) iff it is the image of a set of trees under a monadic second-order transduction (resp. a monadic second-order transduction transforming incidence graphs). (All graphs are finite.) It follows that the property of having bounded clique-width or tree-width is preserved under the transductions of the relevant types. From this result, one gets short proofs that certain graph classes have bounded or unbounded clique-width or tree-width. One gets logical characterizations of graph hierarchies based on tree-width and clique-width that are independent on the original definitions. These hierarchies are thus robust in this logical perspective. Several problems remain open in this area, and will be presented.

Ordnung muss sein! – Plane curves and partial orders

by János Pach

Abstract: As Gallai and Hajos discovered half a century ago, the *intersection* graph G of any system of n segments on a line is a perfect graph. We can introduce a partial order on the segments, by setting $I < J$ iff I is entirely to the left of J , and notice that G is the *incomparability* graph associated with this partial order. Every incomparability graph is perfect. In particular, it contains an independent set or a complete subgraph of size \sqrt{n} .

The structure of intersection graphs of segments or, more generally, *curves* in the *plane* is more complicated. Nevertheless, many favorable “quasi-perfect” properties remain true for this wider class of graphs. One of the reasons behind this phenomenon is our ability to introduce some natural partial orders on

the curves and explore their properties. We survey several such results from combinatorial geometry, including the following theorem of Jacob Fox and the speaker: Given any collection C of curves in the plane whose intersection graph is dense, one can pick for each curve $\gamma \in C$ a subcurve γ' such that their intersection graph is also dense and is an incomparability graph. (A graph on n vertices is called *dense*, if it has at least some positive constant times n^2 edges).

Monday morning talks

Full Orientability of Graphs

by Li-Da Tong

Abstract: Let D be an acyclic orientation of a graph G . Then an arc of D is called dependent if its reversal creates a directed cycle. Let $d_{\min}(G)$ (*resp.* $d_{\max}(G)$) denote the minimum (*resp.* maximum) of the number of dependent arcs over all acyclic orientations of G . A graph G is called fully orientable if G has an acyclic orientation with exactly d dependent arcs for every d satisfying $d_{\min}(G) \leq d \leq d_{\max}(G)$. We survey results on the fully orientability of a graph.

keywords: acyclic orientation, dependent arc, fully orientable.

Disjoint sub(di)graphs in digraphs

by Jørgen Bang-Jensen and Matthias Kriesell

Abstract: We survey results and open problems concerning the existence of (arc-)disjoint subdigraphs with certain properties in a digraph. Examples are arc-disjoint spanning strong subdigraphs and disjoint paths with prescribed endvertices.

keywords: disjoint directed and undirected paths, arc-disjoint branchings, decomposition into strong spanning subdigraphs.

Parameterized complexity of the maximum independent set problem and the speed of hereditary properties

by Vadim V. Lozin

Abstract: For a hereditary class X , the number X_n of n -vertex graphs in X (also known as 1 the speed of X) satisfies $\lim_{n \rightarrow \infty} \frac{\log_2 X_n}{\binom{n}{2}} = 1 - \frac{1}{k(X)}$, where $k(X)$ is a natural number called the index of the class. Each class X of index $k > 1$ can be approximated by a minimal class of the same index. In this paper, we use Ramsey theory to show that the maximum independent set problem is fixed-parameter tractable in all minimal classes of index k for all values of k .

keywords: parameterized complexity, Ramsey theory, hereditary properties.

New results on planar and directed multicut

by Cédric Bentz

Abstract: We show that the multicut problem is APX-hard in directed acyclic graphs, even with three source-sink pairs. We also show that it is tractable in planar graphs with a fixed number of terminals, and even FPT if all the terminals lie on the outer face.

keywords: multicut, graph algorithms, APX-hardness.

Partition Critical Hypergraphs

by Zoltán Füredi and Attila Sali

Abstract: A k -uniform hypergraph (X, ε) is 3-color critical if it is not 2-colorable, but for all $E \in \varepsilon$ the hypergraph $(X, \varepsilon \setminus E)$ is 2-colorable. Lovász proved in 1976, that $|E| \leq \binom{n}{k-1}$ for a 3-color critical k -uniform hypergraph with $|X| = n$. Here we prove an ordered version that is a sharpening of

Lovász' result. Let $\varepsilon \subseteq \binom{[n]}{k}$ be a k -uniform set system on an underlying set X of n elements. Let us fix an ordering E_1, E_2, \dots, E_t of ε and a prescribed partition $A_i \cup B_i = E_i (A_i \cap B_i = \emptyset)$ for each member of ε . Assume that for all $i = 1, 2, \dots, t$ there exists a partition $C_i \cup D_i = X (C_i \cap D_i = \emptyset)$, such that $E_i \cap C_i = A_i$ and $E_i \cap D_i = B_i$, but $E_j \cap C_i \neq A_j$ and $E_j \cap C_i \neq B_j$ for all $j < i$. (That is, the i th partition cuts the i th set as it is prescribed, but does not cut any earlier set properly.) Then $t \leq \binom{n-1}{k-1} + \binom{n-1}{k-2} + \dots + \binom{n-1}{0} = \binom{n}{k-1} + O(n^{k-3})$. This is sharp for $k = 2, 3$. Furthermore, if $A_i = E_i$ and $B_i = \emptyset$ for all i , then $t \leq \binom{n}{k-1}$. We also give a n construction of size $\binom{n}{k-1}$.

keywords: color/partition critical hypergraph, linear algebra method.

The Colorful Helly Property for Hypergraphs 1

by Rommel M. Barbosa, Mitre C. Dourado, Erika M. Martins and Jayme L. Szwarcfiter

Abstract: Helly's theorem for convex sets motivated the definition of the p -Helly property for hypergraphs. On the other hand, the colorful Helly theorem for collections of convex sets, by Lovász, generalizes Helly's theorem. Motivated by Lovász's theorem, we define the colorful p -Helly property for a family of p hypergraphs. We describe complexity results related to the latter. We show that it is Co-NP-complete to decide if a family of p hypergraphs is colorful p -Helly, even if $p = 2$. However, for any fixed p , we describe a polynomial time algorithm to decide if such family is colorful p -Helly, provided $p - 1$ of the hypergraphs are p -Helly.

keywords: colorful Helly property, computational complexity, Helly property.

On the Path Separability of Planar Graphs

by Emilie Diot and Cyril Gavoille

Abstract: It is known that every weighted planar graph with n vertices contains three shortest paths whose removal halves the graph into connected components of at most $n/2$ vertices. Whether this property remains true

with the use of two shortest paths only is an open problem. We show that two shortest paths are enough for a large family of planar graphs, called face-separable, composed of graphs for which every induced subgraph can be halved by removing the border of a face in some suitable embedding of the subgraph. We also show that this non-trivial family of graphs includes unbounded treewidth graphs.

keywords: treewidth, planar graphs, path-separable.

Planar graphs without 4, 5 and 8-cycles are acyclically 4-choosable

by Min Chen and André Raspaud

Abstract: In this paper, we prove that planar graphs without 4, 5 and 8-cycles are acyclically 4-choosable.

keywords: planar graphs, acyclic coloring, choosable, cycle.

Monday afternoon talks

Maximum values of Szeged index and edge-Szeged index of graphs

by *Ehsan Chiniforooshan and Baoyindureng Wu*

Abstract: The Szeged index is a graph invariant which is a natural generalization of Wiener index. In this note, we disprove two recent conjectures concerning with the maximum value of Szeged index of graphs, which are due to Khalifeh et al. (Europ. J. Combinatorics (2008), doi:10.1016/j.ejc.2008.09.019) and respectively, to Gutman et al. (Croat. Chem. Acta 81(2)(2008) 263-266) and prove a conjecture on Szeged index due to Klavzar et al. (Appl. Math. Lett. 9(1996), 45-49), which states that the complete bipartite graph $K_{\lceil n/2 \rceil, \lfloor n/2 \rfloor}$ has maximum Szeged index among all connected graphs on n vertices. The last conjecture is previously proved by Dobrynin (Croat. Chem. Acta 70(3), 819-825), but our proof turns out to be much simpler and self-contained.

keywords: Szeged index, Wiener index.

Cubicity of Interval Graphs and the Claw Number

by *Abhijin Adiga and L. Sunil Chandran*

Abstract: Let $G(V, E)$ be a simple, undirected graph. A b -dimensional box is a Cartesian product $I_1 \times I_2 \times \dots \times I_b$, where each I_i is a closed interval on the real line. When each interval has unit length we have a b -dimensional cube. The cubicity (respectively boxicity) of G , $cub(G)$ ($box(G)$) is the minimum positive integer b such that the vertices in G can be mapped to axis parallel b -dimensional cubes (boxes) in such a way that two vertices are adjacent in G if and only if their assigned cubes (boxes) intersect. Suppose $S(m)$ denotes

a star graph on $m + 1$ nodes. We define claw number $\psi(G)$ to be the largest positive integer m such that $S(m)$ is an induced subgraph of G . In this paper we show that for an interval graph G $\lceil \log_2 \psi(G) \rceil \leq \text{cub}(G) \leq \lceil \log_2 \psi(G) \rceil + 2$. We also show that $\text{cub}(G) \leq \lceil \log_2 \alpha \rceil$, where α is the independence number of G . From this we have, for any graph G , $\text{cub}(G) \leq \text{box}(G) \lceil \log_2 \alpha \rceil$.

keywords: cubicity, boxicity, interval graphs, unit-interval graphs, claw number.

Coloring Fuzzy Circular Interval Graphs

by Friedrich Eisenbrand and Martin Niemeier

Abstract: Computing the weighted coloring number of graphs is a classical topic in combinatorics and graph theory. Recently these problems have again attracted a lot of attention for the class of quasi-line graphs and more specifically fuzzy circular interval graphs. The problem is NP-complete for quasi-line graphs. For the subclass of fuzzy circular interval graphs however, one can compute the weighted coloring number in polynomial time using recent results of Chudnovsky and Ovetsky and of King and Reed. Whether one could actually compute an optimal weighted coloring of a fuzzy circular interval graph in polynomial time however was still open. We provide a combinatorial algorithm that computes weighted colorings and the weighted coloring number for fuzzy circular interval graphs efficiently. The algorithm reduces the problem to the case of circular interval graphs, then making use of an algorithm by Gijswijt to compute integer decompositions.

keywords: fuzzy circular interval graph, circular interval graph, vertex coloring, weighted coloring.

A classification of arc-locally semicomplete digraphs

by H. Galeana-Sánchez and I.A. Goldfeder

keywords: arc-local tournament, arc-locally semicomplete digraph, generalization of tournaments, independent set of vertices, product of digraphs.

On the Gapped Consecutive-Ones Property

by Cedric Chauve, Ján Maňuch and Murray Patterson

Abstract: Motivated by problems of comparative genomics and paleogenomics, we introduce the Gapped Consecutive-Ones Property Problem (k, δ) -C1P: given a binary matrix M and two integers k and δ , can the columns of M be permuted such that each row contains at most k sequences of 1's and no two consecutive sequences of 1's are separated by a gap of more than δ 0's. The classical C1P problem, which is known to be polynomial, is equivalent to the $(1,0)$ -C1P Problem. We show that the $(2, \delta)$ -C1P Problem is NP-complete for $\delta \geq 2$. We conjecture that the (k, δ) -C1P Problem is NP-complete for $k \geq 2, \delta \geq 1, (k, \delta) \neq (2, 1)$. We also show that the (k, δ) -C1P Problem can be reduced to a graph bandwidth problem parameterized by a function of k, δ and of the maximum number s of 1's in a row of M , and hence is polytime solvable if all three parameters are constant.

keywords: consecutive-ones property, algorithm, computational complexity.

On the S -Labeling problem

by Guillaume Fertin and Stéphane Vialette

Abstract: Let G be a graph of order n and size m . A labeling of G is a bijective mapping $\theta : V(G) \rightarrow \{1, 2, \dots, n\}$, and we call $\Theta(G)$ the set of all labelings of G . For any graph G and any labeling $\theta \in \Theta(G)$, let $SL(G, \theta) = \sum_{e \in E(G)} \min\{\theta(u) : u \in e\}$. In this paper, we consider the S -Labeling problem, defined as follows: Given a graph G , find a labeling $\theta \in \Theta(G)$ that minimizes $SL(G, \theta)$. The S -Labeling problem has been shown to be NP-complete [Via06]. We prove here basic properties of any optimal S -labeling of a graph G , and relate it to the Vertex Cover problem. Then, we derive bounds for $SL(G, \theta)$, and we give approximation ratios for different families of graphs. We finally show that the S -Labeling problem is polynomi-

altime solvable for split graphs. Due to space constraints, proofs are totally absent from this paper. They will be available in its journal version.

Pebbling Graphs of Diameter Three and Four

by Luke Postle, Noah Streib and Carl Yerger

Abstract: Given a configuration of pebbles on the vertices of a connected graph G , a pebbling move is defined as the removal of two pebbles from some vertex, and the placement of one of these on an adjacent vertex. The pebbling number of a graph G is the smallest integer k such that for each vertex v and each configuration of k pebbles on G there is a sequence of pebbling moves that places at least one pebble on v . We improve on the bound of Bukh by showing that the pebbling number of a graph of diameter three on n vertices is at most $\lfloor 3n/2 \rfloor + 2$, and this bound is best possible. We obtain an asymptotically best possible bound of $3n/2 + \Theta(1)$ for the pebbling number of graphs of diameter four. Finally, we prove an asymptotic upper bound for the pebbling number of graphs of diameter d , namely $(2^{\lceil d/2 \rceil} - 1)n + O(1)$, and this also improves a bound given by Bukh.

keywords: pebbling, diameter, asymptotics.

Colored Pebble Motion on Graphs

by Shinya Fujita, Tomoki Nakamigawa and Tadashi Sakuma

Abstract: Let r, n and n_1, \dots, n_r be positive integers with $n = n_1 + \dots + n_r$. Let X be a connected graph with n vertices. For $1 \leq i \leq r$, let P_i be the i th color class of n_i distinct pebbles. A configuration of the set of pebbles $P = P_1 \dots P_r$ on X is defined as a bijection from the set of vertices of X to P . A move of pebbles is defined as exchanging two pebbles with mutually distinct colors on the two endvertices of a common edge. For a pair of configurations f and g , we write $f \sim g$ if f can be transformed into g by a sequence of finite moves. The relation \sim is an equivalence relation on the set of all the configurations of P on X . We study the number $c(X, n_1, \dots, n_r)$ of

the equivalence classes.

keywords: pebble motion, motion planning, 15-puzzle, graph puzzle.

Augmenting the edge-connectivity of a hypergraph by adding a multipartite graph

by Roland Grappe, Attila Bernáth and Zoltán Szigeti

Abstract: We consider the problem of edge-connectivity augmentation of a hypergraph by adding a multipartite graph. Given a hypergraph H , a partition P of the vertex set and an integer k , find a minimum number of graph edges between different members of P to be added to H in order to make it k -edge-connected. It is a common generalization of edge-connectivity augmentation of graphs with partition constraints [4] and edge-connectivity augmentation of hypergraphs by adding graph edges [3]. We give a min-max theorem for this problem, and our proof yields a polynomial algorithm to find the desired set of edges.

keywords: edge-connectivity augmentation, hypergraphs, partition constraints.

Kneser Colorings of Uniform Hypergraphs

by C. Hoppen, Y. Kohayakawa and H. Lefmann

Abstract: For fixed positive integers r, k and l with $l < r$, and an r -uniform hypergraph H , let $\kappa(H, k, l)$ denote the number of k -colorings of the set of hyperedges of H for which any two hyperedges in the same color class intersect in at least l vertices. Consider the function $KC(n, r, k, l) = \max_{H \in \mathcal{H}_n} \kappa(H, k, l)$, where the maximum runs over the family \mathcal{H}_n of all r -uniform hypergraphs on n vertices. In this paper, asymptotic behavior of the function $KC(n, r, k, l)$ and describe the extremal hypergraphs. This variant of a problem of Erdős and Rothschild, who considered colorings of graphs without a monochromatic triangle, is related to the Erdős-Ko-Rado Theorem [3] on intersecting systems

of sets.

keywords: extremal combinatorics, Turán number, intersecting systems of sets.

Hypergraphs with no odd cycle of given length

by Ervin Györi and Nathan Lemons

Abstract: We give upper bounds for the size of 3-uniform hypergraphs avoiding a given odd cycle using the definition of a cycle due to Berge. In particular, we show that a 3-uniform hypergraph containing no cycle of length $2k + 1$ has less than $4k^4 n^{1+1/k} + O(n)$ edges. Constructions show that these bounds are best possible (up to constant factor) for $k = 1, 2, 3, 5$.

keywords: extremal graph theory, set systems, hypergraphs.

Cliques in graphs with bounded minimum degree

by Allan Lo

Abstract: Let $k_r(n, d)$ be the minimum number of r -cliques in graphs with n vertices and minimum degree d . We evaluate $k_r(n, d)$ for $n/2 \leq d \leq 4n/5$ and some other cases. Moreover, we give a construction, which we conjecture to give all extremal graph (subject to certain conditions on n, d and r).

keywords: number of cliques, minimum degree.

Spectral radius of finite and infinite planar graphs and of graphs of bounded genus

by Zdeněk Dvořák and Bojan Mohar

keywords: planar graphs, spectral radius, maximum degree, decomposition.

Defending Planar Graphs against Star-Cutsets

by *Nicolas Sonnerat and Adrian Vetta*

Abstract: We consider the problem of protecting edges in a graph so that the graph remains connected after the removal of any set of vertices that form a star consisting of unprotected edges. We show that the problem of finding a minimal set of edges to protect (the network protection problem) is NP-complete in general graphs, and present an $O(\log n)$ -approximation algorithm, where the $O(\log n)$ factor is essentially best possible. Our major focus, though, is on the special case of planar graphs. We analyse in detail the structure of minimal star-cutsets in planar graphs, and exploit this structure to construct a polynomial time approximation scheme for the network protection problem.

keywords: star-cutsets, planar graphs, graph connectivity, approximation algorithms.

Monochromatic geometric k -factors in red-blue sets with white and Steiner points

by *D. Garijo, M. A. Garrido, C. I. Grima, A. Márquez, A. Moreno-González, J. R. Portillo, P. Reyes, R. Robles and J. Valenzuela*

Abstract: We study the existence of monochromatic planar geometric k -factors on sets of red and blue points. When it is not possible to find a k -factor we make use of auxiliary points: white points, whose position is given as a datum and which color is free; and Steiner points whose position and color is free. We present bounds on the number of white and/or Steiner points necessary and/or sufficient to draw a monochromatic planar geometric k -factor.

keywords: k -factor, perfect matching, red-blue sets, white points, Steiner points.

Minimizing the Oriented Diameter of a Planar Graph

by Nicole Eggemann and Steven D. Noble

Abstract: We consider the problem of minimizing the diameter of an orientation of a planar graph. A result of Chvátal and Thomassen shows that for general graphs, it is a NP-complete to decide whether a graph can be oriented so that its diameter is at most two. In contrast to this, for each constant l , we describe an algorithm that decides if a planar graph G has an orientation with diameter at most l and runs in time $O(c|V|)$, where c depends on l .

keywords: diameter, graph orientation, graph minors, planar graph.

Tuesday morning talks

Hereditary quasi-random properties of hypergraphs

by *Domingos Dellamonica Jr and Vojtech Rödl*

Abstract: Thomason and Chung, Graham and Wilson were the first to investigate systematically some properties of quasi-random graphs. They have stated several quite disparate properties of random-like graphs and established their equivalence. Simonovits and Sós introduced a new hereditary property that is equivalent to the other quasi-random properties. For a small fixed graph F , a graph G on n vertices is said to have the Simonovits-Sós Property SSP if for every set $X \subseteq V(G)$, the number of labeled copies of F in $G[X]$ is given by $2^{-e(F)}|X|^{v(F)} + o(n^{v(F)})$. A graph that satisfies SSP for some non-empty graph F is quasi-random. Our contribution in this paper is a natural extension of the result of Simonovits and Sós to 3-uniform hypergraphs.

keywords: hypergraph, quasi-randomness, hereditary property.

Quasirandom broadcasting on the complete graph is as fast as randomized broadcasting

by *Anna Huber and Nikolaos Fountoulakis*

Abstract: In this paper, we provide a detailed comparison between a fully randomized protocol for rumour spreading on a complete graph and a quasirandom protocol introduced by Doerr, Friedrich and Sauerwald [2]. In the former, initially there is one vertex which holds a piece of information and during each round every one of the informed vertices chooses one of its neighbours uniformly at random, independently of every other vertex, and informs it. In the quasirandom version of this method (see Doerr et al. [2]) each vertex

is equipped with a cyclic ordering of its neighbours. Once a vertex is informed, it chooses uniformly at random only the first neighbour it will inform and at each subsequent round it informs the successor in its cyclic ordering. The randomized protocol was analyzed by Frieze and Grimmett [4] and their analysis was refined by Pittel [6], who gave a precise description of its evolution. In the present work, we present a precise analysis of the evolution of the quasirandom protocol on the complete graph with n vertices and show that it evolves essentially in the same way as the randomized protocol. In particular, if $S(n)$ denotes the number of rounds that are needed until all vertices are informed, we show that for any slowly growing function $\omega(n)$ with probability $1 - o(1)$ we have $\log_2 n + \ln n - 4 \ln \ln n \leq S(n) \leq \log_2 n + \ln n + \omega(n)$.

keywords: rumour spreading, randomized broadcasting, quasirandom broadcasting, derandomization.

A Time-Randomness Tradeoff for Quasi-Random Rumour Spreading

by Benjamin Doerr and Mahmoud Fouz

Abstract: We give a time-randomness tradeoff for the quasi-random rumour spreading protocol proposed by Doerr et al [3] on complete graphs. In this protocol, the goal is to spread a piece of information originating from one vertex throughout the network. Each vertex is assumed to have a (cyclic) list of its neighbors. Once a vertex is informed by one of its neighbors, it chooses a position in its list uniformly at random and goes on to inform its neighbors starting from that position and proceeding in order of the list. Doerr et al [3] showed that after $O(\log n)$ rounds, the rumour will have been broadcasted to all nodes with probability $1 - o(1)$. We study the broadcast time when the amount of randomness available at each node is reduced. For randomness parameter l , we show that there exists lists such that $(1 - \epsilon)(\log_2 n + \ln n - \log_2 l - \ln l) + l$ steps are needed to inform every vertex with probability at least $1 - O(e^{-\frac{n\epsilon}{2 \ln n}})$.

keywords: randomness in computation, design and analysis of algorithms.

Quasirandom Rumor Spreading on Expanders

by Benjamin Doerr, Tobias Friedrich and Thomas Sauerwald

Abstract: Randomized rumor spreading is an efficient way to distribute information in networks. Recently, a quasirandom version of this protocol has been proposed. It was proven that it works equally well or even better in many settings. In this work, we exhibit a natural expansion property for networks, which ensures that quasirandom rumor spreading informs all nodes of the network in logarithmic time with high probability. This expansion property is satisfied, among others, by many expander graphs, random regular graphs, and Erdős-Rényi random graphs.

Linear Extension Diameter of Downset Lattices of 2-Dimensional Posets

by Stefan Felsner and Mareike Massow

Abstract: The linear extension diameter of a finite poset P is the maximum distance between a pair of linear extensions of P , where the distance between two linear extensions is the number of pairs of elements of P appearing in different orders in the two linear extensions. We prove a formula for the linear extension diameter of Boolean Lattices and characterize all pairs of linear extensions attaining the maximum distance. These results can be extended to all downset lattices of 2-dimensional posets.

keywords: partial orders, linear extensions, graph diameter, boolean lattice.

Formulae and Growth Rates of High-Dimensional Polycubes

by R. Barequet, G. Barequet and G. Rote

Abstract: A d -dimensional polycube is a facet-connected set of cubes in d dimensions. Fixed polycubes are considered distinct if they differ in shape or orientation. A proper $d - D$ polycube spans all d dimensions. In this paper we prove some formulae for fixed (proper and improper) polycubes, show that the growth-rate limit of the number of polycubes in d dimensions is $2ed - o(d)$, and estimate it at $(2d - 3)e + O(1/d)$.

keywords: polyominoes, lattice animals.

On the Sunset Partition Problem

by A. Lladó and J. Moragas

Abstract: A sequence m_1, m_2, \dots, m_k of positive integers is n -realizable if there is a partition X_1, X_2, \dots, X_k of the set $[n]$ such that the sum of the elements in X_i is m_i for each $i = 1, 2, \dots, k$. In this paper we study the n -realizable sequences by adopting a different viewpoint from the one which has been previously used in the literature. We consider the realizability of a sequence in terms of the length k of the sequence or the values of its distinct elements. We characterize all n -realizable sequences with $k \leq 4$ and, for $k \geq 5$, we prove that $n \geq 4k - 1$ and $m_k > 4k - 1$ are sufficient conditions for a sequence to be n -realizable. This sufficient condition complements the one which has been used in connection with the ascending subgraph decomposition conjecture of Alavi et al. [1]. We also characterize realizable sequences whose distinct terms grow exponentially. Finally we consider the modular version of the problem and prove that all sequences in \mathbb{Z}_p of length $k \leq (p - 1)/2$ are realizable for any prime $p \geq 3$. The bound on k is best possible.

keywords: partitions, realizable sequences.

Rainbow-free-3-colorings in abelian groups

by Amanda Montejano and Oriol Serra

Abstract: A 3-coloring of an abelian group G is rainbowfree if there is no 3-term arithmetic progression with its members having pairwise distinct colors. We describe the structure of rainbow-free colorings of abelian groups. This

structural description proves a conjecture of Jungić et al. on the size of the smallest chromatic class c of a rainbow-free coloring of cyclic groups.

keywords: anti-Ramsey theory, arithmetic progressions.

An expected polynomial time algorithm for coloring 2-colorable 3-graphs

by Yury Person and Mathias Schacht

Abstract: We present an algorithm that colors a random 2-colorable 3-uniform hypergraph optimally in expected running time $O(n^5 \log^2 n)$.

keywords: coloring, hypergraphs, average case analysis.

On the Problem of Erdős and Hajnal in the Case of List Colorings

by A.P. Rozovskaya and D.A. Shabanov

Abstract: We deal with the classical problem of Erdős and Hajnal in hypergraph theory and its generalization concerning the list colorings of hypergraphs. Let $m(n, k)(m_{list}(n, k))$ denote the minimum number of edges in an n -uniform hypergraph with chromatic (list chromatic) number $k + 1$. We obtained some new lower bounds for $m(n, k)$ and $m_{list}(n, k)$ which improved previous results for some values of parameters n and k .

keywords: hypergraph, uniform hypergraph, chromatic number, list chromatic number, extremal values.

Circular edge-colorings of cubic graphs with girth six

by *Daniel Král', Edita Máčajová, Ján Mazák and Jean-Sébastien Sereni*

Abstract: We show that the circular chromatic index of a (sub)cubic graph with girth at least six is at most $7/2$.

keywords: cubic graphs, circular coloring, edge coloring.

Acyclic edge-colouring of planar graphs

by *Nathann Cohen, Frédéric Havet and Tobias Müller*

Abstract: A proper edge-colouring with the property that every cycle contains edges of at least three distinct colours is called an acyclic edge-colouring. The acyclic chromatic index of a graph G , denoted $\chi'_a(G)$ is the minimum k such that G admits an acyclic edge-colouring with k colours. We conjecture that if G is planar and $\Delta(G)$ is large enough then $\chi'_a(G) = \Delta(G)$. We settle this conjecture for planar graphs with girth at least 5 and outerplanar graphs. We also show that if G is planar then $\chi'_a(G) \leq \Delta(G) + 25$.

keywords: edge-colouring, graphs of bounded density, planar graph, outerplanar graph.

Counting Homomorphisms to Sparse Graphs

by *Jaroslav Nešetřil and Patrice Ossona de Mendez*

Abstract: We define nowhere dense and somewhere dense classes by means of counting of homomorphisms from test graphs. This seems to be bridging the gap between existential and counting theorems (for graph homomorphisms) and it has application to complexity of Boolean queries.

keywords: graph, counting, homomorphism, boolean query, tree-depth.

Characterising claw-free t -perfect graphs

by *Maya Stein and Henning Bruhn*

Abstract: We characterise the class of all claw-free t -perfect graphs by forbidden t -minors. Moreover, we show that claw-free t -perfect graphs are 3-colourable. Such a colouring can be obtained in polynomial time.

keywords: t -perfect graphs, claw-free graphs, stable set polytope (SSP), colouring.

Loebl-Komlós-Sós Conjecture: dense case

by *Oliver Cooley, Jan Hladký and Diana Piguet*

Abstract: We prove a version of the Loebl-Komlós-Sós Conjecture for large dense graphs. For any $q > 0$ there exists $n_0 \in \mathbb{N}$ such that for any $n > n_0$ and $k > qn$ the following holds: If G has median degree at least k , then any tree of order at most $k + 1$ is a subgraph of G .

keywords: Loebl-Komlós-Sós Conjecture, trees, regularity lemma.

Minimum degree conditions for large subgraphs

by *Peter Allen, Julia Böttcher and Jan Hladký*

Abstract: Much of extremal graph theory has concentrated either on finding very small subgraphs of a large graph (such as Turán's theorem [10]) or on finding spanning subgraphs (such as Dirac's theorem [3] or more recently work of Komlós, Sárközy and Szemerédi [7,8] towards a proof of the Pósa-Seymour conjecture). Only a few results give conditions to obtain some intermediate-sized subgraph. We contend that this neglect is unjustified. To support our contention we focus on the illustrative case of minimum degree conditions which guarantee squared-cycles of various lengths, but also offer results, conjectures and comments on other powers of paths and cycles, generalisations thereof, and hypergraph variants.

keywords: extremal graph theory, minimum degree, large subgraphs.

Tuesday afternoon talks

Short cycles in oriented graphs

by Deryk Osthus, Luke Kelly and Daniela Kühn

Abstract: We show that for each $l \geq 4$ every sufficiently large oriented graph G whose minimum out- and indegrees satisfy $\delta^+(G), \delta^-(G) \geq \lfloor |G|/3 \rfloor + 1$ contains an l -cycle. This is best possible for all those $l \geq 4$ which are not divisible by 3. Surprisingly, for some other values of l , an l -cycle is forced by a much weaker minimum degree condition. We propose and discuss a conjecture regarding the precise minimum degree which forces an l -cycle (with $l \geq 4$ divisible by 3) in an oriented graph. We also give an application of our results to pancyclicity.

keywords: oriented graphs, cycles.

A Decomposition Theorem for Chordal Graphs and its Applications

by M. Habib and J. Stacho

Abstract: We introduce a special decomposition, the so-called split-minors, of the reduced clique graphs of chordal graphs. Using this notion, we characterize asteroidal sets in chordal graphs and clique trees with minimum number of leaves.

keywords: chordal graph, asteroidal set, split-minor, leafage, polynomial time.

Unavoidable subhypergraphs: a -clusters

by Zoltán Füredi and Lale Özkahya

Abstract: One of the central problems of extremal hypergraph theory is the description of unavoidable subhypergraphs, in other words, the Turan problem. Let $a = (a_1, \dots, a_p)$ be a sequence of positive integers, $p \geq 2, k = a_1 + \dots + a_p$. An a -cluster is a family of k -sets $\{F_0, \dots, F_p\}$ such that the sets $F_i \setminus F_0$ are pairwise disjoint ($1 \leq i \leq p$), $|F_i \setminus F_0| = a_i$, and the sets $F_0 \setminus F_i$ are pairwise disjoint, too. Given a there is a unique a -cluster, and the sets $F_0 \setminus F_i$ form an a -partition of F_0 . With an intensive use of the delta-system method we prove that for $k > p > 1$ and sufficiently large $n, (n > n_0(k))$, if F is an n -vertex k -uniform family with $|F|$ exceeding the Eörfds-Koo Rado bound $\binom{n-1}{k-1}$, then F contains an a -cluster. The only extremal family consists $k - 1$ of all the k -subsets containing a given element.

keywords: Erdős-Ko-Rado, set systems, traces.

Sub-Exponentially Many 3-Colorings of Triangle-Free Planar Graphs

by Arash Asadi, Luke Postle and Robin Thomas

Abstract: Thomassen conjectured that every triangle-free planar graph has exponentially many 3-colorings. He proved that it has at least $2^{n^{1/12}/20000}$ distinct 3-colorings where n is the number of vertices. We show that it has at least $2^{\sqrt{n/432}}$ distinct 3-colorings.

keywords: coloring graphs, triangle-free planar graphs.

Wednesday morning talks

4-cycles at the triangle-free process

by Guy Wolfowitz

Abstract: We consider the triangle-free process: given an integer n , start by taking a uniformly random permutation of the edges of the complete n -vertex graph K_n . Then, traverse the edges of K_n according to the order imposed by the permutation and add each traversed edge to an (initially empty) evolving graph - unless its addition creates a triangle. We study the evolving graph at around the time where $\Theta(n^{3/2+\epsilon})$ edges of K_n have been traversed for any fixed $\epsilon \in (0, 10^{-10})$. At that time, we give a tight concentration result for the number of copies of the 4-cycle in the evolving graph. Our analysis combines Spencer's original branching process approach for analysing the triangle-free process with the semi-random method.

keywords: triangle-free process, random graphs.

Coloring the edges of a random graph without a monochromatic giant component

by Reto Spöhel, Angelika Steger and Henning Thomas

Abstract: Our goal is to color the edges of a random graph $G_{n,m}$ (a graph drawn uniformly at random from all graphs on n vertices with exactly m edges) with a fixed number r of colors such that no color class induces a component of size $\Omega(n)$ so called 'giant component'. We prove that for every $r \geq 2$ there exists an analytically computable constant c for which the following holds: For any $c < c_r^*$, with probability $1 - o(1)$ there exists an r -edge-coloring of $G_{n,rcn}$ in which every monochromatic component has sublinearly many vertices. On the other hand, for any $c > c_r^*$, with probability $1 - o(1)$ every r -edge-coloring of $G_{n,rcn}$ contains a monochromatic component on linearly many vertices. In

other words, we prove that the property in question has a sharp threshold at $m = rc_r^*n$

keywords: Ramsey property, random graph, giant component.

A general critical condition for the emergence of a giant component in random graphs with given degrees

by Nikolaos Fountoulakis and Bruce Reed

Abstract: In this contribution, we investigate the giant component problem in random graphs with a given degree sequence. We generalize the critical condition of Molloy and Reed [10], which determines the existence of a giant component in such a random graph, in order to include degree sequences with heavy tails. We show that the quantity which determines the existence of a giant component is the value of the smallest fixed point inside the interval $[0, 1]$ of the generating function $F(s) = \sum_{i \geq 1} \delta_i s^{i-1}$, where δ_i is the asymptotic proportion of the total degree contained in vertices of degree i . Moreover, we show that this quantity also determines the existence of a core (i.e., the maximal subgraph of minimum degree at least 2) that has linear total degree.

keywords: random graphs, degree sequences, giant component.

Vertices of Degree k in Random Unlabeled Trees

by Konstantinos Panagiotou and Makrand Sinha

Abstract: Let H_n be the class of vertex-rooted unlabeled trees with n vertices, and denote by H_n a tree that is drawn uniformly at random from this set. In this work we study the $\log n$ number $\deg_k(H_n)$ of vertices of degree k in H_n . In particular, for $k = O((\log n / (\log \log n))^{1/2})$ we show exponential-type bounds for the probability that $\deg_k(H_n)$ deviates from its expectation. On the technical side, our proofs are based on the analysis of a randomized algorithm that generates unlabeled trees in the so-called Boltzmann model. The analysis of such algorithms is quite well-understood for classes of labeled

graphs. Comparable algorithms for unlabeled classes are unfortunately much more complex. We demonstrate in this work that they can be analyzed very precisely for classes of unlabeled graphs as well.

keywords: random unlabeled trees, degree sequence, Boltzmann sampling.

Distributive Lattice Polyhedra

by Yulia Kempner and Vadim E. Levit

Abstract: Poly-antimatroids are generalization of the notion of antimatroid to multisets. When the underlying set consists of only two elements, such two-dimensional poly-antimatroids correspond to point sets in the integer lattice \mathbb{Z}^d . In this research we concentrate on geometrical properties of two-dimensional poly-antimatroids and prove that these sets form distributive lattice polyhedra. Our findings imply that two-dimensional poly-antimatroids have convex dimension 2. Further we investigate geometrical properties of three-dimensional distributive lattice polyhedra.

keywords: antimatroid, convex dimension, distributive lattice, polyomino.

Chip-Firing, Antimatroids, and Polyhedra

by Kolja Knauer

Abstract: Starting from the chip-firing game of Björner and Lovász we consider a generalization to vector addition systems that still admit algebraic structures as sandpile group or sandpile monoid. Every such vector addition language yields an antimatroid. We show that conversely every antimatroid can be represented this way. The inclusion order on the feasible sets of an antimatroid is an upper locally distributive lattice. We characterize polyhedra, which carry an upper locally distributive structure and show that they can be modelled by chip-firing games with gains and losses. At the end we point out a connection to a membership problem discussed by Korte and Lovász.

keywords: antimatroid, chip-firing game, vector addition language, upper locally distributive lattice, membership problem.

Graph homomorphisms, the Tutte polynomial and " q -state Potts uniqueness"

by Delia Garijo, Andrew Goodall and Jaroslav Nešetřil

Abstract: We establish for which weighted graphs H homomorphism functions from multigraphs G to H are specializations of the Tutte polynomial of G , answering a question of Freedman, Lovász and Schrijver. We introduce a new property of graphs called " q -state Potts uniqueness" and relate it to chromatic and Tutte uniqueness, and also to "chromaticflow uniqueness", recently studied by Duan, Wu and Yu.

keywords: Tutte polynomial, chromatic polynomial, flow polynomial, q -state Potts partition function, graph homomorphism, homomorphism profile.

A note on some inequalities for the Tutte polynomial of a matroid

by Criel Merino, Marcelino Ibañez and M. Guadalupe Rodríguez

Abstract: We prove that if a matroid M contains two disjoint bases (or, dually, if its ground set is the union of two bases), then $T_M(a, a) \leq \max\{T_M(2a, 0), T_M(0, 2a)\}$ for $a \geq 2$. This resembles the conjecture that appears in C. Merino and D.J.A. Welsh, Forests, colourings and acyclic orientations of the square lattice, *Annals of Combinatorics* 3 (1999) pp. 417429: If G is a 2-connected graph with no loops, then $T_G(1, 1) \leq \max\{T_G(2, 0), T(0, 2)\}$. We conjecture that $T_M(1, 1) \leq \max\{T_M(2, 0), T_M(0, 2)\}$ for matroids which contains two disjoint bases or its ground set is the union of two bases. We also prove the latter for some families of graphs and matroids.

keywords: matroid, Tutte polynomial.

Extended Gallai's Theorem

by Yared Nigussie

Abstract: Let G and H be graphs. We say G is H -critical, if every proper subgraph of G except G itself is homomorphic to H . This generalizes the widely known concept of k -color-critical graphs, as they are the case $H = K_{k-1}$. In 1963 [2], Gallai proved that the vertices of degree k in a K_k -critical graph induce a subgraph whose blocks are either odd cycles or complete graphs. We generalize Gallai's Theorem for every H -critical graph, where $H = K_{k-2} + H'$, (the join of a complete graph K_{k-2} with any graph H'). This answers one of the two unknown cases of a problem given in [7]. We also propose an open question, which may be a characterization of all graphs for which Gallai's Theorem holds.

keywords: graph homomorphism, H -coloring, H -critical graphs.

Small clique large chromatic number

by A.M. Raigordskii and O.I. Rubanov

Abstract: In this paper, we will exhibit old and new results concerning distance graphs with simultaneously small clique and large chromatic numbers.

keywords: chromatic numbers, clique numbers, distance graphs, Ramsey theory.

On a Conjecture of Fan and Raspaud

by Edita Máčajová and Martin Škoviera

Abstract: We show that every bridgeless cubic graph having a 2-factor with at most two odd circuits admits three perfect matchings with no common edge. This partially verifies a conjecture of Fan and Raspaud (1994) and supports Fulkerson's conjecture (1971).

keywords: cubic graph, perfect matching, Fulkerson's conjecture.

On distance edge-colourings and matchings

by Ross Kang and Putra Manggala

Abstract: We consider a distance generalisation of the strong chromatic index and the maximum induced matching number, for graphs of bounded maximum degree and Erdős Rényi random graphs.

keywords: graph colouring, graphs of bounded maximum degree, random graphs, distance edge colouring, induced matching.

Spanning trees in 3-connected $K_{3,t}$ -minor-free graphs

by Katsuhiko Ota and Kenta Ozeki

Abstract: Barnette proved that every 3-connected planar graph has a 3-tree, where a 3-tree is a spanning tree whose maximum degree is at most three. In this paper, we consider an improvement of Barnette's result for the direction of $K_{3,t}$ -minor-free graphs. Note that any planar graph is $K_{3,3}$ -minor-free. Actually, we show that for an even integer $t \geq 3$, any 3-connected $K_{3,t}$ -minor-free graph has a $(t - 1)$ -tree.

keywords: spanning tree, planar graphs, $K_{3,t}$ -minor-free graphs.

Ear decompositions of a cubic bridgeless graph and near P_4 -decompositions of its deck

by Roland Häggkvist

Abstract: We show that when building an ear decomposition of a cubic bridgeless graph, it is possible to do this so that at each step, the graph outside the already built two-connected subgraph, has a 2-factor. It shall also be shown that every edge in a cubic bipartite graph is either a chord in some 2-factor or part of a 2-edge-cut. Furthermore every 3-regular bipartite graph has some 2-factor with a chord and if v is a vertex in a bipartite 3-regular graph B then B has a 2-factor F such that the component of F containing v has a chord at v , unless there exists a 2-vertex-cut $\{u, v\}$ such that $B - \{u, v\}$ has three components. We also show that if we let v be a vertex in a bridgeless cubic graph G , then $G - v$ is the edge-disjoint union of paths of length 3 and at most one triangle. Finally let G be a 3-regular multigraph which can be made bipartite by the deletion of at most two edges, then G is 3-edge colourable.

keywords: ear decomposition, chord in 2-factors, P_4 -decomposition, edge 3-colorability.

Every rayless graph has an unfriendly partition

by Henning Bruhn, Reinhard Diestel, Agelos Georgakopoulos and Philipp Sprüssel

Abstract: It is proved that every graph containing no infinite path has an unfriendly partition.

keywords: unfriendly partition, rayless graphs.

Unifying the representation of symmetric crossing families and weakly partitive families

by B.-M. Bui-Xuan and M. Habib

Abstract: The family of non-trivial minimizers of a symmetric submodular function is symmetric crossing, namely it is closed under the complementation of any member and under the intersection of its crossing members. The family of modules of a graph is weakly partitive, namely it is closed under the intersection, union, and difference of its overlapping members. Any symmetric

crossing (resp. weakly partitive) family $F \subseteq 2^X$ has an $O(|X|)$ space representation [5,6] (resp. [4,8]). In [2] we gave a general framework for representing any set family by a tree. This is a natural extension of the above mentioned result on symmetric crossing families. We here show how our framework also captures, in a non-trivial way, the above mentioned result on weakly partitive families. Among the consequences, this is the first result generalizing both the modular decomposition of a graph and the structural behaviour of the minimizers of a symmetric submodular function.

keywords: symmetric crossing family, weakly partitive family, cross-free family, laminar family, symmetric submodular function minimization, modular decomposition.

Thursday morning talks

On the reconstruction of graph invariants

by *T. Kotek*

Abstract: The reconstruction conjecture has remained open for simple undirected graphs since it was suggested in 1941 by Kelly and Ulam. In an attempt to prove the conjecture, many graph invariants have been shown to be reconstructible from the vertex-deleted deck, and in particular, some prominent graph polynomials. Among these are the Tutte polynomial, the chromatic polynomial and the characteristic polynomial. We show that the interlace polynomial, the U -polynomial, the universal edge elimination polynomial ξ and the colored versions of the latter two are reconstructible. We also present a method of reconstructing boolean graph invariants, or in other words, proving recognizability of graph properties (of colored or uncolored graphs), using first order logic.

keywords: reconstruction conjecture, graph polynomial, colored graphs.

On t -Cliques in k -Walk-Regular Graphs

by *C. Dalfó, M.A. Fiol and E. Garriga*

Abstract: A graph is walk-regular if the number of cycles of length l rooted at a given vertex is a constant through all the vertices. For a walk-regular graph G with $d + 1$ different eigenvalues and spectrally maximum diameter $D = d$, we study the geometry of its d -cliques, that is, the sets of vertices which are mutually at distance d . When these vertices are projected onto an eigenspace of its adjacency matrix, we show that they form a regular tetrahedron and we compute its parameters. Moreover, the results are generalized to the case of k -walk-regular graphs, a family which includes both walk-regular and distance-regular graphs, and their t -cliques or vertices at distance t from each other.

keywords: distance-regular graphs, k -walk-regular graphs, spectrum, clique.

Avoider-Enforcer: The Rules of the Game

by Dan Hefetz, Michael Krivelevich, Miloš Stojaković and Tibor Szabó

Abstract: An Avoider-Enforcer game is played by two players, called Avoider and Enforcer, on a hypergraph $F \subseteq 2^X$. The players claim previously unoccupied elements of the board X in turns. Enforcer wins if Avoider claims all vertices of some element of F , otherwise Avoider wins. In a more general version of the game a bias b is introduced to level up the players' chances of winning; Avoider claims one element of the board in each of his moves, while Enforcer responds by claiming b elements. This traditional set of rules for Avoider-Enforcer games is known to have a shortcoming: it is not bias monotone. We relax the traditional rules in a rather natural way to obtain bias monotonicity. We analyze this new set of rules and compare it with the traditional ones to conclude some surprising results. In particular, we show that under the new rules the threshold bias for both the connectivity and Hamiltonicity games, played on the edge set of the complete graph K_n , is asymptotically equal to $n/\log n$.

keywords: positional games, connectivity, Hamiltonicity.

Playing to retain the advantage

by Dan Hefetz, Noga Alon and Michael Krivelevich

Abstract: Let P be a monotone decreasing graph property, let $G = (V, E)$ be a graph, and let q be a positive integer. In this paper, we study the $(1 : q)$ Maker-Breaker game, played on the edges of G , in which Maker's goal is to build a graph that does not satisfy the property P . It is clear that in order for Maker to have a chance of winning, G must not satisfy P . We prove that if G is far from satisfying P , that is, if one has to delete sufficiently many edges from G in order to obtain a graph that satisfies P , then Maker has a winning strategy for this game. We also consider a different notion of being far from satisfying some property, which is motivated by a problem of Duffus, Luczak

and Rödl [3].

keywords: positional games, monotone property.

A Linear Programming Construction of Fully Optimal Bases in Graphs and Hyperplane Arrangements

by Emeric Gioan and Michel Las Vergnas

Abstract: The fully optimal basis of a bounded acyclic oriented matroid on a linearly ordered set has been defined and studied by the present authors in a series of papers, dealing with graphs, hyperplane arrangements, and oriented matroids (in order of increasing generality). This notion provides a bijection between bipolar orientations and uniaactive internal spanning trees in a graph resp. bounded regions and uniaactive internal bases in a hyperplane arrangement or an oriented matroid (in the sense of Tutte activities). This bijection is the basic case of a general activity preserving bijection between reorientations and subsets of an oriented matroid, called the active bijection, providing bijective versions of various classical enumerative results. Fully optimal bases can be considered as a strenghtening of optimal bases from linear programming, with a simple combinatorial definition. Our first construction used this purely combinatorial characterization, providing directly an algorithm to compute in fact the reverse bijection. A new definition uses a direct construction in terms of a linear programming. The fully optimal basis optimizes a sequence of nested faces with respect to a sequence of objective functions (whereas an optimal basis in the usual sense optimizes one vertex with respect to one objective function). This note presents this construction in terms of graphs and linear algebra.

Outerplanar Obstructions for the Feedback Vertex Set

by Juanjo Rué

Abstract: For $k \leq 1$, let F_k be the class containing every graph that contains k vertices meeting all its cycles. The minor-obstruction set for F_k is the set $bs(F_k)$ containing all minor-minimal graph that does not belong to F_k . We denote by Y_k the set of all outerplanar graphs in $bs(F_k)$. In this paper, we provide a precise characterization of the class Y_k . Then, using the symbolic method, we prove that $|Y_k| \sim \alpha \cdot k^{-5/2} \cdot \rho^{-k}$ where $\alpha = 0.02602193$ and $\rho^{-1} = 14.49381704$.

keywords: graph minors, outerplanar graphs, obstructions, feedback vertex set, graph enumeration, singularity analysis.

Some properties of edge intersection graphs of single bend paths on a grid

by Bernard Ries

Abstract: We consider the family of intersection graphs G of paths on a grid, where every vertex v in G corresponds to a single bend path P_v on a grid, and two vertices are adjacent in G if and only if the corresponding paths share an edge on the grid. We first show that these graphs have the Erdős-Hajnal property. Then we present some properties concerning the neighborhood of a vertex in these graphs, and finally we consider some subclasses of chordal graphs for which we give necessary and sufficient conditions to be edge intersection graphs of single bend paths in a grid.

keywords: edge intersection graph, chordal graph, forbidden induced subgraph, neighborhood.

Randomized algorithms for the majority problem

by *Demetres Christofides*

Abstract: In the majority problem, we are given n balls coloured black or white and we are allowed to query whether two balls have the same colour or not. The goal is to find a ball of majority colour in the minimum number of queries. The answer is known to be $n - B(n)$, where $B(n)$ is the number of 1's in the binary representation of n . In [5], De Marco and Pelc proved that even if we use a randomized algorithm which is allowed to fail with probability at most ϵ , we still need linear expected time to determine a ball in majority colour. We prove that any such algorithm has 2 expected running time at least $(2/3 - \delta(\epsilon))n$, where $\delta(\epsilon) \rightarrow 0$ as $\epsilon \rightarrow 0$. Moreover, we provide a randomized algorithm showing that this result is best possible.

keywords: randomized algorithms, majority problem.

Forcing spanning subgraphs via Ore type conditions

by *Julia Böttcher and Sybille Müller*

Abstract: We determine an Ore type condition that allows the embedding of 3-colourable bounded degree graphs of sublinear bandwidth: For all $\Delta, \gamma > 0$ there are $\beta, n_0 > 0$ such that for all $n \geq n_0$ the following holds. Let $G = (V, E)$ and H be n -vertex graphs such that H is 3-colourable, has maximum degree $\Delta(H) \leq \Delta$ and bandwidth $bw(H) \leq \beta n$, and G satisfies $\deg(u) + \deg(v) \geq (4/3 + \gamma)n$ for all $uv \notin E$. Then G contains a copy of H . This improves on the Bollobás-Komlós conjecture for 3-chromatic graphs proven by Böttcher, Schacht, and Taraz [J. Combin. Theory, Ser. B, 98(4), 752777, 2008] and applies a result of Kierstaed and Kostochka [J. Comb. Theory, Ser. B, 98(1), 226234, 2008] about the existence of spanning triangle factors under Ore type conditions.

keywords: extremal graph theory, regularity lemma, spanning subgraphs, Ore condition.

Spanning galaxies in digraphs

by Daniel Gonçalves, Alexandre Pinlou, Stéphan Thomassé and Frédéric Havet

Abstract: A star is an arborescence in which the root dominates all the other vertices. A galaxy is a vertex-disjoint union of stars. The directed star arboricity of a digraph D , denoted by $dst(D)$, is the minimum number of galaxies needed to cover $A(D)$. In this paper, we show that $dst(D) \leq \Delta(D) + 1$ and that if D is acyclic then $dst(D) \leq \Delta(D)$. These results are proved by considering the existence of spanning galaxies in digraphs. Thus, we study the problem of deciding whether a digraph D has a spanning galaxy or not. We show that it is NP-complete (even when restricted to acyclic digraphs) but that it becomes polynomialtime solvable when restricted to strongly connected digraphs.

keywords: directed graph, spanning star forest, even subgraph, directed star arboricity.

Disjoint Even Cycles Packing

by Shuya Chiba, Shinya Fujita, Ken-ichi Kawarabayashi and Tadashi Sakuma

Abstract: We generalize the well-known theorem of Corrádi and Hajnal which says that if a given graph G has at least $3k$ vertices and the minimum degree of G is at least $2k$, then G contains k vertex-disjoint cycles. Our main result is the following; for any integer k , there is an absolute constant c_k satisfying the following; let G be a graph with at least c_k vertices such that the minimum degree of G is at least $2k$. Then either (i) G contains k vertex-disjoint even cycles, or (ii) $(2k - 1)K_1 + pK_2 \subseteq G \subseteq K_{2k-1} + pK_2$ ($p \geq k \geq 2$), or $k = 1$ and each block in G is either a K_2 or a odd cycle, especially, each endblock in G is a odd cycle. In fact, our proof implies the following; the "even cycles" in the conclusion (i) can be replaced by "theta graphs", where a theta graph is a graph that has two vertices x, y such that there are three disjoint paths between x and y . Let us observe that if there is a theta graph, then there is an even cycle in it. Furthermore, if the conclusion (ii) holds, clearly there are no k vertex-disjoint even cycles (and hence no k vertex-disjoint theta graphs).

keywords: even cycle, theta graph, vertex-disjoint.

Cubic bridgeless graphs have more than a linear number of perfect matchings

by Louis Esperet, Frantiek Kardoš and Daniel Král'

Abstract: Lovász and Plummer conjectured in the 1970's that cubic bridgeless graphs have exponentially many perfect matchings. This conjecture has been verified for bipartite graphs by Voorhoeve (1979), and for planar graphs by Chudnovsky and Seymour (2008). In this paper, we provide the first superlinear bound in the general case.

keywords: perfect matchings, cubic graphs.

Obstructions for Tree-depth

by Archontia C. Giannopoulou and Dimitrios M. Thilikos

Abstract: For every $k \geq 0$, we define G_k as the class of graphs with tree-depth at most k , i.e. the class containing every graph G admitting a valid colouring $\rho : V(G) \rightarrow 1, \dots, k$ such that every (x, y) -path between two vertices where $\rho(x) = \rho(y)$ contains a vertex z where $\rho(z) > \rho(x)$. In this paper we study the class $bs(G_k)$ of minor-minimal elements not belonging in G_k for every $k \geq 0$. We give a precise characterization of $G_k, k \leq 3$ and prove a structural lemma for creating graphs $G \in bs(G_k), k > 0$. As a consequence, we obtain a precise characterization of all acyclic graphs in $bs(G_k)$ and we prove that they are exactly $\frac{1}{2}2^{2^{k-1}-k}(1 + 2^{2^{k-1}-k})$.

keywords: graph minors, tree depth, obstructions, graph enumeration, vertex rankings.

On the Tree-Width of Planar Graphs

by Youssou Dieng and Cyril Gavoille

Abstract: We prove that every planar graph G of tree-length l has a tree-decomposition for which every bag is the union of at most 10 shortest paths of length $O(l)$. As a consequence, the tree-width of G is bounded by $O(l)$, generalizing the linear local tree-width result of planar graphs, since the tree-length of a graph does not exceed its diameter. Such a tree-decomposition can be computed in polynomial time without any prior decomposition of the input graph.

keywords: tree-width, tree-length, planar graphs, tree-decomposition.

On Erdős-Szekeres-type problems

by V.A. Koshelev

Abstract: In this paper, we will present some of our recent results concerning the classical Erdős-Szekeres problem in combinatorial geometry.

keywords: general position, convex polygons, empty polygons, Ramsey theory.

Flip Graphs of Bounded-Degree Triangulations

by O. Aichholzer, T. Hackl, D. Orden, P. Ramos, G. Rote, A. Schulz and B. Speckmann

Abstract: We study flip graphs of triangulations whose maximum vertex degree is bounded by a constant k . Specifically, we consider triangulations of sets of n points in convex position in the plane and prove that their flip graph is connected if and only if $k > 6$; the diameter of the flip graph is $O(n^2)$. We also show that for general point sets, flip graphs of triangulations with degree $\leq k$ can be disconnected for any k .

keywords: triangulation, flip graph, degree bound, flipping distance.

Thursday afternoon talks

The tripartite Ramsey number for trees

by Julia Böttcher, Jan Hladký and Diana Piguet

Abstract: We prove that for every $\epsilon > 0$ there are $\alpha > 0$ and $n_0 \in \mathbb{N}$ such that for all $n \geq n_0$ the following holds. For any two-colouring of the edges of $K_{n,n,n}$ one colour contains copies of all trees T of order $k \leq (3 - \epsilon)n/2$ and with maximum degree $\Delta(T) \leq n^\alpha$. This answers a conjecture of Schelp.

keywords: Ramsey theory, trees, regularity lemma, connected matchings.

On Extremal Graphs with Bounded Girth

by Charles Delorme, Evelyne Flandrin, Yuqing Lin, Mirka Miller and Joe Ryan

Abstract: By the extremal number $ex(n; t) = ex(n; \{C_3, C_4, \dots, C_t\})$ we denote the maximum size (number of edges) in a graph of n vertices, $n > t$, and girth (length of shortest cycle) at least $g \geq t + 1$. In 1975, Erdős proposed the problem of determining the extremal numbers $ex(n; 4)$ of a graph of n vertices and girth at least 5. In this paper, we consider a generalized version of this problem, for $t \geq 5$. In particular, we prove that $ex(n; 6)$ for $n = 29, 30$ and 31 is equal to 45, 47 and 49, respectively.

keywords: extremal graph, extremal number, forbidden cycles, size, girth.

Graphs of odd girth 7 with large degree

by Stephan Brandt and Elizabeth Ribe-Baumann

Abstract: We show that every graph with minimum degree $\delta > 4n/17$ and no odd cycles of length 3 or 5 is homomorphic with the Möbius ladder with 6 rungs and include the extremal graph characterization in the case of equality. The key tools used in our observations are simple characteristics of maximal odd girth 7 graphs.

keywords: odd girth, minimum degree, extremal graph theory.

Game chromatic number of toroidal grids

by Jiaojiao Wu and André Raspaud

Abstract: A toroidal grid graph is the Cartesian product of two cycles. We prove that the maximum game chromatic number of toroidal grids is 5.

keywords: game chromatic number, game coloring number, toroidal grids.

Fractionally Edge Colouring Graphs with Large Maximum Degree in Linear Time

by W. Sean Kennedy, Conor Meagher and Bruce Reed

Abstract: For any $c > 1$, we describe a linear time algorithm for fractionally edge colouring simple graphs with maximum degree at least $|V|/c$.

keywords: edge colouring, overfull subgraph, fractional chromatic index.

d -collapsibility is NP-complete for $d \geq 4$

by *Martin Tancer*

Abstract: A simplicial complex is d -collapsible if it can be reduced to an empty complex by repeatedly removing (collapsing) a face of dimension at most $d - 1$ that is contained in a unique maximal face. We prove that the algorithmic question whether a given simplicial complex is d -collapsible is NP-complete for $d \geq 4$ and polynomial time solvable for $d \leq 2$. As an intermediate step, we prove that d -collapsibility can be recognized by the greedy algorithm for $d \leq 2$, but the greedy algorithm does not work for $d \geq 3$.

keywords: simplicial complex, d -collapsibility, d -representability, NP-complete.

On the chromatic numbers of small-dimensional Euclidean spaces

by *A.B. Kupavskii and A.M. Raigordskii*

Abstract: In this paper, we will give a short survey concerning estimates on the chromatic numbers of Euclidean spaces in small dimensions. We will also present some new important bounds.

keywords: chromatic numbers, distance graphs.

Wilson-Schreiber Colourings of Cubic Graphs

by *Mike J. Grannell, Terry S. Griggs, Edita Máčajová and Martin Škovič*

Abstract: An S -colouring of a cubic graph G is an edge-colouring of G by points of a Steiner triple system S such that the colours of any three edges meeting at a vertex form a block of S . In this note we present an infinite family of point-intransitive Steiner triple systems S such that (1) every simple cubic graph is S -colourable and (2) no proper subsystem of S has the same property. Only one point-intransitive system satisfying (1) and (2) was previously

known.

keywords: cubic graph, edge-colouring, Steiner triple system.

List colorings with distinct list sizes, the case of complete bipartite graphs

by Zoltán Füredi and Ida Kantor

Abstract: A graph G is f -choosable if for every collection of lists with list sizes specified by f there is a proper coloring using colors from the lists. The sum choice number, $\chi_{sc}(G)$, is the minimum of $\sum f(v)$, over all f such that G is f -choosable. In this paper we show that $\chi_{sc}(G)/|V(G)|$ can be bounded while the minimum degree $\delta_{min}(G) \rightarrow \infty$. (This is not true for the list chromatic number, $\chi_l(G)$). Our main tool is to give tight estimates for the sum choice number for the complete bipartite graphs $K_{a,q}$.

keywords: graphs, list chromatic number.

Cycle codes of graphs and MDS array codes

by Oriol Serra and Gilles Zémor

Abstract: We investigate how to colour edges of graph so that any two colours make up a spanning tree. This problem is equivalent to transforming the cycle code of a graph into a Maximum Distance Separable (MDS) array code. Adopting this graph-theoretical interpretation allows us to provide a compact description of some families of low density MDS array codes in terms of cycle codes of coloured graphs. This includes a short description of Xu et al.'s "B-code", together with its erasure and error decoding algorithms. We also give a partial answer to Xu et al.'s question about efficient error decoding for the dual B-code. We give alternative families of MDS array cycle codes, and in passing prove that an optimal MDS array cycle code of minimum column distance 4 is given by an appropriate colouring of the Petersen graph. We introduce double array colourings which allow the decoding of column or row errors and provides a new interesting graph theoretical problem. We give

infinite families of graphs which admit double array colourings.

Weighted perfect codes in Lee metric

by *P. Dorbec, S. Gravier, I. Honkala and M. Mollard*

Abstract: In this talk, we will present results about perfect weighted coverings of radius 1 in the Lee metric. Weighted coverings are a very natural generalization of many classes of codes. Perfect weighted coverings are well studied in the Hamming metric, but also in other contexts with different names, such as regular-sets, multiple coverings or $[a, b]$ -dominating sets. In this talk, we present results of existence as well as of non-existence for perfect weighted coverings of radius one on the multidimensional grid graphs.

keywords: Weighted codes, Lee metric, regular sets, multiple coverings.

Identifying Codes in Trees and Planar Graphs

by *David Auger*

Abstract: We deal with a few issues related to the problem of finding the minimum size of an identifying code in a graph. First, we provide a linear algorithm which computes an identifying code with minimal size in a given tree. Second, we extend known NP-hardness results by showing that this problem remains NP-hard in the class of planar graphs with arbitrary high girth and maximal degree at most 4. We give similar results for the problem of finding the minimum size of an $(r, \leq l)$ -identifying code, for all $r \geq 1$ and $l \in \{1; 2\}$.

keywords: graph theory, identifying codes, planar graphs, NP-completeness.

Friday morning talks

Antibandwidth and Cyclic Antibandwidth of Hamming Graphs

by *Stefan Dobrev, Rastislav Kráľovič, Dana Pardubská, Ľubomír Török and Imrich Vrto*

Abstract: The antibandwidth problem is to label vertices of graph $G(V, E)$ bijectively by integers $0, 1, \dots, |V| - 1$ in such a way that the minimal difference of labels of adjacent vertices is maximised. In this paper we study the antibandwidth of Hamming graphs. We provide labeling algorithms and tight upper bounds for general Hamming graphs $\prod_{k=1}^d K_{n_k}$. We have exact values for special choices of n_i 's and equality between antibandwidth and cyclic antibandwidth values.

keywords: antibandwidth, Hamming graph.

Hypercube 1-factorizations from extended Hamming codes

by *Petr Gregor*

Abstract: Based on the extended Hamming code, for $n = 2^r$ we construct a proper edgecoloring of the n -dimensional hypercube Q^n with n colors (i.e. 1-factorization) such that every edge has exactly one parallel edge from each color class except its own. Two edges are said to be parallel if they are opposite on a common 4-cycle. We study properties of this coloring and applications for some Turán-type problems.

keywords: hypercube, 1-factorization, extended Hamming code, Turán problems.

On even-cycle-free subgraphs of the hypercube

by Zoltán Füredi and Lale Özkahya

Abstract: It is shown that the size of a subgraph of the hypercube Q_n without a cycle of length $4k + 2$ for integer $k \geq 3$ is of order $o(|E(Q_n)|)$.

keywords: hypercube, generalized Turan problem.

Long paths and cycles in faulty hypercubes: existence, optimality, complexity

by Tomáš Dvořák, Jiří Fink, Petr Gregor and Václav Koubek

Abstract: A fault-free cycle in the n -dimensional hypercube Q_n with f faulty vertices is long if it has length at least $2^n - 2f$. If all faulty vertices are from the same bipartite class of Q_n , such length is the best possible. We prove a conjecture of Castañeda and Gotchev [2] asserting that $f_n = \binom{n}{2} - 2$ where f_n is the largest integer such that for every set of at most f_n faulty vertices, there exists a long fault-free cycle in Q_n . Furthermore, we present several results on similar problems of long paths and long routings in faulty hypercubes and their complexity.

keywords: hypercube, faulty vertex, long path, long cycle, NP-hard.

Combinatorial properties of Catalan pairs

by Filippo Disanto, Simone Rinaldi, Luca Ferrari and Renzo Pinzani

Abstract: We define the notion of a Catalan pair, which is a pair of (strict) order relations (S, R) satisfying certain axioms. We show that Catalan pairs of size n are counted by Catalan numbers. We study some combinatorial properties of the relations R and S . In particular, we show that the second

component R uniquely determines the pair, and we give a characterization of the poset R in terms of forbidden configurations. We also propose some generalizations of Catalan pairs arising from the modification of one of the axioms.

keywords: Catalan numbers, partially ordered sets, enumeration.

On the maximum number of cycles in outerplanar and series-parallel graphs

by Anna de Mier and Marc Noy

Abstract: Let $c(n)$ be the maximum number of cycles in an outerplanar graph with n vertices. We show that $\lim c(n)^{1/n}$ exists and equals $\beta = 1.502837\dots$, where β is a constant related to the recurrence $x_{n+1} = 1 + x_n^2$, $x_0 = 1$. The same result holds for the n larger class of series-parallel graphs.

keywords: number of cycles, outerplanar graph, series-parallel graph.

Bijections on two variations of noncrossing partitions

by Jang Soo Kim

Abstract: We find bijections on 2-distant noncrossing partitions, 12312-avoiding partitions, 3-Motzkin paths, UH-free Schröder paths and Schröder paths without peaks at even height.

keywords: noncrossing partitions, Motzkin paths, Schröder paths.

Coloring a set of touching strings

by Louis Esperet, Daniel Gonçalves and Arnaud Labourel

Abstract: For a family F of geometric objects in the plane, define $\chi(F)$ as the least integer l such that the elements of F can be colored with l colors, in such a way that any two intersecting objects have distinct colors. When F is a set of Jordan regions that may only intersect on their boundaries, and such that any point of the plane is contained in at most k regions, it can be proven that $\chi(F) \leq 3k/2 + o(k)$ since the problem is equivalent to cyclic coloring of plane graphs [1]. In this paper, we study the same problem when Jordan regions are replaced by Jordan curves that do not cross (two curves are only allowed to "touch" each other). We conjecture that also in this case, $\chi(F)$ is bounded by ck for some $c > 0$. To support this conjecture, we prove it when the curves are x -monotone (any vertical line intersect each curve at most once), and we give a bound in the general case that also depends on how many times two curves intersect.

Degree sequences forcing Hamilton cycles in directed graphs

by Daniela Kühn, Deryk Osthus and Andrew Treglown

Abstract: We prove the following approximate version of Pósa's theorem for directed graphs: every directed graph on n vertices whose in- and outdegree sequences satisfy $d_i^- \geq i + o(n)$ and $d_i^+ \geq i + o(n)$ for all $i \leq n/2$ has a Hamilton cycle. In fact, we prove that such digraphs are pancyclic (i.e. contain cycles of lengths $2, \dots, n$). We also prove an approximate version of Chvátal's theorem for digraphs. This asymptotically confirms conjectures of Nash-Williams from 1968 and 1975.

keywords: directed graphs, Hamilton cycles, degree sequences.

l -distant Hamiltonian walks in Cartesian product graphs

by Olivier Togni

Abstract: We introduce and study a generalisation of Hamiltonian cycles: an l -distant Hamiltonian walk in a graph G of order n is a cyclic ordering of its vertices in which consecutive vertices are at distance l . Conditions for a Cartesian product graph to possess such an l -distant Hamiltonian walk are given and more specific results are presented concerning toroidal grids.

keywords: Hamiltonicity, distance, radio labeling, Gray code.

Hamilton cycles in 6-connected claw-free graphs

by Tomáš Kaiser and Petr Vrána

Abstract: Thomassen conjectured in 1986 that every 4-connected line graph is hamiltonian. In this paper, we show that 6-connected line graphs are hamiltonian, improving on an analogous result for 7-connected line graphs due to Zhan in 1991. Our result implies that every 6-connected claw-free graph is hamiltonian.

keywords: Hamilton cycle, line graph, claw-free graph, connectivity.

Counting flags in triangle-free digraphs

by Jan Hladký, Daniel Král' and Sergey Norin

Abstract: We prove that every digraph on n vertices with minimum out-degree $0.3465n$ contains an oriented triangle. This improves the bound of $0.3532n$ of Hamburger, Haxell and Kostochka. The main tool for our proof is the theory of flag algebras developed recently by Razborov.

keywords: Caccetta-Häggkvist Conjecture, triangles in digraphs, flag algebras.

Codings of rotations on two intervals are full

by A. Blondin Massé, S. Brlek, S. Labbé and L. Vuillon

Chromatic number of sparse colored mixed planar graphs

by Amanda Montejano, Alexandre Pinlou, André Raspaud and Éric Sopena

Abstract: A colored mixed graph has vertices linked by both colored arcs and colored edges. The chromatic number of such a graph G is defined as the smallest order of a colored mixed graph H such that there exists a (arc-color preserving) homomorphism from G to H . We study in this paper the colored mixed chromatic number of planar graphs, partial 2-trees and outerplanar graphs with given girth.

keywords: mixed graph, planar, girth, chromatic number, homomorphism.

On the Plane-Width of Graphs

by Marcin Kamiński, Paul Medvedev and Martin Milani

Abstract: Map vertices of a graph to (not necessarily distinct) points of the plane so that two adjacent vertices are mapped at least a unit distance apart. The plane-width of a graph is the minimum diameter of the image of the vertex set over all such mappings. We establish a relation between the plane-width of a graph and its chromatic number, and connect it to other well-known areas, including the circular chromatic number and the problem of packing unit discs in the plane.

keywords: plane-width, realization of a graph, chromatic number, circular chromatic number.

Lower Bounds for Pinning Lines by Balls

by Otfried Cheong, Xavier Goaoc and Andreas Holmsen

Abstract: It is known that if $n \geq 2d$ pairwise disjoint balls in R^d have a unique line l intersecting them in a given order \prec , one can always remove a ball so that l remains the only line intersecting the balls in the order induced by \prec . We show that the constant $2d$ is best possible, in any dimension, and derive lower bounds on Helly numbers for sets of line transversals to disjoint balls in arbitrary dimension.

keywords: discrete geometry, geometric transversal, Helly-type Theorem.

Friday afternoon talks

Discrete Concavity and Zeros of Polynomials

by Petter Brändén

Abstract: Murota et al. have recently developed a theory of discrete convex analysis as a framework to solve combinatorial optimization problems using ideas from continuous optimization. This theory concerns M -convex functions on jump systems. We introduce here a family of M -concave functions arising naturally from polynomials (over the field of Puiseux series) with prescribed non-vanishing properties. We also provide a short proof of Speyer's "hive theorem" which he used to give a new proof of Horn's conjecture on eigenvalues of sums of Hermitian matrices. Due to limited space a more coherent treatment and proofs will appear elsewhere.

keywords: M -convex, jump system, matroid, half-plane property, Puiseux series, Tarski's principle, hive, Horn's conjecture.

On the Superconnectivity in graphs with odd girth g and even girth h

by Luis Pedro Montejano, Camino Balbuena and Pedro García-Vázquez

Abstract: A maximally connected graph G of minimum degree δ is said to be superconnected (for short super- κ) if all disconnecting sets of cardinality δ are the neighborhood of some vertex of degree δ . Sufficient conditions on the diameter to guarantee that a graph of odd girth g and even girth $h \geq g + 3$ is super- κ are stated. Also polarity graphs are shown to be super- κ .

keywords: polarity graphs, superconnectivity, diameter, girth, girth pair.

On the distribution of permanents of matrices over finite fields

by *Le Anh Vinh*

Abstract: For a prime power q , we study the distribution of permanents of $n \times n$ matrices over a finite field F_q of q elements. We show that if A is a sufficient large subset of F_q then the set of permanents of $n \times n$ matrices with entries in A covers all (or almost) F_q^* . When $q = p$ is a prime, and A is a subinterval of $[0, p - 1]$ of q cardinality $|A| \gg p^{1/2} \log p$, we show that the number of matrices with entries in A having permanent t is asymptotically close to the expected value. We also study this problem in more general settings.

keywords: permanent, matrices over finite fields.

Factorization and catenary degree in 3-generated numerical semigroups

by *Francesc Aguiló-Gost and Pedro A. García-Sánchez*

Abstract: Given a numerical semigroup $S(A)$, generated by $A = \{a, b, N\} \subset \mathbb{N}$ with $0 < a < b < N$ and $\gcd(a, b, N) = 1$, we give a parameterization of the set $F(m; A) = \{(x, y, z) \in \mathbb{N}^3 \mid xa + yb + zN = m\}$ for any $m \in S(A)$. We also give the catenary degree of $S(A)$, $c(A)$. Boths results need the computation of an L -shaped tile, related to the set A , that has time-complexity $O(\log N)$ in the worst case.

keywords: double-loop digraph, numerical semigroup, L -shape, factorization, catenary degree.

Bounds for the b -chromatic number of vertex-deleted subgraphs and the extremal graphs

by *S. Francis Raj and R. Balakrishnan*

keywords: achromatic number, b -chromatic number.

Acyclic choosability of planar graphs : a Steinberg like approach

by *Hervé Hocquard and Mickaël Montassier*

Abstract: An acyclic coloring of a graph G is a coloring of its vertices such that : (i) no two adjacent vertices in G receive the same color and (ii) no bicolored cycles exist in G . A list assignment of G is a function L that assigns to each vertex $v \in V(G)$ a list $L(v)$ of available colors. Let G be a graph and L be a list assignment of G . The graph G is acyclically L -list colorable if there exists an acyclic coloring of G such that $\phi(v) \in L(v)$ for all $v \in V(G)$. If G is acyclically L -list colorable for any list assignment L with $|L(v)| \geq k$ for all $v \in V(G)$, then G is acyclically k -choosable. In this note, we prove that every planar graph without cycles of lengths 4 to 12 is acyclically 3-choosable.

keywords: acyclic choosability, planar graphs, forbidden cycles.

Properties of Groups for the Cage and Degree/Diameter Problems

by *Robert Jajcay and Geoffrey Exoo*

Abstract: A (k, g) -cage is a k -regular graph of girth g of minimum order. While many of the best known constructions of small k -regular graphs of girth g are known to be Cayley graphs, no general theory of the relation between the girth of a Cayley graph and the structure of the underlying group has been developed. We attempt to fill the gap by focusing on the girths of Cayley graphs

of nilpotent and solvable groups, and present a series of results supporting the intuitive idea that the closer a group is to being abelian, the less suitable it is for constructing Cayley graphs of large girths. Specifically, we establish the existence of upper bounds on the girths of Cayley graphs with respect to the nilpotency class and/or the length of the derived sequence of the underlying groups.

keywords: cage, girth, Cayley graph, nilpotent group, solvable group.

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Program

Monday 7 morning

Registration			
8:30-10:00	Xuding Zhu: <i>Total weight choosability of graphs</i>		
11:00-11:20	Coffee break		
	Lecture Room A	Lecture Room B	Lecture Room C
11:25-11:50	Li-Da Tong <i>Full Orientability of Graphs</i>	Vadim Lozín <i>Parameterized complexity of the maximum independent set problem and the speed of hereditary properties</i>	Zoltán Füredi and Attila Sali <i>Partition Critical Hypergraphs</i>
11:50-12:15	Joergen Bang-Jensen and Matthias Kriesell <i>Disjoint sub(\bar{d})-graphs in digraphs</i>	Cédric Bentz <i>New results on planar and directed multicut</i>	Rommel Barbosa, Mitre Dourado, Erika Martins and Jayme Swarcfter <i>The Colorful Helly Property for Hypergraphs</i>
12:15-14:00	Lunch		
			Lecture Room D Emilie Diot and Cyril Gavoille <i>On the Path Separability of Planar Graphs</i> Min Chen and André Raspaud <i>Planar graphs without 4-, 5 and 8-cycles are acyclically 4-choosable</i>

Monday 7 afternoon

Stéphan Thomassé: Kernelization via combinatorial Optimizations				
14:00-15:00	Coffee break			
15:00-15:30	Coffee break			
	Lecture Room A	Lecture Room B	Lecture Room C	Lecture Room D
15:30-15:55	Ehsan Chiniforooshan and Baoyindureng Wu <i>Maximum values of Szeged index and edge-Szeged index of graphs</i>	Cedric Chauve, Jan Manuch and Murray Patterson <i>On the Gapped Consecutive Ones Property</i>	Roland Grappe, Attila Bernáth and Zoltán Szigeti <i>Augmenting the edge-connectivity of a hypergraph by adding a multipartite graph</i>	Zdenek Dvorak and Bojan Mohar <i>Spectral radius of finite and infinite planar graphs and of graphs of bounded genus</i>
15:55-16:20	Abhijit Adiga and Sunil L Chandran <i>Cubicity of Interval Graphs and the Claw Number</i>	Guillaume Fertin and Stéphane Vialette <i>On the S-Labeling problem</i>	Hanno Lefmann, Carlos Hoppen and Yoshiharu Kobayakawa <i>Kneser Colorings of Uniform Hypergraphs</i>	Nicolas Sommerat and Adrian Vetta <i>Defending Planar Graphs against Star-Cutsets</i>
16:20-16:40	Coffee break			
16:40-17:05	Friedrich Eisenbrand and Martin Niemeier <i>Coloring Fuzzy Circular Interval Graphs</i>	Luke Postle, Noah Streib and Carl Yeger <i>Pebbling Graphs of Diameter Three and Four</i>	Ervin Gyori and Nathan Lemons <i>Hypergraphs with no odd cycle of given length</i>	Delia Garijo, Angeles Garrido, Clara I. Grima, et al. <i>Monochromatic geometric k-factors in red-blue sets with white and Steiner points</i>
17:05-17:30	Ilan Goldfeder and Hortensia Galeana-Sanchez <i>A Classification of arc-locally semicomplete digraphs</i>	Tomoki Nakamigawa, Shinya Fujita and Tadashi Sakuma <i>Colored Pebble Motion on Graphs</i>	Allan Lo <i>Cliques in graphs with bounded minimum degree</i>	Nicole Eggemann and Steven Noble <i>Minimizing the Oriented Diameter of a Planar Graph</i>

Tuesday 8 morning

Anders Björner: <i>A q-analogue of the FKG inequality and some applications</i>				
Coffee break				
	Lecture Room A	Lecture Room B	Lecture Room C	Lecture Room D
9:00-10:00				
10:00-10:30				
10:30-10:55	Domingos, Jr Dellamonica and Vojtech Rodl <i>Hereditary quasi-random properties of hypergraphs</i>	Mareike Massow and Stefan Felsner <i>Linear Extension Diameter of Downset Lattices of 2-Dimensional Posets</i>	Yury Person and Mathias Schacht <i>An expected polynomial time algorithm for coloring 2-colorable 3-graphs</i>	Patrice Ossona de Mendez and Jaroslav Nešetřil <i>Homomorphisms to Sparse Graphs</i>
10:55-11:20	Anna Huber and Nikolaos Fountoulakis <i>Quasirandom broadcasting on the complete graph is as fast as randomized broadcasting</i>	Ronnie Barequet, Gill Barequet and Guenter Rote <i>Formulae and Growth Rates of High-Dimensional Polycubes</i>	Dmitry Shabanov and Anastasia Rozovskaya <i>On the Problem of Erdos and Hajnal in the Case of List Colorings</i>	Henning Bruhn and Maya Stein <i>Characterising claw-free t-perfect graphs</i>
11:30-11:55	Benjamin Doerr and Mahmoud Fouz <i>A Time-Randomness Tradeoff for Quasi-Random Rumour Spreading</i>	Anna Lladó and Jordi Moragas <i>On the Sumset Partition Problem</i>	Daniel Kral, Edita Mажarova, Jan Mazak and Jean-Sebastien Sereni <i>Circular edge-colorings of cubic graphs with girth six</i>	Oliver Cooley, Jan Hladky and Diana Pignat Loebli <i>Komlos-Sos Conjecture</i>
11:55-12:20	Benjamin Doerr, Tobias Friedrich and Thomas Sauerwald <i>Quasirandom Rumor Spreading on Expanders</i>	Amanda Montejano and Oriol Serra <i>Rainbow-free 3-colorings in abelian groups</i>	Nathann Cohen, Frederic Havet and Tobias Mueller <i>Acyclic edge-colouring of planar graphs. Extended abstract</i>	Peter Allen, Julia Böttcher, Jan Hladký and Oliver Cooley <i>Minimum degree conditions for large subgraphs</i>
12:20-14:00	Lunch			

Tuesday 8 afternoon

14:00-15:00	Michael Krivelevich: <i>Hamiltonicity problems in random graphs</i>			
15:00-16:00	Coffee break and Posters			
	Lecture Room A	Lecture Room B	Lecture Room C	Lecture Room D
16:00-16:25	Deryk Osthus, Daniela Kuehn and Luke Kelly <i>Short cycles in oriented graphs</i>	Michel Habib and Juraj Stacho <i>A Decomposition Theorem for Chordal Graphs and its Applications</i>	Zoltan Furedi and Lale Ozkaya <i>Unavoidable sub-hypergraphs</i>	Luke Postle, Arash Asadi and Robin Thomas <i>Sub-Exponentially Many 3-Colorings of Triangle-Free Planar Graphs</i>
17:00	DHC - cocktail			

Wednesday 9 morning

Penny Haxell: <i>Packing and covering in hypergraphs</i>				
Coffee break				
	Lecture Room A	Lecture Room B	Lecture Room C	Lecture Room D
9:00-10:00				
10:00-10:30				
10:30-10:55	Guy Wolfvitz <i>4-cycles at the triangle-free process</i>	Yulia Kempner and Vadim Levit <i>Distributive Lattice Polyhedra</i>	Yared Nigusie <i>Extended Gallai's Theorem</i>	Kenta Ozeki <i>Spanning trees in 3-connected $K_{3,t}$-minor-free graphs</i>
10:55-11:20	Reto Spöhel, Angelika Steger and Henning Thomas <i>Coloring the edges of a random graph without a monochromatic giant component</i>	Kolja Knauer <i>Chip-Firing, Antimatroids, and Polyhedra</i>	Oleg Rubanov and Andrei Raigorodskii <i>Small clique and large chromatic number</i>	Roland Häggkvist <i>Ear decompositions of a cubic bridgeless graph and near P_4-decompositions of its deck</i>
11:30-11:55	Nikolaos Fountoulakis and Bruce Reed <i>A general critical condition for the emergence of a giant component in random graphs with given degrees</i>	Delia Garijo, Andrew Goodall and Jaroslav Nešetřil <i>Graph homomorphisms, the Tutte polynomial and q-state Potts uniqueness</i>	Edita Macajova and Martin Skoviera <i>On a Conjecture of Fan and Raspaud</i>	Agelos Georgakopoulos <i>Every rayless graph has an unfriendly partition</i>
11:55-12:20	Konstantinos Panagiotou and Makrand Sinha <i>Ver-tices of Degree k in Random Unlabeled Trees</i>	Criel Merino, Marcelino Ramírez and M. Guadalupe Rodríguez <i>A note on some inequalities for the Tutte polynomial of a matroid</i>	Ross Kang and Putra Manggala <i>On distance edge-colourings and matchings</i>	Binh-Minh Bui-Xuan and Michel Habib <i>Unifying the representation of symmetric crossing families and weakly partitive families</i>
12:20-14:00	Lunch			

Wednesday 9 afternoon

14:00-15:00	Martin Loebel: <i>Optimization by Enumeration</i>
15:00-18:00	Excursion
18:00-19:30	European Prize
19:30-20:30	Degustation
20:30-24:00	Banquet

Thursday 10 morning

Bojan Mohar: <i>Is there a structural graph theory based on the spectral radius?</i>			
Coffee break			
	Lecture Room A	Lecture Room B	Lecture Room C
9:00-10:00			Lecture Room D
10:00-10:30			
10:30-10:55	Tomer Kotek <i>On the reconstruction of graph invariants</i>	Emeric Gioan and Michel Las Vergnas <i>A Linear Programming Construction of Fully Optimal Bases in Graphs and Hyperplane Arrangements</i>	Julia Böttcher and Sybille Müller <i>Forcing spanning subgraphs via Ore type conditions</i>
10:55-11:20	Cristina Dalfó, Miquel Àngel Fiol and Ernest Garriga <i>On t-Cliques in k-Walk-Regular Graphs</i>	Juanjo Rué, Konstantinos Stavropoulos and Dimitrios Thilikos <i>Outerplanar Obstructions for the Feedback Vertex Set</i>	Daniel Gonçalves, Frédéric Havet, Alexandre Pinlou and Stéphan Thomassé <i>Spanning galleries in digraphs</i>
11:30-11:55	Dan Hefetz, Michael Krivelevich, Milos Stojakovic and Tibor Szabo <i>Avoider Enforcer</i>	Bernard Ries <i>Some properties of edge intersection graphs of single bend paths on a grid</i>	Shuya Chiba, Shinya Fujita, Ken-ichi Kawabayashi and Tadashi Sakuma <i>Disjoint Even Cycles Packing</i>
11:55-12:20	Noga Alon, Dan Hefetz and Michael Krivelevich <i>Playing to retain the advantage</i>	Demetres Christofides <i>Randomized algorithms for the majority problem</i>	Louis Esperet, František Kardoš and Daniel Král <i>Cubic bridgeless graphs have more than a linear number of perfect matchings</i>
12:20-14:00		Lunch	Oswin Aichholzer, Thomas Hackl, David Orden, Pedro Ramos, Günter Rote, André Schulz and Bettina Speckmann <i>Flip Graphs of Bounded-Degree Triangulations</i>

Thursday 10 afternoon

Prize winning lectures	
Coffee break and Posters	
14:00-15:30	
15:30-16:30	
16:30-16:55	Diana Pignet, Julia Böttcher and Jan Hladky <i>The tripartite Ramsey number for trees</i>
16:30-17:20	Charles Delorme, Evelyn Flandrin, Yuqing Lin, Mirka Miller and Joe Ryan <i>On Extremal Graphs with Bounded Girth</i>
16:30-16:55	Jiaojiao Wu and Andre Raspaud <i>Game chromatic number of toroidal grids</i>
16:55-17:20	William Kennedy, Conor Meagher and Bruce Reed <i>Fractionally Edge Colouring Graphs with Large Maximum Degree in Linear Time</i>
17:20-17:55	Stephan Brandt and Elizabeth Ribe-Baumann <i>Graphs of odd girth 7 with large degree</i>
	Martin Tancer <i>d-collapsibility is NP-complete for d greater or equal to 4</i>
	Andrei Raigorodskii and Andrei Kupavskii <i>On the chromatic numbers of small-dimensional Euclidean spaces</i>
	Mike J. Grannell, Terry S. Griggs, Edita Mажorova and Martin Skoviera <i>Wilson-Schreiber Colourings of Cubic Graphs</i>
	Oriol Serra and Gilles Zemor <i>Cycle codes of graphs and MDS array codes</i>
	Paul Dorbec, Sylvain Gravier, Iiro Honkala and Michel Mollard <i>Weighted codes in Lee metric</i>
	David Auger <i>Identifying Codes in Trees and Planar Graphs</i>

Friday 11 morning

Bruno Courcelle: <i>Logical characterizations of graph hierarchies</i>				
Coffee break				
	Lecture Room A	Lecture Room B	Lecture Room C	Lecture Room D
9:00-10:00				
10:00-10:30				
10:30-10:55	Ljubomír Török, Imrich Vrtó, Stefan Dobrev, Rastislav Kráľovič and Dana Pardubská <i>Antibandwidth and Cyclic Bandwidth of Hamiltonian Graphs</i>	Simone Rinaldi, Filippo Disanto, Luca Ferrari and Renzo Pinzani <i>Combinatorial properties of Catalan pairs</i>	Daniela Kuehn, Deryk Osthus and Andrew Treglown <i>Degree sequences in forcing Hamilton cycles in directed graphs</i>	Alexandre Blondin Massé, Srećko Bilek, Sébastien Labbé and Laurent Vuillon <i>Codings of rotations on two intervals are full</i>
10:55-11:20	Petr Gregor <i>Hypercube 1-factorizations from extended Hamming codes</i>	Anna de Mier and Marc Noy <i>On the maximum number of cycles in outer-parallel and series-parallel graphs</i>	Olivier Togni <i>ℓ-distant Hamiltonian walks in Cartesian product graphs</i>	Amanda Montejano, Alexandre Pinlou, André Raspaud and Éric Sopena <i>Chromatic number of sparse colored mixed planar graphs</i>
11:30-11:55	Zoltan Furedi and Lale Ozkaya <i>On even-cycle-free subgraphs of the hypercube</i>	Jang Soo Kim <i>Bijections on two variations of non-crossing partitions</i>	Tomas Kaiser and Petr Vrana <i>Hamilton cycles in 6-connected claw-free graphs (Extended abstract)</i>	Marcin Kaminski, Paul Medvedev and Martin Milanic <i>On the Plane-Width of Graphs</i>
11:55-12:20	Tomáš Dvořák, Jirí Fink, Petr Gregor and Václav Koubek <i>Long paths and cycles in faulty hypercubes</i>	Louis Esperet, Daniel Gonçalves and Arnaud Labourel <i>Coloring a set of touching strings</i>	Jan Hladky, Daniel Kral and Sergey Norin <i>Counting flags in triangle-free digraphs</i>	Otfried Cheong, Xavier Goaoc and Andreas Holmsen <i>Lower Bounds for Pinning Lines by Balls</i>
12:20-14:00	Lunch			

Friday 11 afternoon

Janos Pach: <i>Ordnung muss sein! – Plane curves and partial orders</i>	
14:00-15:00	
Coffee break	
15:00-15:30	
15:30-15:55	<p>Petter Branden <i>Discrete concavity and zeros of polynomials</i></p> <p>Le Anh Vinh <i>On the distribution of permanents of matrices over finite fields</i></p> <p>Francis Raj S and Balakrishnan Ranganaswami <i>Bounds for the b-chromatic number of vertex-deleted subgraphs and the extremal graphs</i></p> <p>Geoffrey Exoo and Robert Jajcay <i>Properties of Groups for the Cage and Degree/Diameter Problems</i></p>
15:55-16:20	<p>Luis Pedro Montejano, Camino Balbuena and Pedro García Vázquez <i>On the Superconnectivity in graphs with odd girth g and even girth h</i></p> <p>Francesc Aguiló-Gost and Pedro A. García-Sánchez. <i>Factorization and categorical degree in 3-generated numerical semigroups</i></p> <p>Hervé Hocquard and Mickaël Montassier <i>Acyclic choosability of planar graphs: a Steinerberg like approach</i></p>