Foreword

Discrete Mathematics Days conference is the 10th edition of the Jornadas de Matemática Discreta y Algorítmica (JMDA), the Spanish biannual meeting on discrete mathematics. In its ten editions, the JMDA has helped to establish a Spanish network of researchers in the broad areas around Discrete Mathematics and its applications and to enhance the international visibility of this community.

We are grateful to the Universitat Politècnica de Catalunya for its financial and logistic support, particularly to the Department of Mathematics and the Facultat de Matemàtiques i Estadística. We also acknowledge the support of the Societat Catalana de Matemàtiques and of the Real Sociedad Matemática Española.

We thank all members of the Program Committee for their generous commitment to the scientific success of the meeting. We also thank all members of the Organizing Committee for all their work in preparing the event.

We are pleased to welcome you to Barcelona and we wish you a very fruitful conference.

The Organizing Committee
General Information

Venue

The conference will take place at the Facultat de Matemàtiques i Estadística (FME, Carrer Pau Gargallo 5, 08028 Barcelona) of the Universitat Politècnica de Catalunya, Barcelona.

How to reach FME from metro station *Palau Reial*:

![Map of Palau Reial](image1)

How to reach FME from metro station *Zona Universitària*:

![Map of Zona Universitària](image2)
**Internet access**

Eduroam network works in all the conference place. There is also the option to connect to the network XSF-UPC (Xarxa sense fils, UPC). Once selected, enter at your browser and select 'Guest/convidat’ in order to connect.

**Lunch**

All lunches will be provided at the restaurant of the Physics Faculty. Each meal will consist on a large vegetarian selection and a buffet (pizzas, fish, ...), plus a drink and a dessert. Coffee is also included in the same restaurant. Each participant has a 3-day ticket to be used in the restaurant to pay the corresponding lunch.
Conference Dinner

The conference dinner will be done in restaurant La Camarga (Carrer d’Aribau, 117, 08036 Barcelona) on Thursday 7th at 20:00. The restaurant is very well connected with the metro station Diagonal as well as the train station Provença.

Please, also note that both stations (Diagonal and Provença) are connected underground.

How to reach the conference dinner from metro station:

![Map showing the location of La Camarga restaurant near Diagonal and Provença stations]
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<td>11:10-11:30</td>
<td>Tien-Nam Le and Paul Wollan. Forcing clique immersions through chromatic number</td>
<td>Clemens Huemer, Alexander Pilz, Carlos Seara and Rodrigo Silveira. Production matrices for geometric graphs</td>
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<tr>
<td>11:30-11:40</td>
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<td>11:40-12:00</td>
<td>Nicholas Cavenagh and Reshma Ramadurai. On the distances between Latin Squares and the smallest defining set size</td>
<td>Pilar Cano, Guillem Perarnau and Oriol Serra. Rainbow perfect matchings in r-partite graph structures</td>
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<td>14:00-15:00</td>
<td><strong>Sudakov: Equiangular lines and spherical codes in Euclidean spaces</strong></td>
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<td>15:30-15:50</td>
<td>Dennis Clemens, Julia Ehrenmüller and Yury Person. A Dirac-type theorem for Hamilton Berge cycles in random hypergraphs</td>
<td>Francesc Aguiló, Miquel A. Fiol and Sonia Pérez. A geometric approach to dense Cayley digraphs of finite Abelian groups</td>
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<td>Thomassé: Decomposing a graph into paths and trees</td>
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<td>Lutz Warnke. Upper tails for arithmetic progressions in random subsets</td>
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<td>Thomas Selig and Mark Dukes. Decomposing recurrent states of the abelian sandpile model</td>
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<td>Marc Noy, Clément Requilé and Juanjo Rué. Random cubic planar graphs revisited</td>
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<td>David Orden, Iván Marsa Maestre, Jose Manuel Gimenez-Guzman and Enrique De La Hoz De La Hoz. Bounds on spectrum graph coloring</td>
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<td>11:10-11:30</td>
<td>Ljuben Mutafchiev. On the Distribution of the Number of Goldbach Partitions of a Randomly Chosen Positive Even Integer</td>
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<td>David E. Roberson. Homomorphisms of Strongly Regular Graphs</td>
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<td>11:40-12:00</td>
<td>Cesar Ceballos, Arnaud Padró and Camilo Sarmiento. Tropical Catalan subdivisions</td>
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<td></td>
<td>Cristina Fernandez-Cordoba, Carlos Vela and Merce Villanueva. Construction and classification of $\mathbb{Z}_{(2^n)}$-linear Hadamard codes</td>
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<td>12:00-12:20</td>
<td>Francisco Criado and Francisco Santos. The maximum diameter of pure simplicial complexes and pseudo-manifolds</td>
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<td>Ivan Bailera, Joaquim Borges and Josep Rifà. About some Hadamard full propelinear $(2t,2,2)$-codes. Rank and Kernel</td>
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<td>12:30-14:00</td>
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<td>14:00-14:20</td>
<td>Boštjan Brešar, Tatiana Romina Hartinger, Tim Kos and Martin Milanič. 1-perfectly orientable $K_4$-minor-free and outerplanar graphs</td>
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<td>José Cáceres, Delia Garijo, Antonio González, Alberto Márquez, María Luz Puertas and Paula Ribeiro. Shortcut sets for plane Euclidean networks</td>
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<td>14:20-14:40</td>
<td>Mariusz Grech and Andrzej Kisielewicz. Cerný conjecture for edge-colored digraphs with few junctions</td>
<td>Guillaume Bagan, Fairouz Beggas, Mohammed Haddad and Hamamache Kheddouci. Edge Monitoring Problem on Interval Graphs</td>
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<td>14:40-15:00</td>
<td>Richard Lang, Laura Gellert and Henning Bruhn. Chromatic index, treewidth and maximum degree</td>
<td>Josep M. Brunat and Montserrat Mauroso. Extreme Weights in Steinhaus Triangles</td>
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<td>15:00-15:30</td>
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<td>15:30-15:50</td>
<td>Gabor Wiener. On constructions of hypotraceable graphs</td>
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<td>Carlos Marijuán and Miriam Pisonero. Comparison of weighted digraphs' spectral radii that differ in a certain subdigraph</td>
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<td>15:50-16:10</td>
<td>Nacho López Lorenzo, Hebert Pérez-Rosés, Jordi Pujolans and María Zdimalová. A variant of the McKay-Miller-Sirán construction for mixed graphs</td>
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<td>Bruno Amaro, Leonardo Lima, Carla Oliveira, Carlile Lavor and Nair Maria Maia de Abreu. A note on the sum of the largest signless Laplacian eigenvalues</td>
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<td>16:10-16:30</td>
<td>Vadim Levit and Eugen Mandrescu. Crowns in bipartite graphs</td>
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<td>Carlos Marijuán, Jesús García López de Lacalle and Luis Miguel Pozo Coronado. Structural and spectral properties of minimal strong digraphs</td>
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<td>16:30-16:50</td>
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<td>16:50-17:30</td>
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**20:00: Conference dinner at 'La Camarga' (C. Aribau 117)**
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<td><strong>Král</strong>: Graph Limits and extremal combinatorics</td>
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<tr>
<td>10:30-10:50</td>
<td>Monica Blanco and Francisco Santos. Enumerating lattice 3-polytopes</td>
<td>Anurag Bishnoi, Pete L. Clark, Aditya Potukuchi and John R. Schmitt. On the Alon-Füredi bound</td>
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<td>11:40-12:00</td>
<td>Mucuy-Kak Guevara, Camino Balbuena and Hortensia Galeana-Sanchez. Relation between number of kernels (and some else) of a digraph and its partial line digraphs</td>
<td>M. José Jiménez and Andrés M. Encinas. Combinatorial Recurrences and Linear Difference Equations</td>
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<td>12:00-12:20</td>
<td>Josep Fàbrega, Jaume Martí-Farré and Xavier Muñoz. Layer structure of De Bruijn and Kautz digraphs. An application to deflection routing</td>
<td>Yonah Biers-Ariel, Anant Godbole and Yiguang Zhang. Preferential Arrangement Superpatterns</td>
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<td>12:30-14:00</td>
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Abstracts of the talks

Invited Speakers

On sets defining few ordinary planes
Simeon Ball, Universitat Politècnica de Catalunya

Let $S$ be a set of $n$ points in the real plane with the property that the number of lines incident with exactly two points of $S$ is less than $Kn$ where $K < c(\log \log n)^c$, for some constant $c$. In 2013, Green and Tao [2] classified all such sets for sufficiently large $n$. In this talk I will give a short review of the Green-Tao theorem and then consider $S$ to be a set of $n$ points in real 3-space. I will then outline a proof of the following theorems from [1]. If the number of planes incident with exactly three points of $S$ is less than $Kn^2$ for some $K = o(n^{1/6})$ then, for $n$ sufficiently large, $S$ all but at most $O(K)$ points of $S$ are contained in the intersection of two quadrics. If the number of planes incident with exactly three points of $S$ is less than $\frac{1}{7}n^2 - cn$ for some constant $c$ then, for $n$ sufficiently large, either $S$ differs by at most $O(1)$ points from a prism, $S$ differs by at most $O(1)$ points from a skew-prism, or $S$ contains four collinear points.

References


**Equiangular lines and spherical codes in Euclidean spaces**  
*Benny Sudakov, ETH Zürich*

A set of lines in \( \mathbb{R}^d \) is called equiangular if the angles between any two of them are the same. The problem of estimating the size of the maximum family of equiangular lines has had a long history since late 1940’s. A closely related notion is that of a spherical code, which is a collection \( C \) of unit vectors in \( \mathbb{R}^d \) such that \( x \cdot y \in L \) for any distinct \( x, y \in C \) and some set of real numbers \( L \). Spherical codes have been extensively studied since their introduction in the 1970’s by Delsarte, Goethals and Seidel. Despite a lot of attention in the last forty years, there are still many open interesting questions about equiangular lines and spherical codes. In this talk we report recent progress on some of them. Joint work with I. Balla, F. Drexler and P. Keevash.

**Decomposing a graph into paths and trees**  
*Stéphan Thomassé, ENS Lyon*

Thomassen’s proof of the existence of a 3-flow in a 8-edge connected graph has a direct corollary: the edges of an 8-edge connected graph can be partitioned into 3-stars, provided that the total number of edges is divisible by 3. Barat and Thomassen asked if the 3-star could be replaced by any tree \( T \). With Bensmail, Harutyunyan, Le and Merker, we positively answered this question by showing that if a graph has high edge-connectivity (depending on \( T \)) and number of edges divisible by the number of edges of \( T \), then the edges of \( G \) can be decomposed into copies of \( T \).

I will present this result and some extensions of them to paths (where only degree requirement suffices if connectivity is at least some fixed value independent of the length of the path).
obtained with Bensmail, Harutyunyan, Le and some recent improvements obtained with Klimosova.
I will conclude with some related open questions on subset sums.

**Graph limits and extremal combinatorics**

*Daniel Král, University of Warwick*

Theory of combinatorial limits has opened new links between analysis, combinatorics, computer science, group theory and probability theory. In the talk, we first explore a link between dense graph limits and the flag algebra method of Razborov, which has found many applications in extremal combinatorics. We then study the structure of graphons, analytic objects represented large dense graphs. Motivated by problems in extremal graph theory, we will focus on graphons that are uniquely determined by finitely many density constraints, so-called finitely forcible graphons, and we present counterexamples to several conjectures on their structure.
Contributed talks - Wednesday
Wednesday July 6th 10:30-12:20 Main Room

Loose Hamiltonian cycles forced by \((k - 2)\)-degree - approximate version
Josefran De Oliveira Bastos, Guilherme Oliveira Mota, Mathias Schacht, Jakob Schnitzer and Fabian Schulenburg

We prove that for all \(k \geq 3\) and \(1 \leq \ell < k/2\), every \(k\)-uniform hypergraph \(\mathcal{H}\) on \(n\) vertices with \(\delta_{k-2}(\mathcal{H}) \geq \left(\frac{4(k-\ell)-1}{4(k-\ell)^2} + o(1)\right) \binom{n}{\ell/2}\) contains a Hamiltonian \(\ell\)-cycle if \(k - \ell\) divides \(n\). This degree condition is asymptotically best possible.

Highly Connected Subgraphs of Graphs with Given Independence Number (Extended Abstract)
Shinya Fujita, Henry Liu and Amines Sarkar

Let \(G\) be a graph on \(n\) vertices with independence number \(\alpha\). What is the largest \(k\)-connected subgraph that \(G\) must contain? We prove that if \(n\) is sufficiently large (\(n \geq \alpha^2k + 1\) will do), then \(G\) contains a \(k\)-connected subgraph on at least \(n/\alpha\) vertices. This is sharp, since \(G\) might be the disjoint union of \(\alpha\) equally-sized cliques. For \(k \geq 3\) and \(\alpha = 2, 3\), we shall prove that the same result holds for \(n \geq 4(k - 1)\) and \(n \geq \frac{27(k - 1)}{4}\) respectively, and that these lower bounds on \(n\) are sharp.

Forcing clique immersions through chromatic number
Tien-Nam Le and Paul Wollan

Building on recent work of Dvořák and Yepremyan, we show that every simple graph of minimum degree \(7t + 7\) contains \(K_t\) as an immersion and that every graph with chromatic number at least \(3.54t + 4\) contains \(K_t\) as an immersion.
**On the distances between Latin Squares and the smallest defining set size**

*Nicholas Cavenagh and Reshma Ramadurai*

We show that for each Latin square $L$ of order $n \geq 2$, there exists a Latin square $L' \neq L$ of order $n$ such that $L$ and $L'$ differ in at most $8\sqrt{n}$ cells. Equivalently, each Latin square of order $n$ contains a Latin trade of size at most $8\sqrt{n}$. We also show that the size of the smallest defining set in a Latin square is $\Omega(n^{3/2})$.

**On the Construction of Triples of Diagonal Latin Squares of Order 10**

*Oleg Zaikin, Alexey Zhuravlev, Stepan Kochemazov and Edward Vatutin*

We provide a triple of diagonal Latin squares of order 10 that is the closest to being a triple of mutually orthogonal diagonal Latin squares found so far. It was obtained by constructing all orthogonal mates for diagonal Latin squares generated according to a specific scheme. We also show that a triple of mutually orthogonal diagonal Latin squares of order 10 cannot be constructed based on diagonal Latin squares from specific families.

**Wednesday July 6th 10:30-12:20 Room S04**

**Exact value of 3 color weak Rado number**

*M Pastora Revuelta, Luis Boza, J. Manuel Marín and M. Isabel Sanz*

For integers $k$, $n$, $c$ with $k$, $n \geq 1$ and $c \geq 0$, the $n$ color weak Rado number $WR_k(n,c)$ is defined as the least integer $N$, if it exists, such that for every $n$-coloring of the set $\{1, 2, ..., N\}$, there exists a monochromatic solution in that set to the equa-
tion \( x_1 + x_2 + \ldots + x_k + c = x_{k+1} \), such that \( x_i \neq x_j \) when \( i \neq j \). If no such \( N \) exists, then \( WR_k(n,c) \) is defined as infinite.

In this work, we consider the main issue regarding the 3 color weak Rado number for the equation \( x_1 + x_2 + c = x_3 \) and the exact value of the \( WR_2(3,c) = 13c + 22 \) is established.

**A Convex Polytope and an Antimatroid for any Given, Finite Group**

*Jean-Paul Doignon*

For any given finite group \( G \), we construct a convex polytope and an antimatroid whose automorphism groups are both isomorphic to \( G \). The convex polytope is combinatorial in the sense of Naddef and Pulleyblank (1981), in particular it is binary; the diameter of its skeleton is at most 2; any automorphism of the polytope skeleton is the restriction of some isometry. The antimatroid is the antimatroid induced on a set of points in some euclidean space; any of its automorphisms is induced by some isometry.

**Production matrices for geometric graphs**

*Clemens Huemer, Alexander Pilz, Carlos Seara and Rodrigo I. Silveira*

We present production matrices for non-crossing geometric graphs on point sets in convex position, which allow us to derive formulas for the numbers of such graphs. Several known identities for Catalan numbers, Ballot numbers, and Fibonacci numbers arise in a natural way, and also new formulas are obtained, such as a formula for the number of non-crossing geometric graphs with root vertex of given degree. The characteristic polynomials of some of these production matrices are also presented. The proofs make use of Riordan arrays.
Rainbow perfect matchings in r-partite graph structures
Pilar Cano, Guillem Perarnau and Oriol Serra
A rainbow matching in an edge-colored hypergraph is a matching such that each pair of its edges have distinct colors. We extend the result of Erdös and Spencer on the existence of rainbow matchings in the complete bi-partite graph $K_{n,n}$ to complete r-partite r-uniform hypergraphs, complete bipartite graphs with edges having the same multiplicity $m \geq 1$, and d-regular bipartite graphs. The results use the Lopsided version of the Local Lovász Lemma.

On rainbow matchings in bipartite graphs
Ron Aharoni, Eli Berger, Daniel Kotlar, and Ran Ziv
We present recent results regarding rainbow matchings in bipartite graphs. Using topological methods we address a known conjecture of Stein and show that if $K_{n,n}$ is partitioned into $n$ sets of size $n$, then a partial rainbow matching of size $2n/3$ exists. We generalize a result of Cameron and Wanless and show that for any $n$ matchings of size $n$ in a bipartite graph with $2n$ vertices there exists a full matching intersecting each matching at most twice. We show that any $n$ matchings of size approximately $3n/2$ have a rainbow matching of size $n$. Finally, we show the uniqueness of the extreme case for a theorem of Drisko.
Wednesday July 6th  15:30-16:30 Main Room

A Dirac-type theorem for Hamilton Berge cycles in random hypergraphs
Dennis Clemens, Julia Ehrenmüller and Yury Person

A Hamilton Berge cycle of a hypergraph on \( n \) vertices is an alternating sequence \((v_1, e_1, v_2, \ldots, v_n, e_n)\) of distinct vertices \( v_1, \ldots, v_n \) and distinct hyperedges \( e_1, \ldots, e_n \) such that \( \{v_1, v_n\} \subseteq e_n \) and \( \{v_i, v_{i+1}\} \subseteq e_i \) for every \( i \in [n-1] \). We prove a Dirac-type theorem for Hamilton Berge cycles in random \( r \)-uniform hypergraphs by showing that for every integer \( r \geq 3 \) there exists \( k = k(r) \) such that for every \( \gamma > 0 \) and \( p \geq \frac{\log k(r)(n)}{n^{r-1}} \) asymptotically almost surely every spanning subhypergraph \( H \subseteq H^{(r)}(n, p) \) with minimum vertex degree \( \delta_1(H) \geq (\frac{1}{2^{r-1}} + \gamma) p^{(n-1)} \) contains a Hamilton Berge cycle. The minimum degree condition is asymptotically tight and the bound on \( p \) is optimal up to possibly the logarithmic factor. As a corollary this gives a new upper bound on the threshold of \( H^{(r)}(n, p) \) with respect to Berge Hamiltonicity.

Positive graphs
Tamás Hubai, Dávid Kunszenti-Kovács and László Lovász

We call a graph positive if it has a nonnegative homomorphism number into any target graph with real edge weights. The Positive Graphs Conjecture offers a structural characterization: these are exactly the graphs that can be obtained by gluing together two copies of the same graph along an independent set of vertices. In this talk I will discuss our recent results on the Positive Graphs Conjecture.
On limits of sparse random graphs
Lluis Vena

We present a notion of convergence for sequences of finite graphs \( \{G_n\} \) which can be seen as a generalization of the Benjamini-Schramm convergence notion for bounded degree graphs, regarding the distribution of \( r \)-neighbourhoods of the vertices, and the left-convergence notion for dense graphs, regarding, given any graph \( F \), the limit of the probabilities that a random map from \( V(F) \) to \( V(G_n) \) is a graph homomorphism. This convergence notion allows us to define, for each \( p(n) \) and with high probability, a limit for a sequence of Erdős-Renyi random graphs with \( G_n \sim G(n,p(n)) \).

A geometric approach to dense Cayley digraphs of finite Abelian groups
Francesc Aguiló, Miquel A. Fiol and Sonia Pérez

We give a method for constructing infinite families of dense (or eventually likely dense) Cayley digraphs of finite Abelian groups. The diameter of the digraphs is obtained by means of the related minimum distance diagrams. A dilating technique for these diagrams, which can be used for any degree of the digraph, is applied to generate the digraphs of the family. Moreover, two infinite families of digraphs with distinguished metric properties will be given using these methods. The first family contains digraphs with asymptotically large ratio between the order and the diameter as the degree increases (moreover it is the first known asymptotically dense family). The second family, for fixed degree \( d = 3 \), contains digraphs with the current best known density.
A construction of dense mixed graphs of diameter 2
Gabriela Araujo-Pardo, Camino Balbuena, Mirka Miller and Maria Ždímalová

A mixed graph is said to be dense if its order is close to the Moore bound and it is optimal if there is not a mixed graph with the same parameters and bigger order. We give a construction that provides dense mixed graphs of undirected degree $q$, directed degree $\frac{q-1}{2}$ and order $2q^2$, for $q$ being an odd prime power. Since the Moore bound for a mixed graph with these parameters is equal to $\frac{9q^2-4q+3}{4}$, the defect of these mixed graphs is $(\frac{q-2}{2})^2 - \frac{1}{4}$. In particular we obtain a known mixed Moore graph of order 18, undirected degree 3 and directed degree 1 called Bosák’s graph and a new mixed graph of order 50, undirected degree 5 and directed degree 2, which is proved to be optimal.

A new family of small regular graphs of girth 5
Encarnación Abajo, Gabriela Araujo-Pardo, Camino Balbuena and Manuel Bendala

A $(k, g)$-cage is a $k$-regular graph of girth $g$ of minimum order. In this work, we focus on girth $g = 5$, where cages are known only for degrees $k \leq 7$. When $k \geq 8$, except perhaps for $k = 57$, the order of a $(k, 5)$-cage is strictly greater than $1 + k^2$. Considering the relationship between finite geometries and graphs we establish upper constructive bounds that improve the best so far.
Poster Session
Wednesday July 6th 16:40-17:30

The Orthogonal Art Gallery Theorem with Constrained Guards
T. S. Michael, Val Pinciu
Let $P$ be an orthogonal polygon with $n$ vertices, and let $V^*$ and $E^*$ be specified sets of vertices and edges of $P$. We prove that $P$ has a guard set of cardinality at most $\lfloor (n+3|V^*|+2|E^*|)/4 \rfloor$ that includes each vertex in $V^*$ and at least one point of each edge in $E^*$. Our bound is sharp and reduces to the orthogonal art gallery theorem of Kahn, Klawe and Kleitman when $V^*$ and $E^*$ are empty.

Independent $[1,2]$-domination of grid graphs via min-plus algebra
Sahar Aleid, José Cáceres and Maria Luz Puertas
Domination of grids has been proved to be a demanding task and with the addition of independence it become more challenging. It is known that no grid with $m,n \geq 5$ has a perfect code, that is an independent vertex set such that each vertex not in it has exactly one neighbor in that set. So it is interesting to study the existence of an independent dominating set for grids that allows at most two neighbors, such a set is called independent $[1,2]$-set. In this paper we develop a dynamic programming algorithm using min-plus algebra that computes the minimum cardinality of an independent $[1,2]$-set for the grid graph $P_m \Box P_n$. 

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**Vertex-disjoint cycles in bipartite tournaments**
*Diego González-Moreno, Camino Balbuena and Mika Olsen*

Let $k \geq 2$ be an integer. Bermond and Thomassen [Bermond J. C., Thomassen, C., Cycles in digraphs a survey, Journal of Graph Theory 5(1) (1981) 1–43] conjectured that every digraph $D$ with $\delta^+(D) \geq 2k - 1$ contains at least $k$ vertex-disjoint cycles. In this work we prove that every bipartite tournament with minimum out-degree at least $2k - 2$ and minimum in-degree at least one contains $k$ vertex-disjoint cycles of length four, whenever $k \geq 3$. Finally, we show that every bipartite tournament with minimum degree at least $(3k - 1)/2$ contains $k$ vertex-disjoint cycles of length four.

**Network Majority on Tree Topological Network**
*Tadashi Sakuma, Ravindra B. Bapat, Shinya Fujita, Sylvain Legay, Yannis Manoussakis, Yasuko Matsui and Zsolt Tuza*

Let $G = (V, E)$ be a graph, and $w : V \to \mathbb{Q}_{>0}$ be a positive weight function on the vertices of $G$. For every subset $X$ of $V$, let $w(X) = \sum_{v \in G} w(v)$. A non-empty subset $S \subset V(G)$ is a weighted safe set if, for every component $C$ of the subgraph induced by $S$ and every component $D$ of $G \setminus S$, we have $w(C) \geq w(D)$ whenever there is an edge between $C$ and $D$.

In this paper we show that the problem of computing the minimum weight of a safe set is NP-hard for trees, even if the underlining tree is restricted to be a star, but it is polynomially solvable for paths. Then we define the concept of a parameterized infinite family of “proper central subgraphs” on trees, whose polar ends are the minimum-weight connected safe sets and the centroids. We show that each of these central subgraphs includes a centroid. We also give a linear-time algorithm to find all of these subgraphs on unweighted trees.
**Combinatorial bounds on connectivity for dominating sets in maximal outerplanar graphs**

*Santiago Canales, Irene Castro, Gregorio Hernández and Mafalda Martins*

In this article we study some variants of the domination concept attending to the connectivity of the subgraph generated by the dominant set. This study is restricted to maximal outerplanar graphs. We establish tight combinatorial bounds for connected domination, semitotal domination, independent domination and weakly connected domination for any n-vertex maximal outerplanar graph.

**A Moore-like bound for mixed abelian Cayley graphs**

*Nacho López, Hebert Pérez-Rosés and Jordi Pujolàs*

We give an upper bound for the number of vertices in mixed abelian Cayley graphs with given degree and diameter.

**The Complexity of Measuring Power in Generalized Opinion Leader Decision Models**

*Xavier Molinero and Maria Serna*

We analyze the computational complexity of the power measure in models of collective decision: the generalized opinion leader-follower model and the oblivious and non-oblivious influence models. We show that computing the power measure is \#P-hard in all these models, and provide two subfamilies in which the power measure can be computed in polynomial time.

**Kirchhoff index of a non-complete wheel**

*Silvia Gago*

In this work, we compute the group inverse of the combinatorial Laplacian of a non-complete wheel that has been obtained
by adding a vertex to a weighted cycle and some edges conveniently chosen. The obtained group inverse is an incomplete block matrix with a block Toeplitz structure and it is used to obtain the effective resistances and the Kirchhoff index of the weighted non-complete wheel.

**The achromatic number of Kneser graphs**
Christian Rubio-Montiel, Gabriela Araujo-Pardo and Juan Carlos Díaz-Patiño

The achromatic number $\alpha$ of a graph is the largest number of colors that can be assigned to its vertices such that adjacent vertices have different color and every pair of different colors appears on the end vertices of some edge. We estimate the achromatic number of Kneser graphs $K(n,k)$ and determine $\alpha(K(n,k))$ for some values of $n$ and $k$. Furthermore, we study the achromatic number of some geometric type Kneser graphs.

**Comparing decoding methods for quaternary linear codes**
Roland D. Barrollet a, Jaume Pujol and Mercè Villanueva

Permutation decoding is a technique which involves finding a subset $S$, called PD-set, of the permutation automorphism group of a code $C$. Constructions of small PD-sets for partial decoding for two families of $\mathbb{Z}_4$-linear codes (Hadamard and Kerdock) are given. Moreover, different decoding methods for $\mathbb{Z}_4$-linear codes are compared by showing their performance applied to these two families.

**On the bipartite vertex frustration of graphs**
Pedro García Vázquez

The bipartite vertex (resp. edge) frustration of a graph $G$, denoted by $\psi(G)$ (resp. $\varphi(G)$), is the smallest number of vertices (resp. edges) that have to be deleted from $G$ to obtain a bi-
partite subgraph of $G$. A sharp lower bound of the bipartite vertex frustration of the line graph $L(G)$ of every graph $G$ is given. In addition, the exact value of $\psi(L(G))$ is calculated when $G$ is a forest.

**The group inverse of subdivision networks**
Ángeles Carmona, Margarida Mitjana and Enric Monsó
In this paper, given a network and a subdivision of it, we show how the Group Inverse of the subdivision network can be related to the Group Inverse of initial given network. Our approach establishes a relationship between solutions of related Poisson problems on both networks and takes advantage on the definition of the Group Inverse matrix.

**Roman-type variation of the mixed domination in graphs**
Juan Carlos Valenzuela, Houssein Abdollahzadeh Ahangar and Teresa Haynes
Roman domination in graphs is concerned with the problem of finding a vertex labelling, with minimum weight, satisfying certain conditions. In this work, the authors initiate the study of a generalization to labellings of both vertices and edges in a graph.

**Natural visibility graphs for diagnosing attention deficit hyperactivity disorder (ADHD)**
Ainara Mira-Iglesias, J. Alberto Conejero and Esperanza Navarro-Pardo
Reaction times are described as a measure of perception, decision making, and other cognitive processes. For each individual, they usually follow an ex-gaussian distribution. However, this approach omits relationships between consecutive answers to tasks geared to evaluate attention. We show how natural
visibility graphs (NVG’s) can provide a further insight for analyzing these times and in the prediction of attention deficit hyperactivity disorder (ADHD) among young students.

**q-Stirling numbers of the second kind and q-Bell numbers for graphs**

Zsófia R. Kereskényiné Balogh and Michael J. Schlosser

Stirling numbers of the second kind and Bell numbers for graphs were defined by Duncan and Peele in 2009. In a previous paper, one of us, jointly with Nyul, extended the known results for these special numbers by giving new identities, and provided a list of explicit expressions for Stirling numbers of the second kind and Bell numbers for particular graphs. In this work we introduce q-Stirling numbers of the second kind and q-Bell numbers for graphs, and provide a number of explicit examples. Connections are made to q-binomial coefficients and q-Fibonacci numbers.
Contributed talks - Thursday

Thursday July 7th  10:30-12:20 Main Room

Upper tails for arithmetic progressions in random subsets
Lutz Warnke
We study the upper tail of the number of arithmetic progressions of a given length in a random subset of \{1,\ldots,n\}, establishing exponential bounds which are best possible up to constant factors in the exponent (improving results of Janson and Rucinski). The proof extends to Schur triples, and, more generally, to the number of edges in random induced subhypergraphs of ‘almost linear’ \(k\)-uniform hypergraphs.

Random cubic planar graphs revisited
Marc Noy, Clément Requilé and Juanjo Rué
The goal of our work is to analyze random cubic planar graphs according to the uniform distribution. More precisely, let \(G\) be the class of labelled cubic planar graphs and let \(g_n\) be the number of graphs with \(n\) vertices. Then each graph in \(G\) with \(n\) vertices has the same probability \(1/g_n\).

This model was analyzed first by Bodirsky, Löffler, Kang and McDiarmid, and here we revisit and extend their work. The motivation for this revision is twofold. First, some proofs in the mentioned work where incomplete with respect to the singularity analysis and we aim at providing full proofs. Secondly, we obtain new results that considerably strengthen those there and shed more light on the structure of random cubic planar graphs.

We present a selection of our results on asymptotic enu-
meration and on limit laws for parameters of random graphs.

On the Distribution of the Number of Goldbach Partitions of a Randomly Chosen Positive Even Integer

Ljuben Mutafchiev

Let $P = \{p_1, p_2, \ldots\}$ be the set of all odd primes arranged in increasing order. A Goldbach partition of the even integer $2k > 4$ is a way of writing it as a sum of two primes from $P$ without regard to order. Let $Q(2k)$ be the number of all Goldbach partitions of the number $2k$. Assume that $2k$ is selected uniformly at random from the interval $(4, 2n]$, $n > 2$, and let $Y_n = Q(2k)$ with probability $1/(n - 2)$. We prove that the random variable $\frac{Y_n}{n/(\frac{1}{2} \log n)^2}$ converges weakly, as $n \to \infty$, to a uniformly distributed random variable in the interval $(0, 1)$. The method of proof uses size-biasing and the Laplace transform continuity theorem.

Tropical Catalan subdivisions

Cesar Ceballos, Arnau Padrol and Camilo Sarmiento

We revisit the associahedral subdivision of the Pitman-Stanley polytope to provide geometric realizations of the v-Tamari lattice of Préville-Ratelle and Viennot (which generalizes the m-Tamari lattice) as the dual of a triangulation of a polytope, as the dual of a mixed subdivision and as the edge-graph of a polyhedral complex induced by a tropical hyperplane arrangement. The method generalizes to type $B_n$.

The maximum diameter of pure simplicial complexes and pseudo-manifolds

Francisco Criado and Francisco Santos

We construct $d$-dimensional pure simplicial complexes and pseudo-
manifolds (without boundary) with $n$ vertices whose combinatorial diameter grows as $c_d n^{d-1}$ for a constant $c_d$ depending only on $d$, which is the maximum possible growth. Moreover, the constant $c_d$ is optimal modulo a singly exponential factor in $d$. The pure simplicial complexes improve on a construction of the second author that achieved $c_d n^{2d/3}$. For pseudo-manifolds without boundary, as far as we know, no construction with diameter greater than $n^2$ was previously known.

Thursday July 7th  10:30-12:20 Room S04

**Decomposing recurrent states of the abelian sandpile model**

*Thomas Selig and Mark Dukes*

The recurrent states of the Abelian sandpile model (ASM) are those states that appear infinitely often. For this reason they occupy a central position in ASM research. We present several new results for classifying recurrent states of the Abelian sandpile model on graphs that may be decomposed in a variety of ways. These results allow us to classify, for certain families of graphs, recurrent states in terms of the recurrent states of its components. We use these decompositions to give recurrence relations for the generating functions of the level statistic on the recurrent configurations. We also interpret our results with respect to the sandpile group.

**Bounds on spectrum graph coloring**

*David Orden, Iván Marsa Maestre, Jose Manuel Gimenez-Guzman and Enrique De La Hoz De La Hoz*

We propose two vertex-coloring problems for graphs, endorsing
the spectrum of colors with a matrix of interferences between pairs of colors. In the Threshold Spectrum Coloring problem, the number of colors is fixed and the aim is to minimize the maximum interference at a vertex (interference threshold). In the Chromatic Spectrum Coloring problem, a threshold is settled and the aim is to minimize the number of colors (among the available ones) for which respecting that threshold is possible. We prove general upper bounds for the solutions to each problem, valid for any graph and any matrix of interferences. We also show that both problems are NP-hard and perform experimental results proposing a DSATUR-based heuristic for each problem, in order to study the gap between the theoretical upper bounds and the values obtained.

Homomorphisms of Strongly Regular Graphs
David E. Roberson
We prove that if $G$ and $H$ are primitive strongly regular graphs with the same parameters and $\varphi$ is a homomorphism from $G$ to $H$, then $\varphi$ is either an isomorphism or a coloring (homomorphism to a complete subgraph). Moreover, any such coloring is optimal for $G$ and its image is a maximum clique of $H$. Therefore, the only endomorphisms of a primitive strongly regular graph are automorphisms or colorings. This confirms and strengthens a conjecture of Peter Cameron and Priscila Kazanidis that all strongly regular graphs are cores or have complete cores. The proof of the result is elementary, mainly relying on linear algebraic techniques.

Construction and classification of $\mathbb{Z}_{2^n}$-linear Hadamard codes
Cristina Fernández-Córdoba, Carlos Vela and Merce Villanueva

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The $\mathbb{Z}_{2s}$-additive and $\mathbb{Z}_2\mathbb{Z}_4$-additive codes are subgroups of $\mathbb{Z}_{2s}^n$ and $\mathbb{Z}_2^\alpha \times \mathbb{Z}_4^\beta$, respectively. Both families can be seen as generalizations of linear codes over $\mathbb{Z}_2$ and $\mathbb{Z}_4$. A $\mathbb{Z}_{2s}$-linear (resp. $\mathbb{Z}_2\mathbb{Z}_4$-linear) Hadamard code is a binary Hadamard code which is the Gray map image of a $\mathbb{Z}_{2s}$-additive (resp. $\mathbb{Z}_2\mathbb{Z}_4$-additive) code. It is known that there are exactly $\lfloor \frac{t-1}{2} \rfloor$ and $\lfloor \frac{t}{2} \rfloor$ nonequivalent $\mathbb{Z}_2\mathbb{Z}_4$-linear Hadamard codes of length $2^t$, with $\alpha = 0$ and $\alpha \neq 0$, respectively, for all $t \geq 3$. In this paper, new $\mathbb{Z}_{2s}$-linear Hadamard codes are constructed for $s > 2$, which are not equivalent to any $\mathbb{Z}_2\mathbb{Z}_4$-linear Hadamard code. Moreover, for each $s > 2$, it is claimed that the new constructed nonlinear $\mathbb{Z}_{2s}$-linear Hadamard codes of length $2^t$ are pairwise nonequivalent.

**About some Hadamard full propelinear $(2t,2,2)$-codes. Rank and Kernel**

Ivan Bailer a, Joaquim Borges and Josep Rifà

A new subclass of Hadamard full propelinear codes is introduced in this article. We define the $HFP(2t,2,2)$-codes as codes with a group structure isomorphic to $C_{2t} \times C_2^2$. Concepts such as rank and dimension of the kernel are studied, and bounds for them are established. For $t$ odd, $r = 4t - 1$ and $k = 1$. For $t$ even, $r \leq 2t$ and $k \neq 2$, and $r = 2t$ if and only if $t \equiv 0 \pmod{4}$.

Thursday July 7th 14:00-15:00 Main Room

1-perfectly orientable $K_4$-minor-free and outerplanar graphs

Boštjan Brešar, Tatiana Romina Hartinger, Tim Kos and Mar-
A graph $G$ is said to be 1-perfectly orientable if it has an orientation $D$ such that for every vertex $v$, the out-neighborhood of $v$ in $D$ is a clique in $G$. We characterize the class of 1-perfectly orientable $K_4$-minor-free graphs. As a consequence we obtain a characterization of 1-perfectly orientable outerplanar graphs.

**Cerny conjecture for edge-colored digraphs with few junctions**

*Mariusz Grech and Andrzej Kisielewicz*

In this paper we consider the Cerny conjecture in terminology of colored digraphs corresponding to finite automata. We define a class of colored digraphs having a relatively small number of junctions between paths determined by different colors, and prove that digraphs in this class satisfy the Cerny conjecture. We argue that this yields not only a new class of automata for which the Cerny conjecture is verified, but also that our approach may be viewed as a new more systematic way to attack the Cerny conjecture in its generality, giving an insight into the complexity of the problem.

**Chromatic index, treewidth and maximum degree**

*Richard Lang, Laura Gellert and Henning Bruhn*

We conjecture that any graph $G$ with treewidth $k$ and maximum degree $\Delta(G) \geq k + \sqrt{k}$ satisfies $\chi'(G) = \Delta(G)$. In support of the conjecture we prove its fractional version.
Shortcut sets for plane Euclidean networks
José Cáceres, Delia Garijo, Antonio González, Alberto Márquez, María Luz Puertas and Paula Ribeiro
We study the problem of augmenting the locus $N_\ell$ of a plane Euclidean network $N$ by inserting iteratively a finite set of segments, called shortcut set, while reducing the diameter of the locus of the resulting network. We first characterize the existence of shortcut sets, and compute shortcut sets in polynomial time providing an upper bound on their size. Then, we analyze the role of the convex hull of $N_\ell$ when inserting a shortcut set. As a main result, we prove that one can always determine in polynomial time whether inserting only one segment suffices to reduce the diameter.

Edge Monitoring Problem on Interval Graphs
Guillaume Bagan, Fairouz Beggas, Mohammed Haddad and Hamamache Kheddouci
Edge monitoring is a simple and effective mechanism for the security of wireless sensor networks. The idea is to award specific roles (monitors) to some sensor nodes of the network. A node $v$ monitors an edge $e$ if both extremities together with $v$ form a triangle in the graph. Given an edge colored graph $G = (V, E, c)$, the color $c(e)$ is a positive integer representing the number of monitors needed by the edge $e$. The problem is to seek a minimum cardinality subset of monitors $S$ such that every edge $e$ in the graph is monitored by at least $c(e)$ vertices in $S$. If vertices of $G$ are weighted, the objective then is to minimize the total weight of vertices of $S$ and the problem is called
weighted edge monitoring problem. In this paper, we present a polynomial-time algorithm for finding an edge monitoring set of minimum weight in interval graphs.

**Extreme Weights in Steinhaus Triangles**

*Josep M. Brunat and Montserrat Maureso*

Let \( \{0 = w_0 < w_1 < w_2 < \ldots < w_m\} \) be the set of weights of binary Steinhaus triangles of size \( n \), and let \( W_i \) be the set of sequences in \( \mathbb{F}_2^n \) that generate triangles of weight \( w_i \). In this paper we obtain the values of \( w_i \) and the corresponding sets \( W_i \) for \( i \in \{2, 3, m\} \), and partial results for \( i = m - 1 \).

**Thursday July 7th 15:30-16:30 Main Room**

**On constructions of hypotraceable graphs**

*Gábor Wiener*

A graph \( G \) is hypohamiltonian/hypotraceable if it is not hamiltonian/traceable, but all vertex deleted subgraphs of \( G \) are hamiltonian/traceable. Until now all hypotraceable graphs were constructed using hypohamiltonian graphs; extending a method of Thomassen we present a construction that uses so-called almost hypohamiltonian graphs (nonhamiltonian graphs, whose vertex deleted subgraphs are hamiltonian with exactly one exception). As an application, we construct a planar hypotraceable graph of order 138, improving the best known bound of 154. We also prove a structural type theorem showing that hypotraceable graphs possessing some connectivity properties are all built using either Thomassen’s or our method.
A variant of the McKay-Miller-Širán construction for mixed graphs
Nacho López Lorenzo, Hebert Pérez-Rosés, Jordi Pujolàs and Mária Ždímalová

The Degree/Diameter Problem is an extremal problem in graph theory with applications in network design. One of the main research areas in the Degree/Diameter Problem consists of finding large graphs whose order approach the theoretical upper bounds as much as possible. In the case of directed graphs there exist some families that come close to the theoretical upper bound asymptotically. In the case of undirected graphs there also exist some good constructions for specific values of the parameters involved (degree and/or diameter). One such construction was given by McKay, Miller, and Širán, which produces large graphs of diameter 2 with the aid of the voltage assignment technique. Here we show how to re-engineer the McKay-Miller-Širán construction in order to obtain large mixed graphs of diameter 2, i.e. graphs containing both directed arcs and undirected edges.

Crowns in bipartite graphs
Vadim Levit and Eugen Mandrescu

A set $S \subseteq V(G)$ is stable (or independent) if no two vertices from $S$ are adjacent. Let $\Psi(G)$ be the family of all local maximum stable sets of graph $G$, i.e., $S \in \Psi(G)$ if $S$ is a maximum stable set of the subgraph induced by $S \cup N(S)$, where $N(S)$ is the neighborhood of $S$. If $I$ is stable and there is a matching from $N(I)$ into $I$, then $I$ is a crown of order $|I| + |N(I)|$, and we write $I \in Crown(G)$.

In this paper we show that $Crown(G) \subseteq \Psi(G)$ holds for every graph, while $Crown(G) = \Psi(G)$ is true for bipartite and
very well-covered graphs.

For general graphs, it is NP-complete to decide if a graph has a crown of a given order. We prove that in a bipartite graph $G$ with a unique perfect matching, there exist crowns of every possible even order.

**Thursday July 7th  15:30-16:30 Room S04**

**Comparison on the spectral radii of weighted digraphs that differ in a certain subdigraph**

Susana Furtado, Charles R. Johnson, Carlos Marijuán and Miriam Pisonero

Let $D_S$ be a weighted digraph of order $n$ with a subdigraph $S$ of order $k$, $M(D_S)$ its adjacency weight matrix and $\rho(D_S)$ its spectral radius. We consider the class $C_k$ of weighted digraphs of order $k$ and we study the preorder in $C_k$ given by $D_{S'} \preceq D_S$ if and only if $\rho(D_{S'}) \leq \rho(D_S)$. We obtain that this order is equivalent to the entry-wise order $M(D_{S'}) \leq M(D_S)$. Several points of view are taken, under varying regularity conditions, and (at most) $k$ polynomial conditions for the comparison are presented.

**A note on the sum of the largest signless Laplacian eigenvalues**

Bruno Amaro, Leonardo de Lima, Carla Oliveira, Carlile Lavor and Nair Abreu

Let $G$ be a graph with $n$ vertices and $e(G)$ edges. The signless Laplacian of $G$, denoted by $Q(G)$, is given by $Q(G) = D(G) + A(G)$, where $D(G)$ is the diagonal matrix of its vertex degrees and $A(G)$ is the adjacency matrix. Let $q_1(G), \ldots, q_n(G)$
be the eigenvalues of $Q(G)$ in non-increasing order and let $T_k(G) = e(G) + \binom{k+1}{2} - \sum_{i=1}^{k} q_i(G)$. In this paper, we obtain an upper bound to $T_k(H)$, where $H$ is isomorphic to $P_3[(n - k - 1)K_1, K_{k-1}, K_2]$ for $2 \leq k \leq n - 2$. Also, we conjecture that $T_k(G)$ is bounded below by $T_k(H)$ for any $G$ with $n \geq 7$ vertices.

**Structural and spectral properties of minimal strong digraphs**

Carlos Marijuán, Jesús García López de Lacalle and Luis Miguel Pozo Coronado

In this article, we focus on structural and spectral properties of minimal strong digraphs (MSDs). We carry out a comparative study of properties of MSDs versus trees. This analysis includes two new properties. The first one gives bounds on the coefficients of characteristic polynomials of trees (double directed trees), and conjectures the generalization of these bounds to MSDs. As a particular case, we prove that the independent coefficient of the characteristic polynomial of a tree or an MSD must be -1, 0 or 1. For trees, this fact means that a tree has at most one perfect matching; for MSDs, it means that an MSD has at most one covering by disjoint cycles. The property states that every MSD can be decomposed in a rooted spanning tree and a forest of reversed rooted trees, as factors. In our opinion, the analogies described suppose a significative change in the traditional point of view about this class of digraphs.
Enumerating lattice $3$-polytopes

Mónica Blanco and Francisco Santos

A lattice $3$-polytope $P \subset \mathbb{R}^3$ is the convex hull of finitely many points from $\mathbb{Z}^3$. The size of $P$ is the number of integer points it contains, and the width of $P$ is the minimum, over all integer linear functionals $f$, of the length of the interval $f(P)$.

We present our results on a full enumeration of lattice $3$-polytopes via their size and width: for any fixed $n \geq d + 1$ there are infinitely many $3$-polytopes of width one and size $n$, but they are easy to describe (they lie between two consecutive lattice planes). Those of width larger than one are finitely many for each size, and the full list of them can be obtained by one of two methods: (a) most of them contain two proper sub-polytopes of width larger than one, and thus can be obtained from the list of size $n - 1$ using computer algorithms. (b) the ones that cannot have very precise structural properties that allow for a direct enumeration of them.

We have implemented the algorithms in MATLAB and run it until obtaining the following: There are $9, 76, 496, 2675, 11698, 45035$ and $156464$ lattice $3$-polytopes of width larger than one and of sizes $5, 6, 7, 8, 9, 10$ and $11$, respectively.
Enumeration Problems on the Expansion of a Chord Diagram

Tomoki Nakamigawa

A chord diagram is a set of chords of a circle such that no pair of chords has a common endvertex. A pair of chords is called a crossing if the two chords intersect. A chord diagram $E$ is called nonintersecting if $E$ contains no crossing. For a chord diagram $E$ having a crossing $S = \{x_1x_3, x_2x_4\}$, the expansion of $E$ with respect to $S$ is to replace $E$ with $E_1 = (E \setminus S) \cup \{x_2x_3, x_4x_1\}$ or $E_2 = (E \setminus S) \cup \{x_1x_2, x_3x_4\}$. A chord diagram $E = E_1 \cup E_2$ is called complete bipartite of type $(m, n)$, denoted by $C_{m,n}$, if (1) both $E_1$ and $E_2$ are nonintersecting, (2) for every pair $e_1 \in E_1$ and $e_2 \in E_2$, $e_1$ and $e_2$ are crossing, and (3) $|E_1| = m$, $|E_2| = n$. Let $f_{m,n}$ be the cardinality of the multiset of all nonintersecting chord diagrams generated from $C_{m,n}$ with a finite sequence of expansions. In this paper, it is shown $\sum_{m,n} f_{m,n} (\frac{x^m}{m!}) (\frac{y^n}{n!})$ is $\frac{1}{(\cosh x \cosh y - (\sinh x + \sinh y))}$.

Counting triangulations of balanced subdivisions of convex polygons

Andrei Asinowski, Christian Krattenthaler and Toufik Mansour

We compute the number of triangulations of a convex $k$-gon each of whose sides is subdivided by $r-1$ points. We find explicit formulas and generating functions, and we determine the asymptotic behaviour of these numbers as $k$ and/or $r$ tend to infinity. We connect these results with the question of finding the planar set of $n$ points in general position that has the minimum possible number of triangulations.

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Relation between number of kernels (and generalizations) of a digraph and its partial line digraphs

Mucuy-kak Guevara, Camino Balbuena and Hortensia Galeana-Sánchez

Let \( D = (V, A) \) be a digraph and consider an arc subset \( A' \subseteq A \) and a surjective mapping \( \phi : A \rightarrow A' \) such that, i) the set of heads of \( A' \) is \( H(A') = V \) and ii) \( \phi|A' = Id \) and for every vertex \( j \in V \), \( \phi(\omega^-(j)) \subseteq \omega^-(j) \cap A' \). Then, the partial line digraph of \( D \), denoted by \( \mathcal{L}(A', \phi)D \) (for short \( \mathcal{L}D \) if the pair \((A', \phi)\) is clear from the context), is the digraph with vertex set \( V(\mathcal{L}D) = A' \) and set of arcs \( A(\mathcal{L}D) = \{(ij, \phi(j, k)) : (j, k) \in A\} \). In this paper we prove the following results: Let \( k, l \) be two natural numbers such that \( 1 \leq l \leq k \), and \( D \) a digraph with \( \delta^-(D) \geq 1 \). Then the number of \((k, l)\)-kernels of \( D \) is less than or equal to the number of \((k, l)\)-kernels of \( \mathcal{L}D \). Moreover, if \( l < k \) and the girth of \( D \) is at least \( l + 1 \), then these two numbers are equal. The number of semikernels of \( D \) is equal to the number of semikernels of \( \mathcal{L}D \). Also we introduce the concept of \((k, l)\)-Grundy function as a generalization of the concept of Grundy function and we prove that the number of \((k, l)\)-Grundy functions of \( D \) is equal to the number of \((k, l)\)-Grundy functions of every partial line digraph \( \mathcal{L}D \).

Layer structure of De Bruijn and Kautz digraphs. An application to deflection routing.

Josep Fàbrega, Jaume Martí-Farré and Xavier Muñoz

In the main part of this paper we present polynomial expressions for the cardinalities of some sets of interest of the nice distance-layer structure of the well-known De Bruijn and Kautz digraphs. More precisely, given a vertex \( v \), let \( S^*_i(v) \) be the set of vertices at distance \( i \) from \( v \). We show that \( |S^*_i(v)| = \)
\(d^i - a_{i-1}d^{i-1} - \cdots - a_1 d - a_0\), where \(d\) is the degree of the digraph and the coefficients \(a_k \in \{0, 1\}\) are explicitly calculated. Analogously, let \(w\) be a vertex adjacent from \(v\) such that \(S_i^*(v) \cap S_j^*(w) \neq \emptyset\) for some \(j\). We prove that \(|S_i^*(v) \cap S_j^*(w)| = d^i - b_{i-1}d^{i-1} - \cdots - b_1 d - b_0\), where the coefficients \(b_t \in \{0, 1\}\) are determined from the coefficients \(a_k\) of the polynomial expression of \(|S_i^*(v)|\). An application to deflection routing in De Bruijn and Kautz networks serves as motivation for our study. It is worth-mentioning that our analysis can be extended to other families of digraphs on alphabet or to general iterated line digraphs.

Friday July 8th 10:30-12:20 Room S04

**On the Alon-Füredi bound**

Anurag Bishnoi, Pete L. Clark, Aditya Potukuchi and John R. Schmitt

A 1993 result of Alon and Füredi gives a sharp upper bound on the number of zeros of a multivariate polynomial in a finite grid over an integral domain. We give a generalization of the Alon-Füredi Theorem and discuss the relationship between Alon-Füredi, our generalization and the results of DeMillo-Lipton, Schwartz and Zippel. A direct coding theoretic interpretation of our main result in terms of Reed-Muller type affine variety codes is shown, which gives us the minimum Hamming distance of these codes. We also apply the Alon-Füredi Theorem to quickly recover – and sometimes strengthen– some old and new results in finite geometry.

**Multiple Covers with Balls II: Weighted Averages**
Voronoi diagrams and Delaunay triangulations have been extensively used to represent and compute geometric features of point configurations. We introduce a generalization to poset diagrams and poset complexes, which contain order-$k$ and degree-$k$ Voronoi diagrams and their duals as special cases. Extending a result of Aurenhammer from 1990, we show how to construct poset diagrams as weighted Voronoi diagrams of average balls.

Refining the Hierarchies of Classes of Geometric Intersection Graphs
Sergio Cabello and Miha Jejčič
We analyse properties to show the strict containment between some natural classes of geometric intersection graphs. For example, we show that, for each integer $k \geq 1$, the class of intersection graphs of segments with $k$ different lengths is a strict subclass of the class of intersection graphs of segments with $k+1$ different lengths, and the class of outer-segment graphs is a strict subclass of the class of outer-string graphs.

Combinatorial Recurrences and Linear Difference Equations
M. José Jiménez and Andrés M. Encinas
In this work we introduce the triangular arrays of depth greater than 1 given by linear recurrences, that generalize some well known recurrences that appear in enumerative combinatorics. In particular, we focussed on triangular arrays of depth 2, since they are closely related with the solution of linear three-term recurrences. We show through some simple examples how this triangular arrays appear as essential components in the expression of some classical orthogonal polynomials and combinato-
rial numbers.

**Preferential Arrangement Superpatterns**

Yonah Biers-Ariel, Anant Godbole and Yiguang Zhang

A *superpattern* is a string of characters of length $n$ that contains as a subsequence, and in a sense that depends on the context, all the smaller strings of length $k$ in a certain class. We prove structural and probabilistic results on superpatterns for preferential arrangements, including (i) a theorem that demonstrates that a string is a superpattern for all preferential arrangements if and only if it is a superpattern for all permutations; and (ii) a result that is reminiscent of a still unresolved conjecture of Alon on the smallest permutation on $[n]$ that contains all $k$-permutations with high probability.
Participants

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- Anurag Bishnoi (Ghent University)
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• Tomasz Kobos (Jagiellonian University)
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• Tien-Nam LE (ENS Lyon)
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• Antoni Lozano Bojados (UPC Barcelona)
• Nair Maria Maia de Abreu (Universidade Federal do Rio de Janeiro)
• Carlos Marijuán (Universidad de Valladolid)
• Yasuko Matsui (Tokai University)
• Sam Mattheus (Universiteit Gent)
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• Mercè Mora UPC (Barcelona)
• Ljuben Mutafchiev (American University in Bulgaria)
• Tomoki Nakamigawa (Shonan Institute of Technology)
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• Marc Noy (UPC Barcelona)
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• Shin-ichi Otani (Kanto Gakuin University)
• Arnau Padrol (Université Pierre et Marie Curie)
• Guillem Perarnau (University of Birmingham)
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• Hebert Perez-Roses (University of Lleida)
• Julian Pfeifle (UPC Barcelona)
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• Lluis Vena (Charles University)
• Lutz Warnke (University of Cambridge)
• Geoff (Whittle Victoria University)
• Gabor Wiener (Budapest University of Technology and Economics)
• Oleg Zaikin (Matrosov Institute for System Dynamics and Control Theory of Siberian Branch of Russian Academy of Sciences)
<table>
<thead>
<tr>
<th>Time</th>
<th>Wednesday July 6th</th>
<th>Thursday July 7th</th>
<th>Friday July 8th</th>
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</thead>
<tbody>
<tr>
<td>8:00-8:50</td>
<td>Registration</td>
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<td>8:50-9:00</td>
<td>Opening of the conference</td>
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<tr>
<td>9:00-10:00</td>
<td>Ball: On Sets defining few ordinary planes</td>
<td>Thomassé: Decomposing a graph into paths and trees</td>
<td>Král: Graph Limits and extremal combinatorics</td>
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<tr>
<td>10:00-10:30</td>
<td>Coffee break (R, Q rooms)</td>
<td>Coffee break (R, Q rooms)</td>
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<td>10:30-11:30</td>
<td>Parallel sessions</td>
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<td>11:30-11:40</td>
<td>Short break</td>
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<tr>
<td>11:40-12:20</td>
<td>Parallel sessions</td>
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<td>Parallel sessions</td>
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<tr>
<td>12:20-14:00</td>
<td>LUNCH (Physics Building)</td>
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<tr>
<td>14:00-15:00</td>
<td>Sudakov: Equiangular lines and spherical codes in Euclidean spaces</td>
<td>Parallel sessions</td>
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<tr>
<td>15:00-15:30</td>
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<td>Coffee break (R, Q rooms)</td>
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<tr>
<td>15:30-16:30</td>
<td>Parallel sessions</td>
<td>Parallel sessions</td>
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<td>16:30-16:40</td>
<td>Short break</td>
<td>16:30 - 16:50 Group Photo</td>
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<tr>
<td>16:40-17:30</td>
<td>16:40-17:30 POSTER SESSION</td>
<td>16:50 - 17:30 BUSINESS Meeting</td>
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<td>20:00: Conference dinner at 'La Camarga' (C. Aribau 117)</td>
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