Twelfth International Colloquium on Graphs and Optimization

Leukerbad, Switzerland

June 29 - July 3, 2025

ABSTRACT BOOKLET

Organizers: Alain Hertz
Bernard Ries
David Schindl

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June 29 - July 3, 2025

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POLYTECHNIQUE MONTRÉAL
LE GÉNIE EN PREMIÈRE CLASSE

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Haute école de gestion Genève

Conference schedule

The conference will take place in room **308** of the building "Haute Ecole de Santé – Filière Physiothérapie", Thermenstrasse 41, 3954 Leukerbad.

Each contributed talk lasts 25 minutes, including questions. The chairperson of each contributed talk session is the last speaker of that session.

Sunday June 29

From 17:00	**Registration at Hotel Quellenhof**
From 18:00	**Welcome cocktail at Hotel Quellenhof**

Monday June 30

9:10 - 9:25	**Opening session**
9:25 - 10:40	**Contributed talks (chair: Tellache)**
Spinrad	New problems related to sorting
Meunier	Aircraft routing: periodicity and complexity
Tellache	Linear Lexicographic Optimization and Preferential Bidding System
10:40 - 11:00	**Coffee break**
11:00 - 12:00	**Plenary session (chair: Speranza)**
Archetti	Branch-and-cut algorithms for colorful components problems
12:00 - 14:00	**Lunch break**
14:00 - 15:15	**Contributed talks (chair: Mélot)**
Devillez-Dusollier	Extremal chemical graphs of maximum degree at most 3 for 33 degree-based topological indices
Hertz-Schindl	Complete polyhedral description of chemical graphs of maximum degree 3
Bonte-Mélot	Research tools for graph theorists and chemists

15:15 - 15:45 **Coffee break**

15:45 - 17:00 **Contributed talks (chair: de Werra)**

Carlier	More powerful energetic reasoning using redundant resources for the Cumulative Scheduling Problem
Gachet	Balanced assignments of periodic tasks
de Werra	Scheduling incomplete round robin tournaments with a minimum number of breaks

From 18:00 **Dinner at the restaurant Weidstübli**

Tuesday July 1

9:25 - 10:40 **Contributed talks (chair: Ljubic)**

Correcher	Variable fixation and decomposition algorithms on the generalized vertex cover problem
Casteigts	Temporal Cliques admit Sparse Spanners
Ljubic	Obtaining k-degree anonymous networks via mathematical programming

10:40 - 11:00 **Coffee break**

11:00 - 12:15 **Contributed talks (chair: Katoh)**

MacGillivray	Limited Broadcast Domination in Graph Classes
Delle Donne	Mathematical programming approaches for the Power Dominating Set problem with channel limitation
Katoh	Minimum weight 1-Steiner Laman graph in the plane

12:15 - 17:00 **Lunch break and free afternoon**

From 17:00 **Dinner at Leukerbad Therme**

Wednesday July 2

9:00 - 10:40 **Contributed talks (chair: Picouleau)**

Cameron K.	A positive instance of Scott's Conjecture on chi-boundedness of graphs with no induced subdivision of a fixed graph
Cameron B.	Critical (P_5, W_4)-free graphs
Milanič	Linear colorings of graphs
Picouleau	Matching 3-cut in cubic graphs
10:40 - 11:00	**Coffee break**
11:00 - 12:00	**Plenary session (chair: Cameron K.)**
Hoang	Coloring graphs with forbidden induced subgraphs
12:00 - 14:00	**Lunch break**
14:00 - 15:15	**Contributed talks (chair: Salazar Gonzalez)**
Bangerter	A column generation approach for the routing of electricity technicians
Speranza	Fifty years of vehicle routing problems
Salazar Gonzalez	Solving the Multi-Color Traveling Salesman Problem
15:15 - 15:45	**Coffee break**
15:45 - 17:00	**Contributed talks (chair: Dallard)**
Gimbel	Abelian Group Labels on Regions of Planar Graphs
Gollin	Sharing Beer on a Graph
Dallard	Induced minors: properties and polynomial-time detection
From 18:00	**Dinner at the restaurant Gemmi Lodge 2350**

Thursday July 3

9:25 - 10:40	**Contributed talks (chair: Ekim)**
Erdem	Perfect Graph Modification Problems: An Integer Programming Approach
Sritharan	Quasi-triangulated graphs

Ekim	Integer Programming Formulations and Benders Decomposition for the Defensive Domination Problem
10:40 - 11:00	**Coffee break**
11:00 - 12:15	**Contributed talks (chair: Szachniuk)**
Petris	A Branch-Price-and-Cut Algorithm for the Kidney Exchange Problem
Swiercz	Can graphs help us to detect structural variants in genomes?
Szachniuk	GO for RNA: graphs and optimization in structure reconstruction
12:15 - 12:20	**Closing session**

Social activities

Sunday June 29: Welcome Cocktail at Hotel Quellenhof

A welcome cocktail will be organised on Sunday evening at Hotel Quellenhof, starting at **6pm**.

Please be aware that no dinner is organized on Sunday evening. Participants are supposed to make their own plans if they want to have dinner after the welcome cocktail.

You can register for the conference and get your conference material from **5pm** on at the same hotel.

Monday June 30: Barbecue at Restaurant Weidstübli

The dinner on Monday evening will take place at the restaurant Weidstübli at **7pm**.

The dinner will be preceded by an apero starting around **6pm**. The Weidstübli can be reached by a 15-minute walk from the village center.

You can get there on your own, or you can meet us at the starting point of the walk (Dorfplatz) at **5.40pm**.

Tuesday July 1st: Raclette at Leukerbad Therme

On Tuesday, we will enjoy a raclette evening at Leukerbad Therme.

The meeting point will be at 5pm at the main entrance on Thermenstrasse 56. Please be there on time !

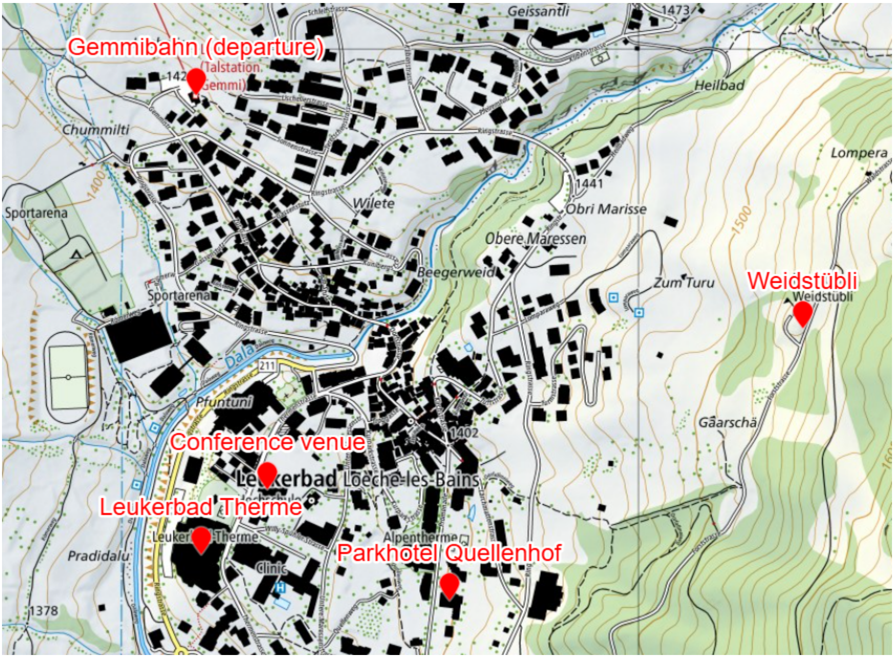
Wednesday July 2nd: Banquet at Gemmi Lodge

The banquet will take place at Gemmi Lodge 2350 on Wednesday evening.

The meeting point will be at the departure station of the "Gemmibahn", at 5.50pm. Please be on time!

Locations map

The locations of the conference and social activities are summarized here:



List of abstracts

Plenary lectures

Contributed talks

Branch-and-cut algorithms for colorful components problems

Claudia Archetti
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joint work with Carmine Sorgente and Martina Cerulli

We tackle three optimization problems in which a colored graph, where each node is assigned a color, must be partitioned into colorful connected components. A component is defined as colorful if each color appears at most once. The problems differ in the objective function, which determines which partition is the best one. These problems have applications in community detection, cybersecurity, and bioinformatics. We present integer non-linear formulations, which are then linearized using standard techniques. To solve these formulations, we develop exact branch-and-cut algorithms, embedding various improving techniques, such as valid inequalities, bounds limiting the number of variables, and warm-start and preprocessing techniques. Extensive computational tests on benchmark instances demonstrate the effectiveness of the proposed procedures. The branch-and-cut algorithms can solve reasonably sized instances efficiently. To the best of our knowledge, we are the first to propose an exact algorithm for solving these problems.

Coloring graphs characterized by forbidden induced subgraphs

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The Coloring Problem is to decide if a given graph can be colored with at most k colors, given an integer k, such that no two adjacent adjacent vertices receive the same color. Given a set L of graphs, a graph G is L-free if G does not contain any graph in L as an induced subgraph. The complexity of the Coloring Problem on L-free graphs is known whenever L contains a single graph.
There has been keen interest in coloring graphs whose forbidden list L contains basic graphs such as induced paths, induced cycles and their complements. In this talk, I will provide a survey of recent progress on this topic.

A column generation approach for the routing of electricity technicians

Elise Bangerter
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joint work with David Schindl, Meritxell Pacheco Paneque and Nour Elhouda Tellache

The maintenance of an electricity distribution network involves numerous daily technical interventions. In this problem, we are given a set of interventions each with associated time windows, location, necessary skills and duration, as well as a set of teams of technicians with associated set of skills. We need to find feasible routes on the interventions for each team, considering the time windows and skills, and ensure that each team returns to its departure depot before the end of the day. The primary objective is to maximize the total duration of completed interventions and as a secondary objective, we aim to minimize the overall routing cost. This problem can be formulated as a capacitated vehicle routing problem with time windows. Due to the large number of teams and interventions, this results in a large-scale optimization problem, and its operational nature limits the time available for exact solving. Here, we propose a column generation approach where one subproblem per vehicle has to be solved and each potential route of a vehicle is considered as a new column in the master problem. To generate these routes, we rely on dynamic programming. Real-world instances from EDF (Electricité de France) of historical technicians' interventions will be used to evaluate the effectiveness of the proposed methods.

A positive instance of Scott's Conjecture on chi-boundedness of graphs with no induced subdivision of a fixed graph

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joint work with Ni Luh Dewi Sintiari, Sophie Spirkl

Let $\chi(G)$ denote the chromatic number of graph G and let $\omega(G)$ denote the size of the largest clique in G. A hereditary class of graphs is called χ-bounded if there is a fixed function f such that for each graph G in the class, $\chi(G) \leq f(\omega(G))$. Perfect graphs are the graphs with f the identity function for all induced subgraphs.
A subdivsion of a graph is obtained by replacing some of its edges by vertex-disjoint paths. For a fixed graph H, let Forb*(H) denote the class of graphs which do not contain any subdivision of H as an induced subgraph. Scott(1997) conjectured that for any graph H, Forb*(H) is χ-bounded. He proved his conjecture when H is a tree and when H is the complete graph on 4 vertices, K_4.
Scott's Conjecture was disproved by Pawlik et al.(2014); another counterexample is the graph obtained from K_4 by subdividing each edge of a 4-cycle once (Chalopin et al. 2016). Finding graphs H for which the conjecture holds remains intriguing. The graph K_4^+ is K_4 with one edge subdivided and K_4^{++} is K_4 with two non-adjacent edges subdivided. Esperet and Trotignon proved that Forb*(K_4^+) is χ-bounded. I will show that a superclass of Forb*(K_4^{++}) is χ-bounded.

Critical (P_5, W_4)-free graphs

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joint work with Wen Xia, Jorik Jooken, Jan Goedgebeur, Iain Beaton and Shenwei Huang

The family of P_5-free graphs is of particular interest when studying graph colouring as P_5 is the largest connected graph whose forbidding as an induced subgraph results in polynomial-time algorithms to decide k-colourability for all k (assuming $P \neq NP$). These algorithms can be extended to certifying ones for subfamiles of P_5-free graphs if there are only finitely many $(k+1)$-critical graphs among the subfamily, where a critical graph is one whose chromatic number decreases with the deletion of any vertex. In this talk, we will sketch our latest result that there are only finitely many k-critical (P_5, W_4)-free graphs for all $k \geq 1$ where W_4 is the wheel of order 5. We will also discuss other graph families where our proof techniques could be applied as well their limitations. A brief overview of alternate techniques will also be discussed.

More powerful energetic reasoning using redundant resources for the Cumulative Scheduling Problem

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joint work with Antoine Jouglet, Kristina Kumbria and Abderrahim Sahli

In this presentation, we are dealing with the Cumulative Scheduling Problems(CuSP). In the CuSP-decision, we are given a set I of n non-preemptive tasks, meaning that once a task begins execution, it cannot be interrupted until completion. A constant amount m of a given resource is available over the time horizon to process the tasks. Each task i has a release date r_i, a processing time p_i, and a deadline d_i. The task i must be executed within its time window $[r_i, d_i]$, and throughout its execution it requires a constant known amount c_i of resources. The objective of this decision problem is to detect infeasibility. Until now, for this problem, the most efficient algorithm is based on energy reasoning. We have already proposed a more powerful energetic reasoning by solving a tripartition problem and built a checker by using a Dynamic Programming method. In the CuSP-optimization, the deadline d_i is replaced by the tail q_i which is equal to $C_{\max} - d_i$ and the objective is to find the minimal makespan $C_{\max}$. The energetic lower bound corresponds to the minimal value for which infeasibility may not be detected. We can solve this problem by using the checker already proposed for the CuSP-decision. We also improved the efficiency of the method by introducing redundant resources. Computation results confirm the efficiency of the proposed methods.

Temporal Cliques admit Sparse Spanners

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A temporal graph is a graph whose edges are present only at certain points in time. These graphs received growing attention over the past two decades, due to their ability to model various types of dynamic networks. On the theoretical side, temporal graphs pose a number of challenges. For instance, reachability (defined in terms of paths that traverses edges in chronological order) is neither symmetric not transitive. Among other consequences, temporal graphs in general do not admit sparse spanners (small subsets of the edges that preserve all-pair reachability, the analog of a spanning tree). In this talk, I will focus on the special case of temporal cliques (the underlying graph is a complete graph). I will show that, in this case, spanners of size O(n log n) are guaranteed whatever the schedule of the edges.

Variable fixation and decomposition algorithms on the generalized vertex cover problem

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joint work with Mercedes Landete, Juanjo Peiró and Hande Yaman

The generalized vertex cover problem arises in real-world scenarios where connections between locations can be left uncovered at a certain cost. This presentation introduces novel results on variable fixation and decomposition algorithms designed to address this problem efficiently. To validate our approach, we compare our methods with traditional non-decomposition procedures through extensive numerical experiments. Finally, we outline potential enhancements to our algorithms and suggest promising directions for future research on this problem.

Induced minors: properties and polynomial-time detection

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An induced minor of a graph G is a graph H that can be obtained from G by means of vertex deletions and edge contractions. It is known since 1995 that there exist graphs H for which the problem of deciding, given a graph G, whether H is an induced minor of G is NP-complete. In 2023, Korhonen and Lokshtanov showed that this can happen even when H is a tree. Earlier this year, Aboulker et al. showed that NP-completeness holds even when H has maximum degree 3 and no two adjacent vertices of degree 3.
In this talk, we will present some sufficient structural conditions on H and G that guarantee the existence of efficient algorithms for deciding if H is an induced minor of G.

Scheduling incomplete Round Robin Tournaments with a minimum number of breaks

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joint work with S. Urrutia and L. Assunçao

In a Single Round Robin Tournament (SRR) involving $2n$ teams, each team plays one game in each one of the $r = 2n - 1$ rounds and meets every other team. In many situations each team has its own venue and all games are played in one of the venues of the teams involved. So for the teams there are Home games and Away games. For many reasons related for instance to the strengths of the various teams of the tournament, one has to consider incomplete Single Round Robin Tournaments (iSRR) with $r < 2n - 1$ rounds. Each team plays r games but does not have to play against every other team. For these iSRR one would also like to have as few breaks as possible in the alternation of Home games and Away games of each team. While this has been studied in depth for complete SRR, things are quite different for iSRR. We intend to derive some properties of iSRR having a minimum number of breaks and to provide an algorithm to construct such iSRR.

Mathematical programming approaches for the Power Dominating Set problem with channel limitation

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joint work with Mauro Lucci and Mariana Escalante

The power dominating set problem (PDS) is a graph optimization problem with applications related to the control and monitoring of electric power systems using devices called *phasor measurement units* (PMUs). The objective of PDS is to find a minimum set of vertices on which to install PMUs that allow monitoring all remaining vertices by recursively applying two observation rules.
One of these, the *domination* rule, assumes that a vertex with a PMU can monitor all its neighbors. In real-world applications, PMUs have a predefined number of channels that limits the number of neighbors they can monitor. In this work, a novel integer linear programming formulation is proposed for PDS and for the variant of PDS that considers PMUs with channel limitation. The formulation is based on a set of constraints to forbid circular precedencies in the domination rules. As the number of constraints grows exponentially, an algorithm is developed to handle them in a dynamic fashion (as lazy constraints) with an efficient separation routine.
Computational experiments are performed on benchmark instances with up to 13.659 vertices to compare the performance of the new formulation with others adapted from the PDS literature. An interesting behavior is observed, where the best-performing formulation depends strongly on the number of limited channels. In particular, the new formulation is effective in instances with moderate channel limitations.

Extremal chemical graphs of maximum degree at most 3 for 33 degree-based topological indices

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joint work with Sébastien Bonte, Alain Hertz and Hadrien Mélot

A large number of degree-based topological indices have been proposed in the literature to study properties of graphs modeling molecular structures. One can wonder if all these invariants are really distinct from an extremal perspective. In this talk, we will give a clear answer for connected graphs of maximum degree at most 3. We characterize the extremal graphs, meaning those that maximize or minimize 33 degree-based topological indices. This study shows that five graph families are sufficient to characterize the extremal graphs of 29 of these 33 indices. In other words, the extremal properties of this set of degree-based topological indices vary very little.

Integer Programming Formulations and Benders Decomposition for the Defensive Domination Problem

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joint work with Bilge Varol and Kübra Tanınmış

The defensive domination problem considers situations where security threats or need for aid in a network may occur at many places (unknown in advance) simultaneously, and we need to be able to defend/counter all possible threats. A security/aid team is only capable of assisting one node. Therefore, a distinct team must be assigned to each of the nodes that are threatened at the same time.

A k-attack on a graph G is a set of k distinct vertices $\{a_1, \ldots, a_k\}$ which are said to be under attack. A k-attack A can be countered or defended by a subset of defender vertices X if and only if there exists an injective function f from A to X, such that either $f(a_i) = a_i$ or $(a_i, f(a_i))$ is an edge of G, for all $i = 1, \ldots, k$. Given a graph G, a subset D of V is a k-defensive dominating set of G if and only if D can counter <u>any</u> k-attack in G. We consider the problem of deciding whether a given graph has a k-defensive dominating set of size at most L.

If k is not fixed, the defensive domination problem is not even in NP. Besides, if k is fixed, it is NP-complete even in split graphs. On the positive side, there are polynomial time solvable cases for special graph classes including paths, cycles, co-chain graphs, threshold graphs and proper interval graphs. However, to the best of our knowledge, no exact solution procedure solving the defensive domination problem in general case has been proposed in the literature.

In this work, we provide an integer programming formulation and develop a Benders decomposition approach. Our computational results show that the Benders decomposition approach outperforms the integer programming formulation, especially when the graph becomes larger and denser.

Perfect Graph Modification Problems: An Integer Programming Approach

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joint work with Tınaz Ekim and Z. Caner Taşkın

Graph modification problems have been studied for several special graph classes. The literature is rather rich in NP-completeness results and polynomial time solvable cases. However, to the best of our knowledge, only a few exact algorithms have been suggested to address hard cases. In this work, we propose exact solution methods based on integer programming for three perfect graph modification problems: minimum perfect edit, minimum perfect completion and the perfect graph sandwich problem. The minimum perfect edit problem inquires the smallest number of edge additions and deletions to make a graph perfect, while the completion problem allows only edge additions. In the perfect graph sandwich problem, only a given subset of non-edges can be changed to edges, and the problem asks whether a perfect graph can be obtained in this way. The proposed methods are based on the Strong Perfect Graph Theorem. We represent odd holes and odd antiholes as linear inequalities, and formulate an integer programming model to solve minimum perfect edit problem. To address the exponential number of constraints, we propose a cutting plane algorithm which relies on detecting odd holes and odd antiholes. To enhance the practical efficiency of the cutting plane algorithm, the expected number of odd holes and odd antiholes in random graphs is addressed. In addition, a heuristic algorithm to obtain perfect graphs is developed and used to obtain improved upper bounds for the edit and the completion problems. Lastly, we demonstrate empirical effectiveness of the proposed methods through computational experiments.

Balanced assignments of periodic tasks

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joint work with Frédéric Meunier

Assume given tasks that need to be repeated every week at specific times and a number of indistinguishable workers to perform them. We address the problem of assigning these periodic tasks in a *balanced* way, i.e., so that each worker performs each task with the same frequency over the long term. Two versions of this problem are considered: the basic version, for which the sole constraint is that a worker cannot perform two tasks at the same time and the extended version where additional constraints on the feasibility of weekly schedules can be introduced. As an illustration, the latter version covers the case of a limit on the total number of working hours per week.
This work shows that, for the two versions of the studied problem, whenever there exists an assignment so that each worker performs every task with the same frequency over the long term, such an assignment can always be made periodic. We prove that the period can be made equal to the number of workers for all instances of the basic version. Furthermore, for this version, we establish a necessary and sufficient condition for the existence of a balanced assignment, which can be verified in polynomial time. For the extended version, a sufficient condition of existence is established as well. As a tool to obtain our results, we introduce a problem of pebbles moving along arcs on an arc-colored directed graph and that need to visit each arc with the same frequency in the long term. This problem and the results obtained about it might be of independent interest.

Abelian Group Labels on Regions of Planar Graphs

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University of Alaska

We consider planar maps with a given abelian group where the vertices are labelled with nonzero elements from the group in such a way that the labels on each region sum to zero. Much interesting work is being done with this concept where the group in question is Z_3 (it is related to the Four Color Theorem.) We expand on current ideas and show that some are true, more broadly, in abelian groups in general.

Sharing Beer on a Graph

Jochen Pascal Gollin
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joint work with J. Pascal Gollin, Kevin Hendrey, Hao Huang, Tony Huynh, Bojan Mohar, Sang-il Oum, Ningyuan Yang, Wei-Hsuan Yu and Xuding Zhu

Consider the following procedure on a graph G. Initially, there is 1 unit of beer at a fixed vertex r of G and all other vertices have no beer. At any time in the procedure, we can choose an edge uv of G and equalize the amount of beer between u and v. We prove that for every vertex x of G, the amount of beer at x is always at most $1/(d+1)$, where d is the distance from x to r. This bound is best possible and answers a question of Nina Gantert. This problem is motivated by the analysis of consensus formation in the Deffuant model for social interaction, which I will also briefly discuss.

Complete polyhedral description of chemical graphs of maximum degree 3

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joint work with Sébastien Bonte, Gauvain Devillez, Valentin Dusollier and Hadrien Mélot

Chemical graphs are simple undirected connected graphs, where vertices represent atoms in a molecule and edges represent chemical bonds. A degree-based topological index is a molecular descriptor used to study specific physicochemical properties of molecules. Such an index is computed from the sum of the weights of the edges of a chemical graph, each edge having a weight defined by a formula that depends only on the degrees of its endpoints. Given any degree-based topological index and given two integers n and m, we are interested in determining chemical graphs of order n and size m that maximize or minimize the index. By restricting our attention to chemical graphs with maximum degree 3, we show that this reduces to determining the extreme points of a polytope that contains at most 10 facets. We also show that the number of extreme points is at most 16, which means that for any given n and m, there are at most 16 different classes of extremal graphs, independently of the chosen degree-based topological index.

Minimum weight 1-Steiner Laman graph in the plane

Naoki Katoh
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joint work with Hitomi Hayashi, Yuya Higashikawa, Takashi Horiyama, Risa Ishikawa, Naoki Katoh, Ayano Nishii, Junichi Teruyama and Azusa Yamamoto

Laman graphs embedded on generic point sets enjoy the special property of being minimally rigid, when viewed as bar-and-joint frameworks with fixed edge-lengths, which motivates the tremendous interest in their properties.In designing minimally rigid bar-and-joint frameworks with fixed position of joints,the construction cost can be reduced if the total length of the framework becomes samller. Suppose that we are given fixed positions of all joitns in the plane. Then it is reasonable to choose a minimally rigid (i.e., Laman) framework with minimum length which can be easily obtained by a greedy algorithm based on the maroidal property of Laman graphs. We first show that as in the case of minimal Steiner trees, the total length of a Laman framework with minimum length can be reduced if we add extra points (joins) to the set of original points by showing simple examples. In this talk, we will consider the case that we are given a set V of points (joints) in the plane whose positions are fixed. Then we can consider to add on extra point p whose position can be chosen freely. The point p acts as a steiner point. We want to find a position of p so that the total edge length of the minimu weight Laman graph is minimized. Such Laman graph is called a minimal 1-steiner Laman graph.
We shall show that a minimal 1-steiner Laman graph can be obtained in polynomial time if we assume the oracle that computes geometric median.

Obtaining k-degree anonymous networks via mathematical programming

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joint work with Raffaele Cerulli and Carmine Sorgente

Social network data sets are often published and used for analysis purposes in many application domains. This frequently raises privacy issues, as simply hiding users' identities does not prevent potential adversaries from tracing back to the real-world entities associated with specific nodes of the network having sufficiently distinctive features from others.
To protect individuals' privacy, networks need to be properly anonymized before publication.
The k-degree anonymization problem is to determine the smallest set of edge modifications needed to ensure that each user has the same number of connections as at least $k-1$ other users. A network satisfying this property is defined as k-degree anonymous.
In this work, we tackle three versions of the problem allowing for edge insertions and deletions, exclusively or together. This work is the first to apply integer linear programming (ILP) techniques to k-degree anonymous networks.
We introduce two families of ILP formulations and propose an ILP-based heuristic approach based on imposing that the order of the nodes inherited by its degree sequence remains unchanged after performing the modifications, which allows for an efficient ILP reformulation with the k-degree anonymity constraints.
We additionally derive combinatorial bounds on the largest degree of the anonymized network, helping reduce the size of the proposed formulations.
Finally, we conduct computational experiments on benchmark social networks and scale-free networks and perform an instance space analysis to identify the features that mostly affect the performance of the formulations.

Limited Broadcast Domination in Graph Classes

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joint work with Michael A. Henning and Feiran Yang

Imagine that transmitters which can each broadcast at a variety of non-negative integer strengths are located at vertices of a graph G, and that a broadcast of strength $s > 0$ from a vertex v can be *heard* by all vertices whose distance from v is at most s. The goal is minimize the sum of the strengths of the broadcasts subject to the condition that every vertex hears some broadcast.

Formally, *k-limited dominating broadcast* on a graph G is a function $f : V \to \{0, 1, 2, \ldots, k\}$ with the property that for every vertex x, there exists a vertex w such that $f(w) > 0$ and $d(x, w) \leq f(w)$. The *k-limited broadcast domination number of* G, denoted $\gamma_{b,k}(G)$, is the minimum value of $\sum_{x \in V} f(x)$, where the minimum is over all k-limited dominating broadcasts on G.

After noting that the problem of deciding for a given graph G and integer B, whether G has a k-limited dominating broadcast, f, such that $\sum_{x \in V} f(x) \leq B$ is NP-complete, we describe polynomial-time algorithms to find $\gamma_{b,k}(G)$ when G is a strongly chordal graph, an interval graph, a circular arc graph, or a proper interval bigraph.

Research tools for graph theorists and chemists

Sébastien Bonte and Hadrien Mélot
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joint work with G. Devillez and V. Dusollier

The discovery system PHOEG was presented in previous editions of GO. It allows to conjecture relations between graph invariants with the help of a geometrical approach.
This tool is made available to the scientific community via a website. It has been completely rewritten to allow for simplified use by researchers. The new interface will be presented, along with a new tool specifically designed for research in chemical graph theory, called ChemicHull. The latter makes it easy to discover the extremal properties of degree-based topological indices.

Aircraft routing: periodicity and complexity

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École nationale des ponts et chaussées
joint work with Axel Parmentier and Nour ElHouda Tellache

The aircraft routing problem is one of the most relevant problems of operations research applied to aircraft management. It involves assigning flights to aircraft while ensuring regular visits to maintenance bases. This paper examines two aspects of the problem.
First, we explore the relationship between periodic instances, where flights are the same every day, and periodic solutions. The literature has implicitly assumed—without discussion—that periodic instances necessitate periodic solutions, and even periodic solutions in a stronger form, where every two airplanes perform either the exact same cyclic sequence of flights, or completely disjoint cyclic sequences. However, enforcing such periodicity may eliminate feasible solutions. We prove that, when regular maintenance is required at most every four days, there always exist periodic solutions of this form.
Second, we consider the computational hardness of the problem. Even if many papers in this area refer to the NP-hardness of the aircraft routing problem, such a result is only available in the literature for periodic instances. We establish its NP-hardness for a non-periodic version. Polynomiality of a special but natural case is also proven.

Linear colorings of graphs

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joint work with Claire Hilaire, Matjaž Krnc and Jean-Florent Raymond

Motivated by algorithmic applications, Kun, O'Brien, Pilipczuk, and Sullivan (Algorithmica, 2021) introduced the parameter linear chromatic number as a relaxation of treedepth and proved that the two parameters are polynomially related. They conjectured that treedepth could be bounded from above by twice the linear chromatic number. We investigate the properties of linear chromatic number and provide improved bounds in several graph classes.

A Branch-Price-and-Cut Algorithm for the Kidney Exchange Problem

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joint work with Claudia Archetti, Diego Cattaruzza, Maxime Ogier and Frédéric Semet

We study a Kidney Exchange Problem (KEP) with altruistic donors and incompatible patient-donor pairs. Kidney exchanges can be modelled in a directed graph as circuits starting and ending in an incompatible pair or as paths starting at an altruistic donor. For medical reasons, circuits and paths are of limited length and are associated with a medical benefit to perform the transplants. The aim of the KEP is to determine a set of disjoint kidney exchanges of maximal medical benefit or maximal cardinality.
We consider a set packing formulation for the KEP with exponentially-many variables associated with circuits and paths, and develop a Branch-Price-and-Cut algorithm (BPC) to solve it. We decompose the pricing problem into a subproblem to price out the path variables and several subproblems to price out the circuit variables. We strengthen the linear relaxation via the inclusion of a family of non-robust inequalities.
We perform extensive computational experiments to assess the performances of the BPC algorithm on three sets of instances from the literature and on a newly generated set of challenging instances. On the easiest instances, it yields comparable results with the literature, while on the other sets it clearly outperforms the previous results. Hence, contrary to the existing literature, the BPC algorithm is the only exact approach able to effectively solve various and difficult instances with both objective functions and long chains and cycles.

Matching 3-cut in cubic graphs

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joint work with Valentin Bouquet

Given $G = (V, E)$ a connected cubic graph, a matching 3-cut consists of a matching $M \subseteq E$ such that $G' = (V, E \setminus M)$ has 3 connected components.

A necessary condition for $G = (V, E)$ cubic with $|V| = n$ and girth $g(G)$ to have a matching 3-cut is $n \geq 2\lceil \frac{3g(G)}{2} \rceil$.

This condition is not sufficient: for $g(G) = 7$ there are cubic graphs G_1, G_2 both with $n = 4g(G) = 28$ such that G_1 has a matching 3-cut whereas G_2 has not.

We show that for $n \geq 4g(G) + 2 = 30$ every connected cubic graph G has a matching 3cut.

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Solving the Multi-Color Traveling Salesman Problem

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joint work with Roberto Wolfler-Calvo

This work concerns the Multi-Color TSP, which is motivated by a more complex real-world problem known in the lilterature as Overnight Security Service Problem, optimizing the routes of a fleet of guards that should check a set of buildings in an urban area for security reasons.
The Multi-Colour Travelling Salesman Problem is a particular case of the Overnight Security Service Problem with one guard and identical time costs between buildings. In this particular case, each colour corresponds to a building, and each node is a potential visit.
The goal is to find a Minimum Cost Hamiltonian Cycle bounding the number of other nodes visited between consecutive points with the same colour. The paper describes several mathematical formulations for the Multi-Colour Travelling Salesman Problem. Since some formulations involve an exponential number of constraints, we describe constraint-generation procedures to be used within a Branch-and-Cut framework. Computational results proving the efficacy of our approach are obtained on real-world and randomly-generated instances.

Fifty years of vehicle routing problems

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joint work with M.G. Speranza, C. Archetti, L. C. Coelho and P. Vansteenwegen

Vehicle routing problems (VRPs) are a large class of well-studied and computationally hard combinatorial optimization problems. In the classical capacitated VRP, a fleet of homogeneous capacitated vehicles, that start and end their route at a depot, must satisfy customers' demand at minimum cost. Many variants and extensions of this problem have been studied. In this talk an overview of the most-studied variants and extensions of the VRP is presented together with the most recent developments and trends.

New Problems Related to Sorting

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This research started with considering how the 2/3-1/3 conjecture should change when the underlying order to be discovered is a partial order, rather than a total order.

The natural algorithm for trying to discover an unknown underlying partial order is to randomly choose to compare a pair of elements x and y, such that the relationship between x and y is not implied by the result of previous comparisons. Surprisingly, this natural approach does not seem to have been studied for the sorting problem. The open question for sorting is the expected number of queries the algorithm will make in the expected case. We give experimental evidence indicating the number of comparisons this seems to make in the expected case, and prove a nontrivial upper bound on this value.

Quasi-triangulated graphs

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joint work with Elaine Eschen and Chinh T. Hoang

A graph is chordal (or triangulated) if it does not have any chordless cycle on 4 or more vertices as an induced subgraph. A graph is co-chordal if its complement is chordal. A graph is quasi-triangulated if each of its induced subgraphs has a vertex that is either simplicial (its neighbors form a clique) or co-simplicial (its non-neighbors form an independent set) in the induced subgraph. The class of quasi-triangulated graphs, introduced by Voloshin, is a generalization of the class of chordal graphs and also the class of co-chordal graphs. We survey some known results on quasi-triangulated graphs and present some recent work with Elaine Eschen and Chinh T. Hoang.

Can graphs help us to detect structural variants in genomes?

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joint work with Dominik Witczak and Jacek Błażewicz

Genetic diversity in genomes is crucial for populations to adapt and survive in dynamic environments. This diversity arises from genetic mutations, which manifest in the genome as structural variants (SVs). Several types of structural variants exist: deletions, duplications, insertions, inversions and translocations. Current SV detection tools tend to specialize in certain SV types, limiting their overall utility. Some methods can identify breakpoints where SVs appear, but they cannot accurately classify variant types. Detection precision also varies depending on data quality and the sequencing technology used. At present, the majority of available data in genomic databases comes from high-quality short reads, which remains the most affordable sequencing technology.
We propose a tool GrassSV, that identifies potential SV breakpoints and performs de novo assembly of reads in these regions. We use graph based approach to assembly reads. Through in-depth analysis of contig mapping patterns, GrassSV can accurately annotate the specific types of SV. The method's robustness was demonstrated on the human Genome in a Bottle dataset, as well as on synthetic data derived from the yeast genome to assess both precision and recall. GrassSV was the only method capable of detecting all SV types while minimizing false positive results.

GO for RNA: graphs and optimization in structure reconstruction

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joint work with Maciej Antczak, Paulina Hladki and Marek Justyna

Graph models offer powerful mathematical tools for representing molecular structures, making them particularly well-suited for capturing the complex interactions within RNA molecules. These molecules adopt their final, energetically optimal conformation through a folding process in which structural elements form stable and transient interactions. The latter can be analyzed at various levels: atomic (bonds between atoms), nucleotide (base pairing and long-range contacts), or chain-level in multistrand molecules, depending on the researchers' interests.
In our studies, we use graphs to model and analyze RNA structure. Specifically, we address the challenge of predicting higher-order structures based on lower-resolution information, where we aim to infer structure at level X from its representation at level $X - i$, with $i \in \{1, 2, 3\}$.
In this talk, we will present the application of graphs to two predictive problems. The first focuses on developing a model for RNA secondary structure prediction from sequence data, capable of generating both canonical and non-canonical base pairs. Despite advances in RNA 2D structure prediction, current methods struggle with non-canonical interactions (Justyna et al., 2023). Our model, trained on high-resolution experimental RNA structures, achieves a high prediction accuracy. The second problem concerns RNA tertiary structure prediction from sequence while preserving secondary structure constraints. We developed a predictive system combining a graph neural network (GNN) with a diffusion model, reconstructing molecular interactions with an INF=1.0. The model was trained on single-, double-, and triple-segment structural descriptors and works well for small RNA molecules (up to 100 nucleotides).

Linear Lexicographic Optimization and Preferential Bidding System

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joint work with Frédéric Meunier and Axel Parmentier

Some airlines use the preferential bidding system to construct the schedules of their pilots. In this system, the pilots bid on the different activities and the schedules that lexicographically maximize the scores of the pilots according to their seniority are selected. A sequential approach to solve this maximization problem is natural: The problem is first solved with the bids of the most senior pilot, and then it is solved with those of the second most senior without decreasing the score of the most senior, and so on. The literature admits that the structure of the problem somehow imposes such an approach. The problem can be modeled as an integer linear lexicographic program. We propose a new efficient method, which relies on column generation for solving its continuous relaxation and returns proven optimality gaps. To design this column generation, we prove that bounded linear lexicographic programs admit "primal-dual" feasible bases, and we show how to compute such bases efficiently. Another contribution on which our method relies is the extension of standard tools for resource-constrained longest path problems to their lexicographic versions. This is useful in our context because the generation of new columns is modeled as a lexicographic resource-constrained longest path problem. Numerical experiments show that this new method is already able to solve to proven optimality industrial instances provided by Air France, with up to 150 pilots. By adding a last ingredient in the resolution of the longest path problems, which exploits the specificity of the preferential bidding system, the method achieves for these instances computational times that are compatible with operational constraints.

	Sunday June 29	Monday June 30	Tuesday July 1	Wednesday July 2	Thursday July 3
09:00 - 10:40		Opening session Spinrad Meunier Tellache	Correcher Casteigts Ljubic	Cameron K. Cameron B. Milanič Picouleau	Erdem Sritharan Ekim
10:40 - 11:00		Coffee break	Coffee break	Coffee break	Coffee break
11:00 - 12:15		Plenary I Archetti	MacGillivray Delle Donne Katoh	Plenary II Hoang	Petris Swiercz Szachniuk
12:15 - 14:00		Lunch break	Lunch break and free afternoon	Lunch break	Closing session
14:00 - 15:15		Devillez - Dusollier Hertz - Schindl Bonte - Mélot		Bangerter Speranza Salazar Gonzalez	
15:15 - 15:45		Coffee break		Coffee break	
15:45 - 17:00		Carlier Gachet de Werra		Gimbel Gollin Dallard	
17:00 - 18:00	Registration	Free time	Dinner	Free time	
from 18:00	Welcome cocktail	Dinner		Banquet	