BGTC 2023

Belgian Graph Theory Conference on Structure and Algorithms

9-11 August 2023
Ghent University

Ghent University

KU Leuven

Contents

Welcome

Welcome to Ghent and welcome to the first Belgian Graph Theory Conference. Although this is the first edition under this name, we already have quite some history to look back at. In 2016, Carol Zamfirescu organised the first Ghent Graph Theory Workshop on Longest Paths and Longest Cycles. With Jan Goedgebeur and Nico Van Cleemput joining the organisation, this was transformed into the Ghent Graph Theory Workshop on Structure and Algorithms, and had editions in 2017 and 2019. This year, KU Leuven joins efforts with Ghent University to organise this first edition of this conference.

We hope everyone finds something interesting in this programme – please have a look at both the scientific programme as well as the social programme. For those in need of tips for a good restaurant or a place to get some beers, we included some pointers.

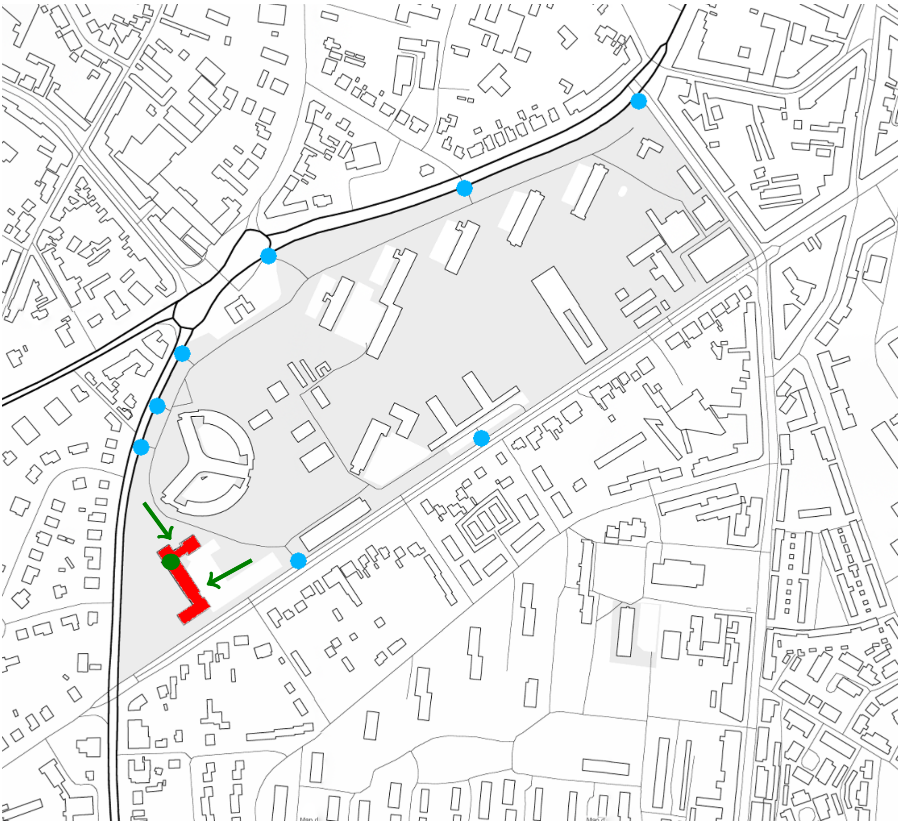
Finally, if you have any problems – mathematical or non-mathematical –, suggestions, or just want to chat, please do not hesitate to contact us.

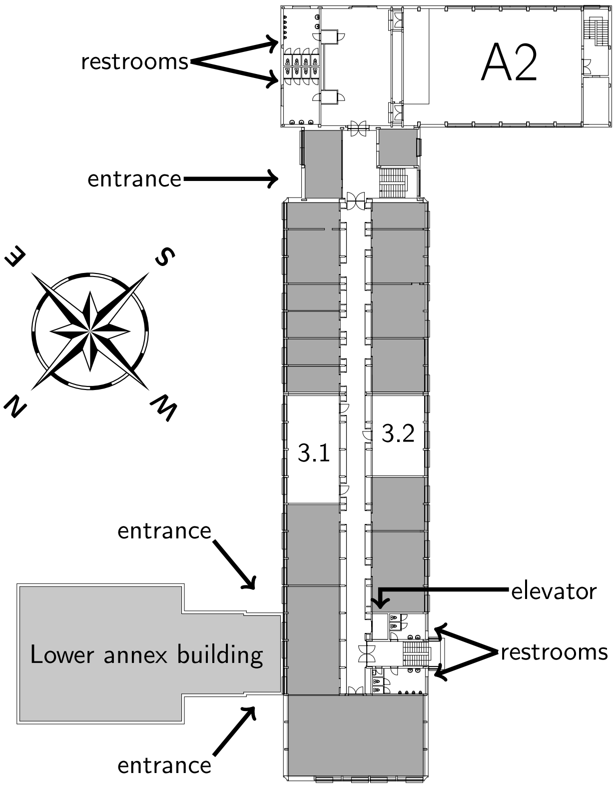
Wishing you an excellent time in Ghent,

Jan Goedgebeur • Davide Mattiolo • Nico Van Cleemput
Heidi Van den Camp • Steven Van Overberghe • Carol Zamfirescu

Venue

The scientific part of the Ghent Graph Theory Workshop takes place on the second and third floor in the S9 building of Campus De Sterre (Krijgslaan 281, 9000 Ghent). Below you can see the campus in grey. The access points to the campus are shown with blue dots. The S9 building is shown in red, and the green arrows show the entrances of the building. The elevator is located at the green dot.





All academic activities for the workshop will happen on the **second and third floor** of the S9 building. Above you see a map of these floors. Room A2 is located on the second floor. All other rooms shown are located on the third floor. The grey areas are offices which are not accessible for participants of the workshop.

All talks will be held in auditorium A2. The coffee breaks will be in room 3.1, and room 3.1 and 3.2 are available for discussions. Eduroam is available in the whole building.

Social programme

The map on the next page situates the workshop venue (S9) in reference to the city centre, and at the same time highlights several key locations for the social programme.

Guided tour

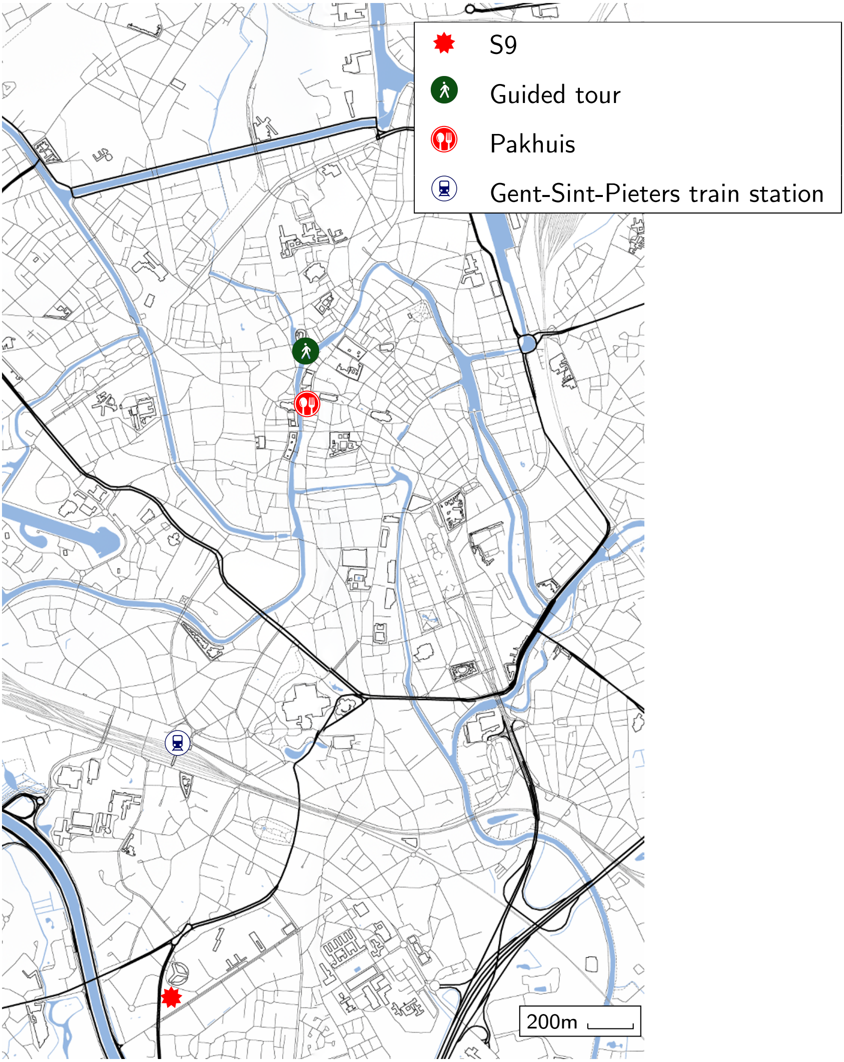
On Thursday at 14h30, we have organised a guided tour of Ghent. The tour will last until 16h30. The tour starts at **Veerleplein 5, 9000 Ghent**. This is right across from the Gravensteen, so if you are lost, try to look for a large medieval castle. The starting point lies directly at a stop of Tram 1. This tram also passes near the conference venue as well as the Gent-Sint-Pieters train station. Take the tram in the direction *Wondelgem* or *Evergem*, and get off at the stop *Gent Gravensteen (Veerleplein)*.

Conference dinner

On Thursday at 18h30, we will gather for the conference dinner at the restaurant **Pakhuis** at **Schuurkenstraat 4, 9000 Ghent**. The restaurant is in the city centre, but is slightly hidden from the more central areas. Try to look for a McDonald's. Do not enter there, but enter the small street right next to it, and then immediately take the street to the left.

Excursion to Bruges

Not officially part of the conference, but on Saturday, we are organising a survivors' excursion to Bruges. We will meet at 9h in the main hall of Gent-Sint-Pieters train station. Details will be provided during the conference, because you will need to buy your own train ticket.


S9
Guided tour
Pakhuis
Gent-Sint-Pieters train station
200m

Schedule

Wednesday August 9

Time	Talk	
09:00 - 09:30	*Badge pick-up*	
09:35 - 09:40	*Opening*	
09:40 - 10:30	**Ádám's conjecture** Carsten Thomassen	p. 10
10:30 - 11:00	*Coffee break*	
11:00 - 11:20	**A construction for a counterexample to the pseudo 2–factor isomorphic graph conjecture** Domenico Labbate	p. 10
11:20 - 11:40	**Isolating cycles in polyhedra** Jens M. Schmidt	p. 10
11:40 - 12:00	**Cycle lengths in 3-connected planar graphs** On-Hei Solomon Lo	p. 11
12:00 - 12:20	**Frustration critical signed graphs** Eckhard Steffen	p. 11
12:20 - 14:00	*Lunch*	
14:00 - 14:20	**The strong path partition conjecture** Marietjie Frick	p. 12
14:20 - 14:40	**On some generalized vertex Folkman numbers** Stanisław Radziszowski	p. 12
14:40 - 15:00	**A complexity framework for forbidden subgraphs** Daniël Paulusma	p. 13
15:00 - 15:20	**Understanding graphs with no long claws** Paweł Rzążewski	p. 13
15:20 - 15:40	*Coffee break*	
15:40 - 16:00	**A 2–bisection with small number of monochromatic edges** Kenta Ozeki	p. 14
16:00 - 16:20	**Graph minor condition for graphs to be k-linked** Shun-ichi Maezawa	p. 14

Time	Talk	
16:20 - 16:40	**Defective acyclic colourings of planar graphs**	
	Ben Seamone	p. 14
16:40 - 17:00	**Some results on the palette index of graphs**	
	Gloria Tabarelli	p. 15

Thursday August 10

Time	Talk	
09:40 - 10:30	**Separating edges with few paths**	
	Marthe Bonamy	p. 16
10:30 - 11:00	*Coffee break*	
11:00 - 11:20	**Berge covers of cubic graphs with colouring defect 3**	
	Martin Škoviera	p. 16
11:20 - 11:40	**Edge-connectivity and the number of pairwise disjoint perfect matchings in r-graphs**	
	Isaak H. Wolf	p. 16
11:40 - 12:00	**Sets of r-graphs that colour all r-graphs**	
	Yulai Ma	p. 17
12:00 - 14:00	*Lunch*	
14:30 - 16:30	*Guided tour of Ghent*	
18:30 - 22:00	*Conference dinner*	

At 14h30, there is a guided tour of Ghent (start at Veerleplein 5, 9000 Ghent). The tour will last until 16h30. Then you have two hours of downtime before the start of the conference dinner. During this time, you can further explore Ghent on your own, have a drink and mathematical discussions, or return to your hotel to change into formal evening wear (not mandatory).
We will reconvene at 18h30 at the restaurant **Pakhuis** (Schuurkenstraat 4, 9000 Ghent).
See page 6 for a map situating the start of the guided tour and the restaurant.

Friday August 11

Time	Talk	
09:40 - 10:30	**Complex nowhere-zero flows on finite graphs** Giuseppe Mazzuoccolo	p. 18
10:30 - 11:00	*Coffee break*	
11:00 - 11:20	**On the Frank number and nowhere-zero flows on graphs** Edita Máčajová	p. 18
11:20 - 11:40	**Skipless chain decompositions and antichain saturation** Carla Groenland	p. 19
11:40 - 12:00	**Spanning trees of smallest maximum degree** Samuel Mohr	p. 19
12:00 - 12:20	**Intuition on average subtree order of graphs** Stijn Cambie	p. 19
12:20 - 14:00	*Lunch*	
14:00 - 14:20	**Symmetry levels of graphs** Tatiana Jajcayová	p. 20
14:20 - 14:40	**Bounding the fractional chromatic number using eigenvalues and symmetry** Krystal Guo	p. 21
14:40 - 15:00	**On expander properties of graphs extremal with regard to their degree/diameter or degree/girth parameter pairs** Robert Jajcay	p. 21
15:00 - 15:15	*Closing remarks*	

Abstracts

Wednesday August 9

Ádám's conjecture

Carsten Thomassen

Á. Ádám proposed in 1964 the conjecture that, if a directed graph contains at least one directed cycle, then it contains an arc whose reversal decreases the number of directed cycles. The conjecture was disproved independently by E.J. Grinberg and the present speaker in the 1980ies. However, this did not close the problem because all known counterexamples were based on parallel arcs.

In this talk we disprove the conjecture also for directed graphs with no parallel arcs.

A construction for a counterexample to the pseudo 2–factor isomorphic graph conjecture

Domenico Labbate *Joint work with: M.Abreu, M.Funk, F. Romaniello*

A graph G admitting a 2-factor is pseudo 2-factor isomorphic if the parity of the number of cycles in all its 2-factors is the same. The speaker with some co–authors gave (2008) a partial characterisation of pseudo 2-factor isomorphic bipartite cubic graphs and conjectured that $K_{3,3}$, the Heawood graph H_0 and the Pappus graph P_0 are the only essentially 4-edge-connected ones. Jan Goedgebeur (2015) computationally found a graph G of order 30 that is a counterexample to the above conjecture. In this talk, we describe how such a graph can be constructed.

Isolating cycles in polyhedra

Jens M. Schmidt *Joint work with: Jan Kessler*

A cycle C of a graph G is *isolating* if every component of $G - V(C)$ consists of a single vertex. We show that isolating cycles in polyhedral graphs can be extended to larger ones: every isolating cycle C of length $6 \leq |E(C)| < \left\lfloor \frac{2}{3}(|V(G)| + 4) \right\rfloor$ implies an isolating cycle C' of larger length that contains $V(C)$. By "hopping" iteratively to such larger cycles, we obtain a powerful and very general inductive motor for proving long cycles and computing them (we will give an algorithm with quadratic running time). This is the first step towards the so far elusive quest of finding a universal induction that captures longest cycles of polyhedral graph classes.

Our motor provides also a method to prove linear lower bounds on the length of Tutte cycles, as C' will be a Tutte cycle of G if C is. We prove in addition that $|E(C')| \leq |E(C)| + 3$ if G contains no face of size five, which gives a new tool for results about cycle spectra, and provides evidence that faces of size five may obstruct many different cycle lengths. As a sample application, we test our motor on the following so far unsettled conjecture about essentially 4-connected graphs. All our results are tight.

Cycle lengths in 3-connected planar graphs

On-Hei Solomon Lo *Joint work with: Qing Cui and Carol T. Zamfirescu*

It is well known that Euler's formula implies every 3-connected planar graph has a cycle of length 3, 4 or 5. Motivated by this fact, it is shown that given any integer k at least 5, every 3-connected planar graph that contains some cycle of length at least k must have a cycle of length between k and $2k+3$; and the number $2k+3$ is tight. In this talk we may also review related problems and results concerning other planar graph classes.

Frustration critical signed graphs

Eckhard Steffen *Joint work with: Chiara Capello, Reza Naserasr, Zhouningxin Wang*

A signed graph (G, Σ) is a graph G together with a set $\Sigma \subseteq E(G)$ of negative edges. A circuit is positive if the product of the signs of its edges is positive. A signed graph (G, Σ) is balanced if all its circuits are positive. The frustration index $l(G, \Sigma)$ is the minimum cardinality of a set $E \subseteq E(G)$ such that $(G - E, \Sigma - E)$ is balanced, and (G, Σ) is k-critical if $l(G, \Sigma) = k$ and $l(G - e, \Sigma - e) < k$, for every $e \in E(G)$.

The talk is about structural properties of sets of non-decomposable and irreducible critical signed graphs. In particular, the question of whether these sets are finite is addressed.

The strong path partition conjecture

Marietjie Frick *Joint work with: Johan de Wet, Jean Dunbar, Ortrud Oellermann*

The number of vertices in a longest path in a graph G is denoted by $\tau(G)$. If a and b are positive integers, we call a partition (A, B) of the vertex set of G an (a, b)-*partition* of G if $\tau(G[A]) \le a$ and $\tau(G[B]) \le b$. If equality holds in both instances, we call (A, B) an *exact* (a, b)-*partition* of G. The Path Partition Conjecture (PPC) asserts that if G is any graph and a, b any pair of positive integers such that $\tau(G) = a + b$, then G has an (a, b)-partition. The Strong PPC asserts that under the same circumstances G has an exact (a, b)-partition. The PPC first appeared in the literature in 1983. From results of three papers (with different sets of authors) published between 1986 and 2005, we know that the PPC holds for all $a \le 8$. In this talk we discuss a recursive procedure for finding exact (a, b)-partitions, which has thus far enabled us to prove that the Strong PPC holds for all $a \le 9$.

On some generalized vertex Folkman numbers

Stanisław Radziszowski *Joint work with: Zohair Raza Hassan, Yu Jiang, David Narváez, Xiaodong Xu*

For a graph G and integers $a_i \ge 1$, the expression $G \to (a_1, \ldots, a_r)^v$ means that for any r-colouring of the vertices of G there exists a monochromatic a_i-clique in G for some colour $i \in \{1, \cdots, r\}$. The vertex Folkman numbers are defined as $F_v(a_1, \ldots, a_r; H) = \min\{|V(G)| : G$ is H-free and $G \to (a_1, \ldots, a_r)^v\}$, where H is a graph. Such vertex Folkman numbers have been extensively studied for $H = K_s$ with $s > \max\{a_i\}_{1 \le i \le r}$. If $a_i = a$ for all i, then we use notation $F_v(a^r; H) = F_v(a_1, \ldots, a_r; H)$.

Let J_k be the complete graph K_k missing one edge, i.e. $J_k = K_k - e$. In this work we focus on vertex Folkman numbers with $H = J_k$, in particular for $k = 4$ and $a_i \le 3$. A result by Nešetřil and Rödl from 1976 implies that $F_v(3^r; J_4)$ is well defined for any $r \ge 2$. We present a new and more direct proof of this fact. The simplest but already intriguing case is that of $F_v(3, 3; J_4)$, for which we establish the upper bound of 135 by using the J_4-free process. We obtain the exact values and bounds for a few other small cases of $F_v(a_1, \ldots, a_r; J_4)$ when $a_i \le 3$ for all $1 \le i \le r$, including $F_v(2, 3; J_4) = 14$, $F_v(2^4; J_4) = 15$, and $22 \le F_v(2^5; J_4) \le 25$. Note that $F_v(2^r; J_4)$ is the smallest number of vertices in any J_4-free graph with chromatic number $r + 1$.

Most of the results were obtained with the help of computations, but some of the upper bound graphs we found are interesting by themselves.

A complexity framework for forbidden subgraphs

Daniël Paulusma *Joint work with: Matthew Johnson, Barnaby Martin, Jelle Oostveen, Sukanya Pandey, Siani Smith, Erik Jan van Leeuwen*

For a set of graphs $\mathcal{H}$, a graph G is $\mathcal{H}$-subgraph-free if G does not contain any graph from $\mathcal{H}$ as a subgraph. We propose a framework for determining the complexity of graph problems for $\mathcal{H}$-subgraph-free graphs. We say that a problem Π is C123 if Π is:

C1. efficiently solvable on graphs of bounded treewidth,

C2. hard on subcubic graphs, and

C3. hardness is preserved under edge subdivision of subcubic graphs.

Our meta-classification says that for every finite set of graphs $\mathcal{H}$, every C123-problem on $\mathcal{H}$-subgraph-free graphs is "efficiently solvable" if $\mathcal{H}$ contains a disjoint union of one or more paths and subdivided claws, and is "computationally hard" otherwise. Apart from unifying a number of known results in the literature, we show that a wide variety of other problems are also C123. When doing this, we distinguish both between polynomial-time solvability and NP-completeness, and between almost-linear-time solvability and having no subquadratic-time algorithm (conditioned on some hardness hypotheses).

Understanding graphs with no long claws

Paweł Rzążewski *Joint work with: P. Gartland, T. Masařík, D. Lokshtanov, Ma. Pilipczuk, Mi. Pilipczuk*

A classic result of Alekseev asserts that for connected H the Max Independent Set (MIS) problem in H-free graphs in NP-hard unless H is a path or a subdivided claw. Recently we have witnessed some great progress in understanding the complexity of MIS in P_t-free graphs. The situation for forbidden subdivided claws is, however, much less understood.

During the talk we will present some recent advances in understanding the structure of graphs with no long induced claws. We are able to use them to obtain a quasipolynomial-time algorithm for the problem.

A 2–bisection with small number of monochromatic edges

Kenta Ozeki *Joint work with: Seungjae Eom*

A k-bisection of G is a partition of its vertex set into two parts of the same cardinality such that every component of each part has at most k vertices. In this talk, we show that every claw-free cubic graph contains a 2-bisection with bounded number of monochromatic edges, where a monochromatic edge of a 2-bisection is an edge connecting two vertices of the same part of the 2-bisection. We also prove that our bound is best possible for all claw-free cubic simple graphs.

Graph minor condition for graphs to be k-linked

Shun-ichi Maezawa

A graph is called k-*linked*, if for any $2k$ distinct vertices $x_1, x_2, \ldots, x_k, y_1, y_2, \ldots, y_k$, there exist k vertex disjoint paths $P_1, P_2, \ldots, P_k$ such that P_i connects x_i and y_i for each $1 \leq i \leq k$. Robertson and Seymour showed that every $2k$-connected graph having K_{3k} as a minor is k-linked. In 2005, Chen, Gould, Kawarabayashi, Pfender, and Wei proved that every 6-connected graph having K_9^- as a minor is 3-linked, where K_k^{-i} is the graph obtained from the complete graph with k vertices by deleting exactly i edges. We improve these two results by showing that every $2k$-connected graph having the graph obtained from K_{3k} by deleting independent k edges as a minor is k-linked.

Defective acyclic colourings of planar graphs

Ben Seamone *Joint work with: On-Hei Solomon Lo, Xuding Zhu*

A vertex colouring of a graph G is called acyclic if the colouring is proper and any two colour classes induce an acyclic subgraph of G. It was shown by Borodin (1979) that every planar graph has an acyclic 5-colouring. Mondal, Nishat, Rahman, and Whitesides (2013) show that any planar triangulation can be made acyclically 3-colourable by subdividing $2n - 5$ of its edges exactly once each, and acyclically 4-colourable by subdividing $\frac{3}{2}n - \frac{7}{2}$ of its edges exactly once each. We extend and complement these results by showing that every planar graph can be made acyclically 3-colourable (resp., 4-colourable) by deleting at most $\frac{13}{10}n - \frac{21}{5}$ (resp., $\frac{3}{5}n - \frac{12}{5}$) edges, and providing tight bounds on the minimum number of edges one needs to remove from a planar graph in order to turn any proper 3-colouring or 4-colouring into an acyclic colouring.

Some results on the palette index of graphs

Gloria Tabarelli *Joint work with: D. Labbate, D. Mattiolo, G. Mazzuoccolo, F. Romaniello*

Given an edge-colouring of a graph, the palette of a vertex is defined as the set of colours of the edges which are incident with it. We define the palette index of a graph as the minimum number of distinct palettes, taken over all edge-colourings, occurring among the vertices of the graph. Several results about the palette index of some specific classes of graphs are known. In this talk we present some new results on the palette index of graphs. Our main theorem gives a sufficient condition for a graph to have palette index larger than its minimum degree. We also give a characterization of graphs with "small" palette index (either 2 or 3) in terms of the existence of suitable decompositions in regular subgraphs. Using previous results, in the talk we present, for every odd r, a family of r-regular graphs with palette index reaching the maximum admissible value, the first known family of simple graphs whose palette index grows quadratically with respect to their maximum degree and we finally provide a complete characterization of regular graphs having palette index 3.

Thursday August 10

Separating edges with few paths

Marthe Bonamy *Joint work with: Fábio Botler, François Dross, Tássio Naia, Jozef Skokan*

A path separates an edge from another if it contains the former and not the latter. How many paths do we need to separate any edge from any other in an arbitrary graph?

This question is in line with the general study of separating systems initiated by Rényi in 1961. We discuss the tools involved in obtaining bounds that are tight up to a constant factor, as well as other related questions.

Berge covers of cubic graphs with colouring defect 3

Martin Škoviera *Joint work with: Ján Karabáš, Edita Máčajová, Roman Nedela*

The colouring defect of a cubic graph is the smallest number of edges left uncovered by any set of three perfect matchings. While 3-edge-colourable graphs have defect 0, those that cannot be 3-edge-coloured have defect at least 3. We show that every bridgeless cubic graph with defect 3 can have its edges covered with at most five perfect matchings, which verifies a long-standing conjecture of Berge for this class of graphs. Moreover, we determine the extremal graphs.

Edge-connectivity and the number of pairwise disjoint perfect matchings in r-graphs

Isaak H. Wolf *Joint work with: Yulai Ma, Davide Mattiolo, Eckhard Steffen*

An r-graph is an r-regular graph in which every odd set of vertices is connected to its complement by at least r edges. In the past years, much research about structural properties of r-graphs has been done. In particular, factors and perfect matchings of such graphs were studied; many problems remain unsolved. We focus on the relation between the edge-connectivity and the number of pairwise disjoint perfect matchings in r-graphs.

For $0 \leq \lambda \leq r$ let $m(\lambda, r)$ be the maximum number s such that every λ-edge-connected r-graph has s pairwise disjoint perfect matchings. There are only a few values of $m(\lambda, r)$ known, for instance $m(3,3) = m(4,r) = 1$, and $m(r,r) \leq r-2$ for all $r \neq 5$, and $m(r,r) \leq r-3$ if r is a multiple of 4. In this talk, some upper bounds for $m(\lambda, r)$ will be presented. Furthermore, we discuss relations between the value of $m(5,5)$ and some well-known conjectures for cubic graphs.

Sets of r-graphs that colour all r-graphs

Yulai Ma *Joint work with: Davide Mattiolo, Eckhard Steffen, Isaak H. Wolf*

An r-regular graph is an r-graph, if every odd set of vertices is connected to its complement by at least r edges. Let G and H be r-graphs. An H-colouring of G is a mapping $f\colon E(G) \to E(H)$ such that each r adjacent edges of G are mapped to r adjacent edges of H. For every $r \geq 3$, let $\mathcal{H}_r$ be an inclusion-wise minimal set of connected r-graphs, such that for every connected r-graph G there is an $H \in \mathcal{H}_r$ which colours G.

In this talk, we show that $\mathcal{H}_r$ is unique and characterize $\mathcal{H}_r$ by showing that $G \in \mathcal{H}_r$ if and only if the only connected r-graph colouring G is G itself.

The Petersen Colouring Conjecture states that the Petersen graph P colours every bridgeless cubic graph. We show that if true, this is a very exclusive situation. Indeed, either $\mathcal{H}_3 = \{P\}$ or $\mathcal{H}_3$ is an infinite set and if $r \geq 4$, then $\mathcal{H}_r$ is an infinite set. Similar results hold for the restriction on simple r-graphs. Moreover, we determine the set of smallest r-graphs of class 2 and show that it is a subset of $\mathcal{H}_r$.

Friday August 11

Complex nowhere-zero flows on finite graphs

Giuseppe Mazzuoccolo *Joint work with: D.Mattiolo, J. Rajník, G. Tabarelli*

The theory of integer nowhere-zero flows on finite graphs has been largely considered in the last decades. The generalization to real numbers is also well-studied, while very few is known in the complex case or, more in general, for flows taking values in $\mathbb{R}^d$. We define a d-dimensional nowhere-zero r-flow on a graph G as a nowhere-zero flow such that the flow value assigned to each edge is an element of $\mathbb{R}^d$ whose (Euclidean) norm lies in the interval $[1, r-1]$. In this talk, we mainly consider the parameter $\phi_d(G)$, which is the minimum of the real numbers r such that G admits d-dimensional nowhere-zero r-flow. For every bridgeless graph G, the 5-flow Conjecture claims that $\phi_1(G) \leq 5$, while a conjecture by Jain suggests that $\phi_d(G) = 2$, for all $d \geq 3$. Here, we mainly address the problem of finding possible upper-bounds and lower-bounds in the case $d = 2$ and we discuss some connections between this problem and some other well-known conjectures, such as the cycle double cover conjecture.

On the Frank number and nowhere-zero flows on graphs

Edita Máčajová *Joint work with: Jan Goedgebeur, Jarne Renders*

An edge e of a graph G is called *deletable* for some orientation o if the restriction of o to $G - e$ is a strong orientation. Inspired by an open problem of Frank, in 2021 Horsch and Szigeti proposed a new parameter for 3-edge-connected graphs, called the Frank number, which refines k-edge-connectivity. The *Frank number* is defined as the minimum number of orientations of G for which every edge of G is deletable in at least one of them. They showed that every 3-edge-connected graph has Frank number at most 7 and that in case these graphs are also 3-edge-colourable graphs the parameter is at most 3. Here we strengthen the latter result by showing that such graphs have Frank number 2, which also confirms a conjecture by Barát and Blászik. Furthermore, we prove two sufficient conditions for cubic graphs to have Frank number 2 and use them in an algorithm to computationally show that the Petersen graph is the only cyclically 4-edge-connected cubic graph up to 36 vertices having Frank number greater than 2.

Skipless chain decompositions and antichain saturation

Carla Groenland *Joint work with: Paul Bastide, Hugo Jacob, and Tom Johnston*

The Boolean lattice is the poset $\{0,1\}^n$ ordered via set inclusion. We show that given disjoint chains $C_1,\ldots,C_m$ in the Boolean lattice, we can create m disjoint skipless chains that cover the elements in $\cup_{i=1}^m C_i$ (where we call a chain skipless if any two consecutive elements differ in size by exactly one). This strengthens a result of Lehman-Ron [JCT-A, 2001]. We find a simple proof for the asymptotics of antichain saturation numbers as corollary (resolving various conjectures), and with additional work can even pinpoint most values exactly.

Spanning trees of smallest maximum degree

Samuel Mohr *Joint work with: Christoph Brause, Jochen Harant, Florian Hörsch*

Given a graph G and a positive integer k, we study the question whether $G^\star$ has a spanning tree of maximum degree at most k where $G^\star$ is the graph that is obtained from G by subdividing every edge once. Using matroid intersection, we obtain a polynomial algorithm for this problem and a characterization of its positive instances. In this talk, we study the class of 3-connected graphs which are embeddable in a fixed surface and the class of $(p-1)$-connected K_p-minor-free graphs for a fixed integer p.

Intuition on average subtree order of graphs

Stijn Cambie *Joint work with: Guantao Chen, Yanli Hao, Nizamettin Tokar*

The mean subtree order (or average subtree order) of a given graph G, denoted $\mu(G)$, is the average number of vertices in a subtree of G.

The study of some extremal problems for this parameter, for general graphs as well as for trees, started with the work by Jamison in the 80s.

Since the clique K_n has the largest number of subtrees of maximal order (n), intuitively one may expect that $\mu(G) \leq \mu(K_n)$ for every graph of order n. One approach to prove this, was a stronger conjecture which stated that deleting an edge decreases the average subtree order. This is hugely false. Cameron and Mol constructed some counterexamples and wondered if the same was true when multiple edges were deleted.

Based on a computer simulation, they predicted that for every $k \in \mathbb{Z}^+$, there are graphs $H \subset G$ for which $\mu(G) < \mu(H)$ and $|E(G) \setminus E(H)| = k$.

In this talk, we present the intuition/ sketch the proofs why their two conjectures are true.

Symmetry levels of graphs

Tatiana Jajcayová

The border line between highly symmetric graphs and asymmetric (rigid) graphs is very thin. For example, removing just a single vertex from a vertex transitive graph may result in a graph with a trivial automorphism group; while removing a vertex from a graph belonging to the family of minimal asymmetric graphs (introduced by Nešetřil) always leads to a graph with a non-trivial automorphism group. Moreover: the graphs in the family of minimal asymmetric graphs are 'just' asymmetric, meaning, every proper induced subgraph on at least two vertices of a graph from this family has non-trivial automorphisms. Since the classical 1963 results of Erdős and Rényi, several measures of symmetricity and asymmetricity of graphs were studied in the literature. Considering the fact that almost all finite graphs are asymmetric, the classical group theory tools for studying symmetries - automorphism groups - are not suitable for the study of asymmetric graphs. As the example of the family of minimal asymmetric graphs demonstrates, the use of the finer concept of a partial automorphism, which is an isomorphism between two induced subgraphs, works better for asymmetric graphs. The set of all partial automorphisms together with the operation of partial composition forms an inverse monoid which is an analogue of the concept of the automorphism group.

In our talk, we will present the framework of inverse monoids of partial automorphisms and use the ratio between the maximal rank of a nontrivial partial automorphism and the order of the graph as a measure of the graph's asymmetricity. We will also address some related algorithmic problems.

Bounding the fractional chromatic number using eigenvalues and symmetry

Krystal Guo *Joint work with: Sam Spiro*

Given a graph G, we let $s^+(G)$ denote the sum of the squares of the positive eigenvalues of the adjacency matrix of G, and we similarly define $s^-(G)$. We prove that

$$\chi_f(G) \geq 1 + \max\left\{\frac{s^+(G)}{s^-(G)}, \frac{s^-(G)}{s^+(G)}\right\}$$

and thus strengthen a result of Ando and Lin, who showed the same lower bound for the chromatic number $\chi(G)$. We in fact show a stronger result wherein we give a bound using the eigenvalues of G and H whenever G has a homomorphism to an edge-transitive graph H. Our proof utilizes ideas motivated by association schemes.

On expander properties of graphs extremal with regard to their degree/diameter or degree/girth parameter pairs

Robert Jajcay

The *Cage* and the *Degree/Diameter Problems* are generally believed to be related; even though the first one calls for finding the smallest k-regular graphs of girth g while the focus of the second problem is on finding largest graphs of maximum degree Δ and diameter d. At the very least, the two classes are connected through the so-called *Moore bound* which is simultaneously a lower bound on the order of the smallest k-regular graphs of girth g and an upper bound on the orders of the largest graphs of maximum degree Δ and diameter d. In our talk, we present another connection between these two classes of extremal graphs by examining the expander properties of infinite families of graphs from both classes. We show that in both cases, graphs whose orders are sufficiently close to the Moore bound (the existence of which is at this point only hypothetical) form *expander families*; families of graphs of high connectivity. In particular, we show that graphs of maximum degree Δ and diameter d, whose orders only differ from the Moore bound by a constant, would necessarily constitute a family of *Ramanujan graphs*, general constructions of which are relatively rare.

The results discussed in the Degree/Diameter part of the talk come from joint work with Slobodan Filipovski. The results concerning the Cage Problem are joint work with Leonard Chidiebere Eze.

Food options

Near the campus

As the group would be too large to go for lunch together, we encourage you to split up in smaller groups and have lunch in one of the restaurants near the campus. Feel free to speak to us about suggestions.

On page 23 you can see a map of the campus and its surroundings. The campus is shown in grey, all talks are in the red building (S9), and the access points to the campus are shown in blue.

Below is an overview of the restaurants/shops near the campus. For each one we note whether it is take-out (TO) or eat-in (EI). If you buy take-out, you can eat it in one of the rooms at the university, or – in case of good weather – there are several picnic tables in the garden behind the S9 building.

A. **Eetoile** *(Oudenaardsesteenweg 34, 9000 Gent)* TO/EI
Healthy foodbar: has salads, quiches, wraps, and soups.
www.eetoile.be

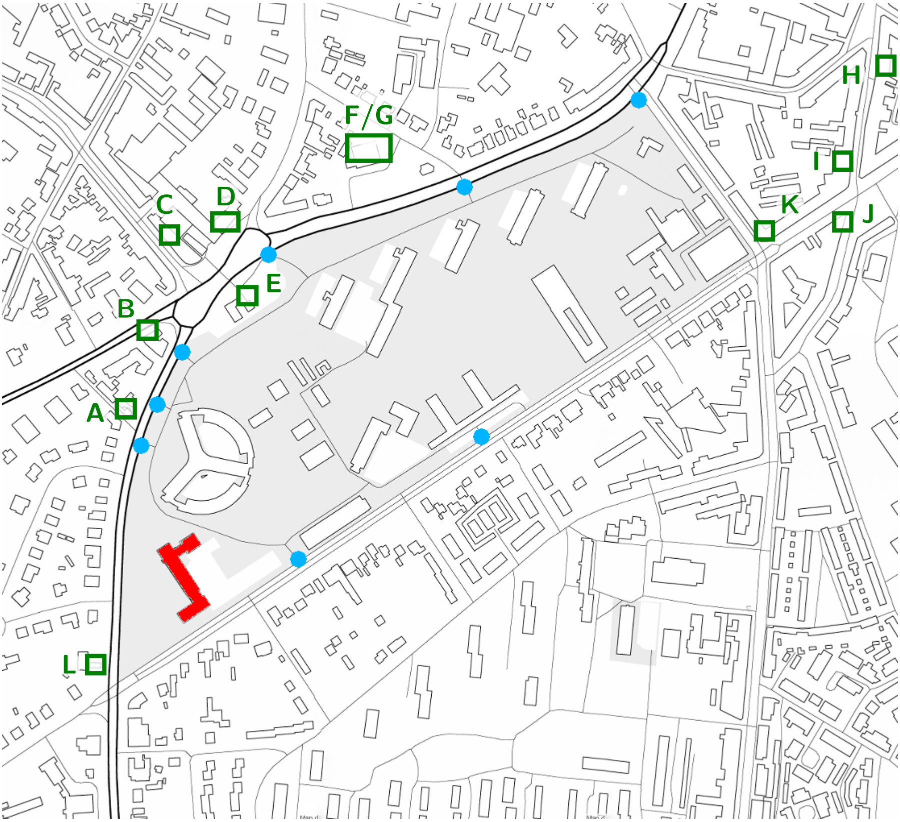
B. **Gran Gusto** *(Kortrijksesteenweg 857, 9000 Gent)* EI
Italian restaurant, but a bit more expensive than average.
grangusto.business.site

C. **De Fritoloog** *(Voskenslaan 413, 9000 Gent)* TO/EI
A Belgian-style friterie.
www.defritoloog.be

D. **Delhaize** *(Kortrijksesteenweg 906, 9000 Gent)* TO
A large supermarket that also sells sandwiches and salads to go.
www.delhaize.be

E. **Select Shop (Shell)** *(Kortrijksesteenweg 831, 9000 Gent)* TO
A gas-station shop that also sells sandwiches.

F. **Pizza Hut** *(Pacificatielaan 6, 9000 Gent)* TO/EI
American-style pizzas. At lunchtime they have an all-you-can-eat buffet.
www.pizzahut.be


H
F/G
I
C
D
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L

G. **Lunch Garden** *(Pacificatielaan 6, 9000 Gent)* EI
A self-service restaurant offering lunch at a reasonable price.
www.lunchgarden.com

H. **Ocean Garden** *(Zwijnaardsesteenweg 399, 9000 Gent)* TO
Chinese take-out restaurant.
oceangarden.byethost3.com

I. **Boekee Garni** *(Zwijnaardsesteenweg 454, 9000 Gent)* EI
Cosy restaurant with healthy and less-healthy food: has salads, wraps, soup, grilled sandwiches, and warm meals.
www.boekeegarni.be

J. **Uniq** *(Zwijnaardsesteenweg 458, 9000 Gent)* TO/EI
Kebab and grill snack bar.
www.uniqkebab.be

K. **Sim Pizza** *(De Pintelaan 252, 9000 Gent)* TO/EI
Italian-style pizzas and some other snacks
www.sim-pizza.be

L. **Go (Texaco)** *(Oudenaardse Steenweg 77-89, 9000 Gent)* TO
A gas-station shop that also sells sandwiches.

For people with special dietary requirements (vegan, vegetarian, . . .) or who are looking for a specific cuisine (Greek, Indian, . . .), there are some options which are slightly further away, but still manageable for lunch. Please contact us for directions.

In the city centre

Belgians are Burgundian people, so you shouldn't have any problem finding restautants in the city centre. Below we list some personal favorites and some restaurants for people with special dietary requirements. In the era of Google Maps, TripAdvisor, and the rest of the internet you shouldn't have any difficulty locating them, but please feel free to contact us to help you find them on a map.

Belgian food

The Belgian cuisine is hard to define, since it has many influences from neighbouring countries. Nevertheless for those willing to sample the local food, we list some restaurants which serve typical Belgian dishes.

De Frietketel The best place to get the typical Belgian fries, since it was elected best friterie of Flanders in 2017. They have a large range of home-made snacks to accompany the fries including a large selection of vegetarian options. Make sure to taste their "stoverijsaus" to dip your fries in together with mayonnaise for the ultimate Belgian experience.

www.facebook.com/De-Frietketel-34597147572

Balls & Glory Real comfort food for Belgians. You get a meatball (meat/chicken/veggie) with a liquid filling (the options change each day) together with mashed potatoes-and-vegetables ("stoemp") accompanied by a gravy and a creamy curry sauce. Or, if you don't like stoemp or aren't that hungry, you can choose a salad to go with your meatball. An ideal spot if you don't want to waste too much time eating. Also well-suited for larger groups.

ballsnglory.be

Het Pakhuis A classic "brasserie" with French and Belgian dishes as we would have them going out for dinner. When you're not looking for creative cooking, but like the classics well prepared, this is a good place to go. Also the venue is quite big, so you have a good chance of finding a spot. **This is also the venue for the conference dinner.**

www.pakhuis.be

Meme Gusta Food like our grandma would prepare it. All the classic flavours of the Belgian cuisine. You might need to make a reservation as we all love grandma's kitchen.

www.meme-gusta.be

Vegetarian/vegan

Ghent has several restaurants which are either completely vegetarian or vegan, or offer a vegetarian or vegan option. A more complete list can be found on the website www.evavzw.be/resto. Unfortunately, this website is only available in Dutch and French, so contact us if you need help navigating it. Below are some of our favourite places.

Greenway Burgers, wraps and salads that taste great. Not a place to wine and dine, but excellent if you want to have a quick meal.

greenway.be

Lokaal Charming place for honest food and delicious tea. Small choice of dishes, but prepared with lots of love.

www.facebook.com/LokaalGent

De Appelier You can get a daily special or a pasta over here. The special is a plate full of different veggies and grains and something like a homemade meat replacer or quiche. There's soup and a dessert of the day as well. Food is served fast here, so if you're in a hurry, this is very healthy fast food!

www.deappelier.be

Trendy places

Ghent is also a hip and happening city. If you want to be a part of this, then below are some places you should really visit.

Hal 16 Situated in Dok-Noord, an old industrial district that is currently undergoing gentrification, this food court houses a microbrewery and three restaurants. It is ideal for larger groups that want to have a beer and cannot decide on a restaurant.

www.hal16.be

Mosquito Coast A travel café where you can have cocktails and tapas but also a decent meal. You might want to make a reservation.

www.mosquitocoast.be

De Superette The project of Michelin star chef Kobe Desramaults with an affordable and more simple menu. The atmosphere is easy going and you get to see bread and pizzas being baked in the oven which has a central place in the restaurant.

www.de-superette.be

Eat Love Pizza Trendy pizza place with quite expensive pizzas but some interesting flavours. You can also choose to have two halves of different flavours instead of picking just one. They also opened a new place Eat Love Lasagna which serves lasagnas.

eatlove.be

Exotic Ghent

You might have had enough of Belgian cuisine? We can't imagine how that is possible, but no worries: we have you covered. Belgians have a wide palate, and so you can find several restaurants in Ghent which serve non-Belgian cuisine.

Gado-Gado Hidden in the narrow streets of the trendy neighbourhood 'Patershol', you will find this Indonesian restaurant. Besides great Indonesian food, they also offer a long list of cocktails and mocktails.

gado-gado.gent

Le Baan Thai This well-established Thai restaurant is also located in 'Patershol'. From the outside you will only see a sign on the wall. After you pass the first two gates, you will have to cross a garden to get to the entrance.

www.lebaanthai.be

AYWA Beirut Streetfood A fine Lebanese streetfood restaurant for those who love to share food and taste a lot of different dishes. You can't make reservations here, but you can also order food for take-out.

aywagent.business.site

Meat lovers

If you got an insatiable desire for meat, then one of the following restaurants might be ideal for you.

Amadeus This is an all-you-can-eat restaurant for ribs. They are prepared with a sweet marinade and come with a jacket-potato with some curried cream inside. There are different restaurants of this chain in Ghent. They have a charming interior, but service is usually more pragmatic.

amadeus-resto.be

De Gekroonde Hoofden This is another all-you-can-eat restaurant for ribs. They have different kind of preparations (honey, somewhat spicy, sweet-and-sour or without marinade) and serve them with Turkish pide bread, a hot tomato and some salad.

degekroondehoofden.be

Pampas This is an all-you-can-eat Brazilian grill restaurant. Giant skewers of meat are being grilled in the kitchen and the waiters go from table to table to slice off a piece for you. There's also fish and prawns on the skewers and grilled vegetables and fruit. This is served with a salad and fries or a jacket-potato.

www.pampas.be

Ankara This is a Turkish restaurant known for its "plateau du chef" which is a huge platter with a combination of different mezzes and grilled meats. Kudos to you if you manage to finish it! You can of course just order a simple dish as well.

www.ankararesto.be

Gastronomy & Co

You might have high standards when it comes to dining. Well, then these restaurants are ideal for you. Note that you will most likely need to make a reservation at least a day in advance, and that these restaurants tend to be quite pricey.

Vrijmoed Michelin star restaurant by young chef Michael Vrijmoed, former sous-chef of Michelin 3-star restaurant Hof van Cleve. There are two set menus from which you can choose: vegetarian or non-vegetarian. Each menu comes in either five, six, or seven courses. We left this in the list, but these days you need to make reservations three months beforehand (and even then it is difficult), but maybe you want to go during your next trip to Ghent.

www.vrijmoed.be

Karel de Stoute Located in the picturesque 'Patershol', this restaurant offers haute cuisine at an 'affordable' price. They only offer the set menu (ranging from two to five courses).

www.restkareldestoute.be

Publiek Publiek is the Michelin star restaurant of Flemish Foodie Olly Ceulenaere and Kelly Dehollander. At noon they serve a healthy lunch. In the evening you can either take the six course menu or just a part of it. Although also often fully booked, this restaurant as the habit of keeping a few tables available for last-minute bookings. If you want to go, be sure to check in the morning whether a table is available.

www.publiekgent.be

Beer

After all this food you might be thirsty, and looking to sample some Belgian beers.

Dok Brewing Company Dok Brewing Company is an innovative microbrewery with a cozy brewpub in Hal 16. This building is located in Dok Noord – a recently gentrified industrial site in the north of Ghent.

www.dokbrewingcompany.be

Waterhuis aan de Bierkant Idyllically located next to the water, this bar has a large selection of Belgian beers. It can however get very crowded during the tourist season.

www.waterhuisaandebierkant.be

Het Trappistenhuis This bar lies outside of the historic centre, and is therefore less visited by tourists. It has more than 170 special Belgian beers.

www.facebook.com/Trappistenhuis

Trollekelder A favourite both with tourists and locals. Ideal place to sample a Belgian beer and have a nice chat.

www.trollekelder.be

Participants

Marthe Bonamy
University of Bordeaux, Bordeaux, France

Sébastien Bonte
Université de Mons, Mons, Belgium

Gunnar Brinkmann
Ghent University, Ghent, Belgium

Stijn Cambie
Institute for Basic Science, Daejeon, South Korea
KU Leuven, Leuven, Belgium

Jozefien D'haeseleer
Ghent University, Ghent, Belgium

Jan De Beule
Vrije Universiteit Brussel, Brussels, Belgium

Patrick De Causmaecker
KU Leuven, Kortrijk, Belgium

Gauvain Devillez
KU Leuven, Kortrijk, Belgium
Université de Mons, Mons, Belgium

Karel Devriendt
Max Planck Institute Leipzig, Leipzig, Germany

Valentin Dusollier
Université de Mons, Mons, Belgium

Marietjie Frick
University of Pretoria, Pretoria, South Africa

Jan Goedgebeur
KU Leuven, Kortrijk, Belgium

Carla Groenland
Utrecht University, Utrecht, The Netherlands

Krystal Guo
University of Amsterdam, Amsterdam, The Netherlands

Pierre Hauweele
Université de Mons, Mons, Belgium

Robert Jajcay
Comenius University, Bratislava, Slovakia

Tatiana Jajcayová
Comenius University, Bratislava, Slovakia

Jorik Jooken
KU Leuven, Kortrijk, Belgium

Stefan Kober
Université Libre de Bruxelles, Brussels, Belgium

Domenico Labbate
University of Basilicata, Potenza, Italy

On-Hei Solomon Lo
Yokohama National University, Yokohama, Japan

Yulai Ma
Paderborn University, Paderborn, Germany

Edita Máčajová
Comenius University, Bratislava, Slovakia

Shun-ichi Maezawa
Tokyo University of Science, Tokyo, Japan

Davide Mattiolo
KU Leuven, Kortrijk, Belgium

Giuseppe Mazzuoccolo
University of Modena and Reggio Emilia, Modena, Italy

Hadrien Mélot
Université de Mons, Mons, Belgium

Samuel Mohr
Masaryk University, Brno, Czech Republic

Kenta Noguchi
Tokyo University of Science, Tokyo, Japan

Kenta Ozeki
Yokohama National University, Yokohama, Japan

Daniël Paulusma
Durham University, Durham, UK

Robin Petit
Université Libre de Bruxelles, Brussels, Belgium

Michiel Provoost
KU Leuven, Kortrijk, Belgium

Stanisław Radziszowski
Rochester Institute of Technology, Rochester, USA

Jarne Renders
KU Leuven, Kortrijk, Belgium

Eileen Robinson
Université Libre de Bruxelles, Brussels, Belgium

Federico Romaniello
Università di Torino, Turin, Italy

Paweł Rzążewski
Warsaw University of Technology, Warsaw, Poland
University of Warsaw, Warsaw, Poland

Vincent Schmeits
University of Amsterdam, Amsterdam, The Netherlands

Jens M. Schmidt
University of Rostock, Rostock, Germany

Ben Seamone
University of Montreal, Montreal, Canada

Robin Simoens
Ghent University, Ghent, Belgium

Martin Škoviera
Comenius University, Bratislava, Slovakia

Eckhard Steffen
Paderborn University, Paderborn, Germany

Leo Storme
Ghent University, Ghent, Belgium

Gloria Tabarelli
University of Trento, Trento, Italy

Carsten Thomassen
Technical University of Denmark, Copenhagen, Denmark

Nico Van Cleemput
Ghent University, Ghent, Belgium

Heidi Van den Camp
Ghent University, Ghent, Belgium

Steven Van Overberghe
Ghent University, Ghent, Belgium

Greet Vanden Berghe
KU Leuven, Ghent, Belgium

Tony Wauters
KU Leuven, Ghent, Belgium

Isaak H. Wolf
Paderborn University, Paderborn, Germany

Lena Yuditsky
Université Libre de Bruxelles, Brussels, Belgium

Carol T. Zamfirescu
Ghent University, Ghent, Belgium

Wednesday August 9

09:00 - 09:30	*Badge pick-up*
09:35 - 09:40	*Opening*
09:40 - 10:30	**Thomassen**
10:30 - 11:00	*Coffee break*
11:00 - 12:20	**Labbate, Schmidt, Lo, Steffen**
12:20 - 14:00	*Lunch on-your-own*
14:00 - 15:20	**Frick, Radziszowski, Paulusma, Rzążewski**
15:20 - 15:40	*Coffee break*
15:40 - 17:00	**Ozeki, Maezawa, Seamone, Tabarelli**

Thursday August 10

09:40 - 10:30	**Bonamy**
10:30 - 11:00	*Coffee break*
11:00 - 12:00	**Škoviera, Wolf, Ma**
12:00 - 14:00	*Lunch on-your-own*
14:30 - 16:30	*Guided tour of Ghent*
18:30 - 22:00	*Conference dinner*

Friday August 11

09:40 - 10:30	**Mazzuoccolo**
10:30 - 11:00	*Coffee break*
11:00 - 12:20	**Máčajová, Groenland, Mohr, Cambie**
12:20 - 14:00	*Lunch on-your-own*
14:00 - 15:00	**Jajcayová, Guo, Jajcay**
15:00 - 15:15	*Closing remarks*