9th Slovenian International Conference on Graph Theory BLED'19

Abstracts of the

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Bled, Slovenia, June 23 – 29, 2019

Institute of Mathematics, Physics and Mechanics

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June 2019

**Abstracts of the 9th Slovenian International Conference on Graph Theory**
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Editors: Sergio Cabello, Bojan Mohar

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# Welcome

We thank all of you for coming to the 9th Slovenian International Conference on Graph Theory, Bled'19, and wish you a pleasant and successful meeting in Bled.

This conference has come a long way from its first meeting in Dubrovnik (now in Croatia) in 1985. The second meeting of the series *Slovenian (International) Conference on Graph Theory* was held at Lake Bled in 1991, following by the subsequent meetings at the same location in 1995, 1999, 2003, 2007, and 2011. In 2015 the meeting took place in Kranjska Gora. For this edition we are back to Bled.

The conference has seen a substantial growth, from 30 participants at the 1991 meeting to well over 300 participants at the present *9th Slovenian Conference on Graph Theory*. We are very happy to see participants that have attended previous editions, always a clear indicator of successful previous meetings, and we welcome the newcomers.

The growth of the conference has been parallel to the growth of graph theory in Slovenia, two achievements to be proud of. Our international colleagues, and friends, are largely responsible for this success. We thank you for this.

In this edition we have 11 plenary speakers and 16 invited special sessions. We believe that the quality of the plenary speakers and the invited special sessions play a key role in the success of the conference. This booklet contains the abstracts of the 287 talks to be delivered at our conference.

Similar to the last edition, the conference is linked to the *Meeting of the International Academy of Mathematical Chemistry*, and the *9th PhD Summer School in Discrete Mathematics* will take place on Rogla the week after the conference. Looking to the future, an event deserves special attention: the *8th European Congress of Mathematics* to take place in Portorož, Slovenia, from July 5 to July 11, 2020. This will be a challenge and a great opportunity to promote Discrete Mathematics at large and in particular Slovenian Discrete Mathematics. We hereby warmly invite you to participate in the event.

The organization of this meeting would not have been possible without financial and technical support from the Institute of Mathematics, Physics and Mechanics, Ljubljana (IMFM); University of Ljubljana, Faculty of Mathematics and Physics (UL FMF); University of Maribor, Faculty of Natural Sciences and Mathematics (UM FNM); University of Primorska, Faculty of Mathematics, Natural Sciences and Information Technologies (UP FAMNIT), and Andrej Marušič Institute (UP IAM); the Society of Mathematicians, Physicists and Astronomers of Slovenia (DMFA); the Slovenian Discrete and Applied Mathematics Society (SDAMS); and Abelium d.o.o.

We hope that you enjoy this instance of our conference and wish you a fruitful, pleasant week devoted to graph theory.

Sandi Klavžar
Dragan Marušič
Bojan Mohar
Tomaž Pisanski

Bled, June 2019

# Contents

# General Information

**Bled'19 – 9th Slovenian International Conference on Graph Theory**
Bled, Slovenia, June 23 – 29, 2019

Organized by:
IMFM (*Institute of Mathematics, Physics and Mechanics*)

In Collaboration with:
DMFA (*Society of Mathematicians, Physicists and Astronomers of Slovenia*) SDAMS (*Slovenian Discrete and Applied Mathematics Society*) UL FMF (*University of Ljubljana, Faculty of Mathematics and Physics*),
UM FNM (*University of Maribor, Faculty of Natural Sciences and Mathematics*),
UP FAMNIT (*University of Primorska, Faculty of Mathematics, Natural Sciences and Information Technologies*),
UP IAM (*University of Primorska, Andrej Marušič Institute*),
Abelium d.o.o.

Scientific Committee:
Sandi Klavžar, Dragan Marušič, Bojan Mohar (chair), Tomaž Pisanski

Organizing Committee:
Boštjan Brešar, Sergio Cabello, Ademir Hujdurović, Rok Požar

Conference Venues:
Hotel Kompas Bled, Cankarjeva Cesta 2, SI-4260, Bled, Slovenia
Best Western Premier Hotel Lovec, Ljubljanska cesta 6, SI-4260, Bled, Slovenia
Rikli Balance Hotel, Cankarjeva Cesta 4, SI-4260, Bled, Slovenia

Conference Website:
https://conferences.matheo.si/e/bled19

## Plenary speakers:

Noga Alon, *Princeton University, USA, and Tel Aviv University, Israel*
Marco Buratti, *Università di Perugia, Italy*
Gareth A. Jones, *University of Southampton, UK*
Gábor Korchmáros, *Università della Basilicata, Italy*
Daniel Král', *Masaryk University, Czech Republic, and University of Warwick, UK*
Daniela Kühn, *University of Birmingham, UK*
Sergei Lando, *University Higher School of Economics, Skolkovo Institute of Science and Technology, Moscow, Russia*
János Pach, *EPFL, Switzerland, and Rényi Institute, Hungary*
Cheryl E. Praeger, *University of Western Australia*
Zsolt Tuza, *Rényi Institute and University of Pannonia, Hungary*
Xuding Zhu, *Zhejiang Normal University, China*

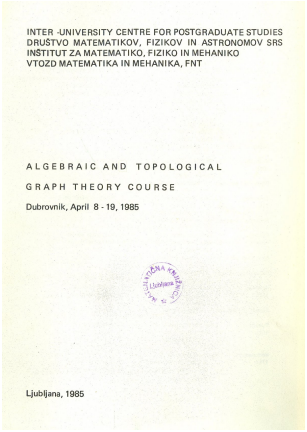
## Invited special sessions and their organizers

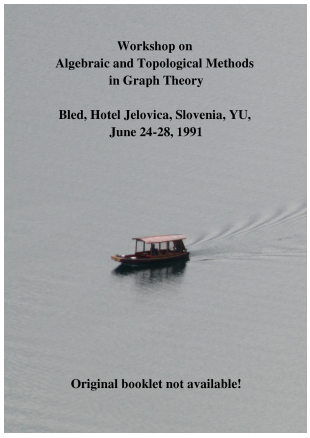
Association Schemes (*Mikhail Muzychuk*)
Biomathematics and Bioinformatics (*Marc Hellmuth*)
Chemical graph theory (*Xueliang Li*) – This session is associated with the meeting of the International Academy of Mathematical Chemistry, IAMC 2019
Configurations (*Gábor Gévay*)
Designs (*Dean Crnković*)
Discrete and computational geometry (*Sergio Cabello*)
Distance-regular graphs (*Štefko Miklavič*)
Domination in graphs (*Michael A. Henning*) – This session celebrates the 70th birthday of Douglas F. Rall.
Finite Geometries (*Tamás Szőnyi*)
Games on graphs (*Csilla Bujtás*)
Graph coloring (*Ingo Schiermeyer*)
Metric Graph Theory (*Ismael G. Yero*)
Polytopes (*Asia Ivić Weiss*) – This session celebrates the life and work of Branko Grünbaum
Spectral Graph Theory (*Francesco Belardo*)
Structural and algorithmic graph theory (*Pierre Aboulker*)
Symmetries of graphs and maps (*Marston Conder*)

# Past Conferences

## 1st Slovenian International Conference on Graph Theory

a. k. a. Algebraic and Topological Graph Theory Course. Dubrovnik (now Croatia), April 8–19, 1985. 47 participants, 10 invited speakers, 37 talks. Scientific Committee: W. Imrich, T. D. Parsons, T. Pisanski.



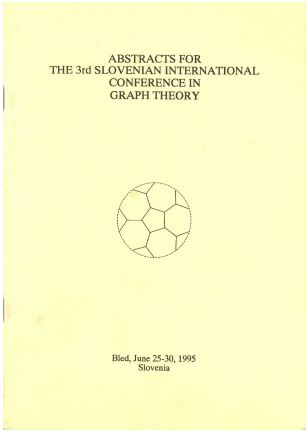



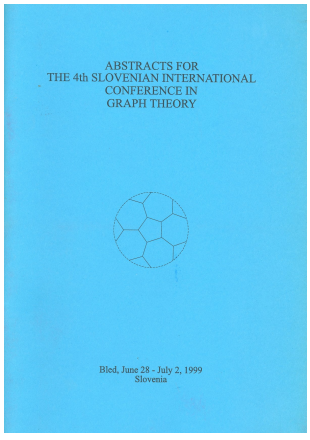

## 2nd Slovenian International Conference on Graph Theory

a. k. a. Workshop on Algebraic and Topological Methods in Graph Theory. Bled, Slovenia, YU, June 24–28, 1991. Around 30 participants, 7 invited speakers. The meeting started in FLR Yugoslavia and ended in independent Slovenia. Scientific Committee: V. Batagelj, D. Marušič, B. Mohar and T. Pisanski. Conference proceedings printed in a special issue of Discrete Math, Vol 134 (1994).

## 3rd Slovenian International Conference on Graph Theory

Bled, June 25–30, 1995. 8 invited speakers, 79 talks, general session and 6 special sessions. Scientific Committee: D. Marušič and B. Mohar. Conference proceedings printed in a special issue of Discrete Math, Vol 182 (1998).



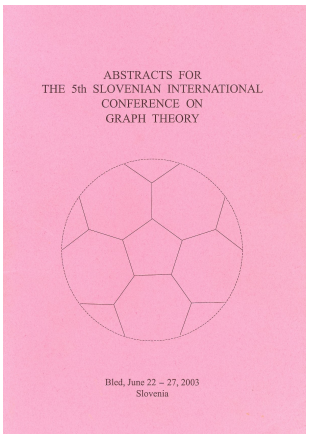




## 4th Slovenian International Conference on Graph Theory

Bled, June 28–July 2, 1999. 18 invited speakers, 92 talks. Scientific Committee: S. Klavžar, D. Marušič and B. Mohar. Proceedings in a special issue of Discrete Math, Vol. 244 (2002).

## 5th Slovenian International Conference on Graph Theory

Bled, June 22–27, 2003. 87 participants, 13 invited speakers, 72 talks. Scientific Committee: B. Brešar, M. Juvan, S. Klavžar, D. Marušič, A. Malnič, B. Mohar, T. Pisanski. Conference proceedings printed in a special issue of Discrete Math, Vol. 307 (2007).



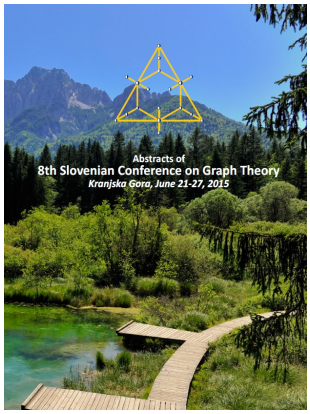


## 6th Slovenian International Conference on Graph Theory

Bled, June 24–30, 2007. 15 invited speakers, 189 registered contributions, general session, 14 minisymposia and 2 satellite conferences. Scientific Committee: S. Klavžar, D. Marušič, B. Mohar, T. Pisanski. Conference proceedings printed in special issues of Discrete Math, Vol. 310 (2010) and Ars Mathematics Contemporanea, Vol. 1 (2008).

## 7th Slovenian International Conference on Graph Theory

Bled, June 19–25, 2011. 10 keynote speakers, 222 registered contributions, general session, 17 minisymposia and 4 satellite events. Scientific Committee: S. Klavžar, D. Marušič, B. Mohar, T. Pisanski. Conference proceedings printed in special issue of Ars Mathematics Contemporanea, Vol. 6 (2013).


## 8th Slovenian Conference on Graph Theory

Kranjska Gora, June 21–27, 2015. 9 plenary speakers, 247 registered contributions, general session, 13 minisymposia and 3 satellite events. Scientific Committee: S. Klavžar, D. Marušič, B. Mohar, T. Pisanski.

## Unavoidable minors for graphs with large $\ell_p$-dimension

Tony Huynh
*Université libre de Bruxelles (ULB)*

A *metric graph* is a pair $(G,d)$, where $G$ is a graph and $d : E(G) \to \mathbb{R}_{\geq 0}$ is a distance function. Let $p \in [1,\infty]$ be fixed. An *isometric embedding* of the metric graph $(G,d)$ in $\ell_p^k = (\mathbb{R}^k, d_p)$ is a map $\phi : V(G) \to \mathbb{R}^k$ such that $d_p(\phi(v),\phi(w)) = d(vw)$ for all edges $vw \in E(G)$. The *$\ell_p$-dimension* of $G$ is the least integer $k$ such that there exists an isometric embedding of $(G,d)$ in $\ell_p^k$ for all distance functions $d$ such that $(G,d)$ has an isometric embedding in $\ell_p^K$ for some $K$.

It is easy to show that $\ell_p$-dimension is a minor-monotone property. We characterize the minor-closed graph classes $\mathcal{C}$ with bounded $\ell_p$-dimension, for $p \in \{2,\infty\}$. For $p = 2$, we give a simple proof that $\mathcal{C}$ has bounded $\ell_2$-dimension if and only if $\mathcal{C}$ has bounded treewidth. In this sense, the $\ell_2$-dimension of a graph is 'tied' to its treewidth.

For $p = \infty$, the situation is completely different. Our main result states that a minor-closed class $\mathcal{C}$ has bounded $\ell_\infty$-dimension if and only if $\mathcal{C}$ excludes a graph obtained by joining copies of $K_4$ using the 2-sum operation, or excludes a Möbius ladder with one 'horizontal edge' removed.

This is joint work with Samuel Fiorini, Gwenaël Joret, and Carole Muller. Preprint available at `https://arxiv.org/abs/1904.02951`.

## Erdős-Pósa Property of Chordless Cycles and its Applications

Eunjung Kim
*CNRS, LAMSADE, Paris-Dauphine University*

A chordless cycle, or equivalently a hole, in a graph $G$ is an induced subgraph of $G$ which is a cycle of length at least four. We prove that the Erdős-Pósa property holds for chordless cycles, which resolves the major open question concerning the Erdős-Pósa property. Our proof for chordless cycles is constructive: in polynomial time, one can find either $k+1$ vertex-disjoint chordless cycles, or $ck^2 \log k$ vertices hitting every chordless cycle for some constant $c$. It immediately implies an approximation algorithm of factor $\mathcal{O}(\mathrm{opt} \log \mathrm{opt})$ for Chordal Vertex Deletion. We complement our main result by showing that chordless cycles of length at least $\ell$ for any fixed $\ell \geq 5$ do not have the Erdős-Pósa property.

We also consider an edge version of Erdős-Pósa property for chordless cycles (this time, triangle is also considered to be a chordless cycle) of length at least $\ell$. Partial results are obtained for different values of $\ell$.

This talk is based on joint work with O-joung Kwon, Pierre Aboulker and Valia Mitsou. (Preprint is available at `https://arxiv.org/abs/1711.00667`.)

## Uniquely restricted $(g,f)$-factors

Miklós Krész
*InnoRenew CoE & UP IAM, Slovenia*
*University of Szeged, Hungary*

The concept of $(g,f)$-factors is a classical generalization of matchings in graphs. Given an undirected graph $G$, let $g$ and $f$ be nonnegative integer-valued functions defined on the vertex set $V$ of $G$ with $g(v) \leq f(v) \leq deg_G(v)$ for all $v \in V$, where $deg_G(v)$ represents the degree of vertex

$v$ in $G$. Then a $(g, f)$-factor is defined as a subgraph $H$ of $G$ with $g(v) \leq deg_H(v) \leq f(v)$ for every $v \in V$.

One of the relevant characteristics of a $(g, f)$-factor is the so-called *degree pattern*: a vector $p_H$ of the degrees of the vertices with a preliminary fixed order of the vertices. A $(g, f)$-factor $H$ is *uniquely restricted* if the degree pattern of any other $(g, f)$-factor in $G$ is different from $p_H$.

The above concept was originally introduced for matchings by M. C. Golumbic, T. Hirst and M. Lewenstein in 2001. They have proved that finding a maximum uniquely restricted matching is NP-hard; consequently research in the recent year mainly focused on special cases of this problem. Another approach was considered by V. E. Levit and E. Mandrescu in a paper from 2003, when posed the question whether it is polynomially solvable for a graph $G$, if all maximum matchings are uniquely restricted. For the above question Penso et al provided recently (Journal of Graph Theory, 2018, **89**].) a positive answer.

In this talk we will show that the above results can be extended to $(g, f)$-factors.

**Acknowledgment**: This research was partially supported by the National Research, Development and Innovation Office - NKFIH Fund No. SNN-117879. The author also acknowledges the European Commission for funding the InnoRenew CoE project (Grant Agreement ♯739574) under the Horizon2020 Widespread-Teaming program and the support of the ARRS grant N1-0093.

## On the End-Vertex Problem of Graph Searches

Matjaž Krnc

*University of Primorska, Koper, and Institute of Mathematics, Physics and Mechanics, Ljubljana, Slovenia*

End vertices of graph searches can exhibit strong structural properties and are crucial for many graph algorithms. The problem of deciding whether a given vertex of a graph is an end-vertex of a particular search was first introduced by Corneil, Köhler, and Lanlignel in 2010. There they showed that this problem is in fact $\mathcal{NP}$-complete for LBFS on weakly chordal graphs. A similar result for BFS was obtained by Charbit, Habib and Mamcarz in 2014. Here, we prove that the end-vertex problem is $\mathcal{NP}$-complete for MNS on weakly chordal graphs and for MCS on general graphs. Moreover, building on previous results, we show that this problem is linear for various searches on split and unit interval graphs.

Preprint available at `https://arxiv.org/abs/1810.12253`.

## Immersion of transitive tournaments

William Lochet

*University of Bergen*

A classical result by Mader shows the existence of a function $g$ such that for every $k$, every graph with minimum degree at least $g(k)$ contains a subdivision of the complete graph on $k$ vertices. An interesting topic is to understand possible generalisations of this result to digraphs. In 1985, Thomassen proved the existence of digraphs with arbitrarily large minimum outdegree and without even directed cycle. This implies in particular that these digraphs do not contain $\overleftrightarrow{K_3}$ as subdivision. In 1985 however, Mader asked the existence of a function $f$ such that digraphs with minimum degree at least $f(k)$ contain a subdivision of the **transitive** tournament on $k$ vertices. This conjecture remains completely open, as the existence of $f(5)$ is still unknown. In 2011, DeVos et al. proposed a weakening of this conjecture asking for immersions instead of subdivisions. In this talk, we will present a proof of this conjecture.

# Speaker Index

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