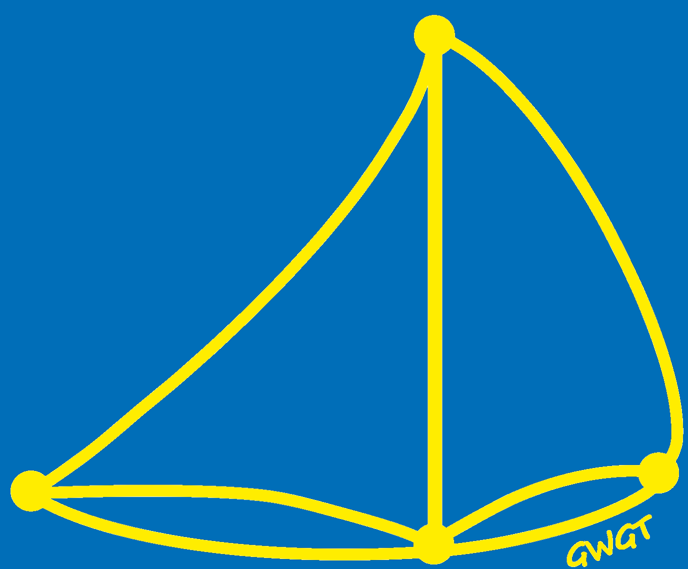
The Fourth Gdańsk Workshop on Graph Theory

List of participants and abstracts



Gdańsk, June 29 – July 1, 2016

List of participants

1. **KRZYSZTOF BARSZCZ**, e-mail: krzysztofbarszcz92@gmail.com
   Gdańsk University of Technology (Poland)
2. **WOJCIECH BARTOSZEK**, e-mail: bartowk@mif.pg.gda.pl
   Gdańsk University of Technology (Poland)
3. **HALINA BIELAK**, e-mail: hbiel@hektor.umcs.lublin.pl
   Maria Curie-Skłodowska University (Poland)
4. **KATARZYNA BRONISZEWSKA**,
   e-mail: katarzyna.anna.wolska@gmail.com
   Maria Curie-Skłodowska University (Poland)
5. **JOANNA CYMAN**, e-mail: joana@mif.pg.gda.pl
   Gdańsk University of Technology (Poland)
6. **KINGA DĄBROWSKA**,
   e-mail: kinga.wiktoria.dabrowska@gmail.com
   University of Maria Curie Słodowska in Lublin (Poland)
7. **MAGDA DETTLAFF**, e-mail: mdettlaff@mif.pg.gda.pl
   Gdańsk University of Technology (Poland)
8. **EWA DRGAS-BURCHARDT**,
   e-mail: E.Drgas-Burchardt@wmie.uz.zgora.pl
   University of Zielona Góra (Poland)
9. **AGATA DRZYSTEK**, e-mail: A.Drzystek@wmie.uz.zgora.pl
   University of Zielona Góra (Poland)
10. **TOMASZ DZIDO**, e-mail: tdz@inf.ug.edu.pl
    University of Gdańsk (Poland)
11. **ANNA FIEDOROWICZ**, e-mail: a.fiedorowicz@wmie.uz.zgora.pl
    University of Zielona Góra (Poland)
12. **HANNA FURMAŃCZYK**, e-mail: hanna@inf.ug.edu.pl
    University of Gdańsk (Poland)

13. **GRZEGORZ GANCARZEWICZ**,
e-mail: ggancarzewicz@gmail.com
Cracow University of Technology (Poland)

14. **ISMAEL GONZÁLEZ YERO**, e-mail: ismael.gonzalez@urv.cat
University of Cádiz (Spain)

15. **IZOLDA GORGOL**, e-mail: i.gorgol@pollub.pl
Lublin University of Technology (Poland)

16. **MARIUSZ GRECH**, e-mail: Mariusz.Grech@math.uni.wroc.pl
University of Wrocław (Poland)

17. **HARALD GROPP**, e-mail: d12@ix.urz.uni-heidelberg.de
Heidelberg University (Germany)

18. **ELIZA JACKOWSKA**, e-mail: elizajackowska@gmail.com
Adam Mickiewicz University (Poland)

19. **STANISLAV JENDROL'**, e-mail: stanislav.jendrol@upjs.sk
Pavol Jozef Safárik University (Slovakia)

20. **KONSTANTY JUNOSZA-SZANIAWSKI**,
e-mail: k.szaniawski@mini.pw.edu.pl
Warsaw University of Technogy (Poland)

21. **SEBASTIAN KIELISZEK**,
e-mail: sebastian.lukasz.kieliszek@gmail.com
University of Maria Curie Słodowska in Lublin (Poland)

22. **WOJCIECH KORDECKI**,
e-mail: wojciech.kordecki@pwsz-legnica.eu
The Witelon State University of Applied Sciences in Legnica (Poland)

23. **ADAM KOSTULAK**, e-mail: dires@ug.gda.pl
University of Gdańsk (Poland)

24. **ANNA KRYSTEK**, e-mail: Anna.Krystek@math.uni.wroc.pl
University of Wrocław (Poland)

25. **MARCIN KRZYWKOWSKI**,
e-mail: marcin.krzywkowski@gmail.com
University of Johannesburg (South Africa)

26. **MAREK KUBALE**, e-mail: kubale@eti.pg.gda.pl
Gdańsk University of Technology (Poland)

27. **MAGDALENA LEMAŃSKA**, e-mail: magda@mif.pg.gda.pl
Gdańsk University of Technology (Poland)

28. **ZBIGNIEW LONC**, e-mail: Z.Lonc@mini.pw.edu.pl
Warsaw University of Technology (Poland)

29. **ROBERT MALONA**, e-mail: ms11014@student.math.uni.opole.pl
Opole University (Poland)

30. **MICHAŁ MAŁAFIEJSKI**, e-mail: mima@kaims.pl
Gdańsk University of Technology (Poland)

31. **MATEUSZ MIOTK**, e-mail: mmiotk@inf.ug.edu.pl
University of Gdańsk (Poland)

32. **MERCÉ MORA**, e-mail: merce.mora@upc.edu
Universitat Politécnica de Catalunya (Spain)

33. **KIEKA MYNHARDT**, e-mail: kmynhardt@gmail.com
University of Victoria (Canada)

34. **KRZYSZTOF PASTUSZAK**,
e-mail: krzysztof_pastuszak@yahoo.com
Gdańsk University of Technology (Poland)

35. **URSZULA PASTWA**, e-mail: urszula@pastwa.pl
Warsaw University of Technology (Poland)

36. **KAMIL POWROŹNIK**, e-mail: kamil.pawel.powroznik@gmail.com
Maria Curie-Skłodowska University (Poland)

37. **JOANNA RACZEK**, e-mail: gardenia@mif.pg.gda.pl
Gdańsk University of Technology (Poland)

38. **JUAN ALBERTO RODRIGUEZ-VELÁZQUEZ**,
e-mail: juanalberto.rodriguez@urv.cat
Rovira i Virgili University (Spain)

39. **MONIKA ROSICKA**, e-mail: mrosicka@inf.ug.edu.pl
University of Gdańsk (Poland)

40. **RIANA ROUX**, e-mail: rianaroux@sun.ac.za
Stellenbosch University (South Africa)

41. **ELŻBIETA SIDOROWICZ**, e-mail: e.sidorowicz@wmie.uz.zgora.pl
University of Zielona Góra (Poland)

42. **JOANNA SOKÓŁ**, e-mail: j.sokol@mini.pw.edu.pl
Warsaw University of Technology (Poland)

43. **CASEY TOMPKINS**, e-mail: ctompkins496@gmail.com
Renyi Institute, Hungarian Academy of Sciences (Hungary)

44. **JERZY TOPP**, e-mail: jtopp@inf.ug.edu.pl
University of Gdańsk (Poland)

45. **DOROTA URBAŃSKA**, e-mail: dorurban@student.pg.gda.pl
Gdańsk University of Technology (Poland)

46. **ŁUKASZ WOJAKOWSKI**,
e-mail: Lukasz.Wojakowski@math.uni.wroc.pl
University of Wrocław (Poland)

47. **RITA ESTHER ZUAZUA VEGA**, e-mail: ritazuazua@gmail.com
National Autonomous University of Mexico (Mexico)

48. **PAWEŁ ŻYLIŃSKI**, e-mail: zylinski@inf.ug.edu.pl
University of Gdańsk (Poland)

SEQUENTIAL SEARCHING IN TREES

Krzysztof Barszcz

Gdańsk University of Technology
e-mail: krzysztofbarszcz92@gmail.com

This presentation is about a game on graph called *graph searching*. There are two sides in the game: fugitives (infinitely fast points which move around the graph) and searchers which must catch fugitives. The goal is to find the minimal number of searchers and the sequence of their moves that always let catch all fugitives. The complexity of this problem varies depending on type of graph. It is NP-complete in general but is polinomial for some classes of graphs e.g. trees. There are many articles about searching graphs but all of them assume that graph is empty (no searchers are already placed on some vertices of the graph on the start). This speech concentrates on the situation when we have searchers on some vertices and we have to catch fugitives without letting them come on the checked area. We present polynomial solution for this problem if the graf is a tree and also present a solution for the following minimalization problem: "How many searchers should be added to make searching of a graph possible?"

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RAMSEY NUMBERS FOR PATHS VERSUS SELECTED GRAPHS

Halina Bielak

UMCS, Lublin,Poland

e-mail: hbiel@hektor.umcs.lublin.pl

Let F and H be two graphs. The *Ramsey number* $R(F, H)$, is defined as the least integer n such that for every graph G of order n either G contains F or $\overline{G}$ contains H as a subgraph, where $\overline{G}$ is the complement of G. We study $R(F, H)$ with F isomorphic to a path and H belonging to a family of graphs. We show some new results concerning Ramsey numbers for paths versus selected graphs.

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TOPOLOGICAL INDICES IN THE GRAPH THEORY

KATARZYNA BRONISZEWSKA, HALINA BIELAK

Marie Curie Skłodowska University

e-mail: katarzyna.anna.wolska@gmail.com, hbiel@hektor.umcs.lublin.pl

There will be presented the relation between Steiner Wiener index and Wiener index for some unicyclic graphs.

The Steiner k-Wiener index $SW_k(G)$ of G is defined by

$$SW_k(G) = \sum_{\substack{S \subseteq V(G) \\ |S|=k}} d(S).$$

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SOME RESULTS FOR RAMSEY NUMBERS OF WHEELS VERSUS OTHER GRAPHS

Halina Bielak, Kinga Dąbrowska

Lublin UMCS

e-mail: hbiel@hektor.umcs.lublin.pl, kinga.wiktoria.dabrowska@gmail.com

We study the Ramsey numbers for some sequences of graphs. The two-color Ramsey number $R(G, H)$ is the smallest integer n such that, for any graph F on n vertices, either F contains G or $\overline{F}$ contains H, where $\overline{F}$ denotes the complement of F.
Hasmawati [3] determined the Ramsey numbers for stars versus wheels $R(K_{1,n}, W_m)$ for $m \geq 2n$. For odd m, Chen et al. [1] showed that if $m \leq n+2$, then $R(K_{1,n}, W_m) = 3n+1$. Hasmawati et.al [2] proved that the values remain the same even if $m \leq 2n-1$. Li and Schiermeyer [4] provded the exact values when $n+2 \leq m \leq 2n-2$. In this paper we present some results for Ramsey numbers for wheels versus selected graphs.

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$\mathcal{P}$-APEX GRAPHS

Mieczysław Borowiecki, Ewa Drgas-Burchardt and Elżbieta Sidorowicz

University of Zielona Góra

e-mail: M.Borowiecki@wmie.uz.zgora.pl, E.Drgas-Burchardt@wmie.uz.zgora.pl, E.Sidorowicz@wmie.uz.zgora.pl

Let $\mathcal{P}$ be an arbitrary class of graphs that is closed under taking induced subgraphs and let $\mathcal{C}(\mathcal{P})$ be the family of forbidden subgraphs for $\mathcal{P}$. We investigate the class $\mathcal{P}(k)$ consisting of all the graphs G for which the removal no more than k vertices results in graphs that belong to $\mathcal{P}$. We show the sharp upper bound on the number of vertices of graphs in $\mathcal{C}(\mathcal{P}(1))$ and we give the construction of graphs in $\mathcal{C}(\mathcal{P}(k))$ of relatively big order for $k \geq 2$. Additionally, when $\mathcal{P}$ is additive, the sufficient conditions that have to be satisfied by a graph to be in $\mathcal{C}(\mathcal{P}(k))$ and the characterization of all forests in $\mathcal{C}(\mathcal{P}(k))$ are given. We pay special attention to $\mathcal{C}(\mathcal{P}(1))$ for a substitution closed class $\mathcal{P}$ with particular emphasis on the class of P_r-free graphs. The new results concerning $\mathcal{C}(\mathcal{P}(k))$ obtained herein are, in part, presented by hypergraph tools. This technique gives a result in hypergraph theory field. It is an unknown sharp upper bound on the order of a hypergraph that has the transversal number equal to two and that is critical with respect to this property. Our investigation is motivated by research on classes of apex-graphs, apex-outerplanar graphs and some others that are present in the graph theory literature.

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ACYCLIC-SUM-LIST COLOURINGS OF BIPARTITE GRAPHS

Ewa Drgas-Burchardt and Agata Drzystek

Faculty of Mathematics Computer Science and Econometrics
University of Zielona Góra
e-mail: e.drgas-burchardt@wmie.uz.zgora.pl, a.drzystek@wmie.uz.zgora.pl

Let $\mathcal{D}_1$ be a class of acyclic graphs, G be a graph and $\mathbf{L}$ be a collection $\{L(v)\}_{v \in V(G)}$ of nonempty sets each of which consists of positive integers. A graph G is $(\mathbf{L}, \mathcal{D}_1)$-*choosable* if there exists a mapping $c : V(G) \to \mathbb{N}$, such that

1. for each $v \in V(G)$ it holds $c(v) \in L(v)$; and
2. for each $i \in \mathbb{N}$ the graph induced in G by all the vertices in the set $c^{-1}(i)$ belongs to $\mathcal{D}_1$.

Let $f : V(G) \to \mathbb{N}$ be a function which assigns list sizes to the vertices of G. A graph G is $(f, \mathcal{D}_1)$-*choosable* if for every $\mathbf{L}$ whose sizes are specified by f (it means $|L(v)| = f(v)$ for each $v \in V(G)$ with $\mathbf{L} = \{L(v)\}_{v \in V(G)}$) the graph G is $(\mathbf{L}, \mathcal{D}_1)$-choosable.

The $\mathcal{D}_1$-*sum-choice-number* of a graph G is the minimum of the sum $\sum_{v \in V(G)} f(v)$ of sizes in f over all f such that G is $(f, \mathcal{D}_1)$-choosable.

Using the notions defined above, we present some results on $\mathcal{D}_1$-sum-choice-numbers of bipartite graphs.

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CONNECTED DOMINATION GAME

Mieczysław Borowiecki, Anna Fiedorowicz
and
Elżbieta Sidorowicz

University of Zielona Góra, Poland

e-mail: M.Borowiecki@wmie.uz.zgora.pl, A.Fiedorowicz@wmie.uz.zgora.pl, E.Sidorowicz@wmie.uz.zgora.pl

A new graph game is introduced, namely, a connected domination game on graphs. It is defined analogously to the well known domination game, first studied by Brešar, Klavžar and Rall in 2010.

The game is played by two players, Dominator and Staller, on a connected graph G. The players alternate taking turns choosing a vertex of G (Dominator starts). A move of a player by choosing a vertex v is legal, if the following two conditions are satisfied: the vertex v dominates at least one new vertex of G and the set of all chosen vertices induces a connected subgraph of G. The game ends when none of the players has a legal move (i.e., G is dominated). The aim of Dominator is to finish as soon as possible, the aim of Staller is opposite.

We present some preliminary results concerning this game, as well as bounds and exact values of the corresponding graph parameter — connected game domination number — for some classes of graphs, including k-trees and Cartesian products of graphs.

GRAPHS WITH EVERY EDGE IN A CYCLE OF LENGTH S

Grzegorz Gancarzewicz

Tadeusz Kościuszko Cracow University of Technology
Institute of Mathematics
ul. Warszawska 24
31-155 Kraków, Poland
e-mail: gancarz@pk.edu.pl

We consider only finite graphs without loops and multiple edges. Let $4 \leqslant s \leqslant n$ and let G be a graph of order n. J.A. Bondy and V. Chvátal introduced the notion of stability and they proved that for graph G the property of containing a cycle of length s is $(2n-s)$-stable and that the property of containing a hamiltonian cycle through an arbitrary chosen edge is $(n+1)$-stable.

For $4 \leqslant s \leqslant n$, we prove that the property of containing a cycle of length s through an arbitrary chosen edge is $(2n-s+1)$-stable and we prove that if G is a 3-connected graph on n vertices satisfying a Fan type condition:

$$\mathrm{d}\,(x\,,y) = 2 \;\Rightarrow\; \max\{\mathrm{d}\,(x)\,,\ \mathrm{d}\,(y)\} \geqslant \frac{2n-s+1}{2}\,,$$

for each pair of vertices x and y in $\mathrm{V}\,(G)$, then for every edge $e \in \mathrm{E}\,(G)$, there is a cycle of length s containing e.

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K-METRIC ANTIDIMENSION VERSUS PRIVACY IN SOCIAL NETWORKS

Rolando Trujillo-Rasua

University of Luxembourg

e-mail: rolando.trujillo@uni.lu

Ismael González Yero

University of Cádiz, Spain

e-mail: ismael.gonzalez@uca.es

Given a simple and connected graph $G = (V, E)$, and an ordered set of vertices $S = \{w_1, \ldots, w_t\} \subseteq V$, the metric representation of a vertex $u \in V$ with respect to S is the t-vector $r(u|S) = (d_G(u, w_1), \ldots, d_G(u, w_t))$, where $d_G(u, v)$ represents the length of a shortest $u - v$ path in G. The set S is a k-antiresolving set if k is the largest positive integer such that for every vertex $v \in V - S$ there exist at least other $k-1$ different vertices $v_1, \ldots, v_{k-1} \in V - S$ such that $v, v_1, \ldots, v_{k-1}$ have the same metric representation with respect to S. The k-metric antidimension of G is the minimum cardinality among all the k-antiresolving sets for G, and G is k-metric antidimensional if k is the largest integer such that G contains a k-antiresolving set [1].

If a set of attacker nodes S is a k-antiresolving set, then an adversary cannot uniquely re-identify other nodes in the network with probability higher than $1/k$. However, given that S is unknown, any privacy measure for a social network should quantify over all possible subsets S. In this sense, we say that a graph G meets (k, ℓ)-*anonymity* with respect to active attacks to its privacy, if k is the smallest positive integer such that the k-metric antidimension of G is lower than or equal to ℓ.

Several combinatorial properties of k-antiresolving sets in graphs are given in this work. Moreover, characterizations for 1-metric antidimensional trees and unicyclic graphs are provided, together with computationally efficient algorithms for deciding whether such graphs are 1-metric antidimensional.

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EXTREMAL GALLAI COLORINGS

IZOLDA GORGOL

Lublin University of Technology
e-mail: i.gorgol@pollub.pl

Gallai coloring is an edge-coloring of a graph without rainbow triangles. Extremal Gallai colorings use maximum possible number of colors. In the talk we present special kind of extremal Gallai colorings which, by double counting technique, lead to a new identity for Fibonacci numbers.

TOTTALY SYMMETRIC EDGE-COLORED GRAPHS

Mariusz Grech and Andrzej Kisielewicz

University of Wrocaw

e-mail: mgrec@math.uni.wroc.pl, kisiel@math.uni.wroc.pl

A k-colored graph $G = (V, f)$ on a set of vertices V is the complete graph on V together with a function f from the set of edges onto the set of colors $\{0, 1, \ldots, k-1\}$. The automorphism group $Aut(G)$ of G is the set of permutations of V preserving the colors of the edges. The extended automorphism group $Ext(G)$ is the set of permutations of V preserving the partition into the colors. Obviously, $Aut(G)$ is a normal subgroup of $Ext(G)$. Moreover, the factor group $Ext(G)/Aut(G)$ may be considered as one acting on the set of colors, and as such is called the symmetry group of colors of G.

A k-colored graph G is called *tottaly symetric* if $Aut(G)$ acts transitively on the set of the edges and $Ext(G)/Aut(G)$ acts as a full symmetry group of colors. (This implies also that $Aut(G)$ is vertex-transitive and arc-transitive.)

For $k = 2$ these graphs were fully described by Peisert [1] as self-complementary symmetric graphs.

We give a full classification of totally symmetric edge-colored graphs for any k. The result realized on the classification of finite simple groups.

References

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SOME SPECIAL ORBITAL MATRICES

Harald Gropp

University of Heidelberg

e-mail: d12@ix.urz.uni-heidelberg.de

Orbital matrices are generalizations of incidence matrices of symmetric designs. The main difference is that these matrices do not only contain the entries 0 and 1 but also greater integers. Somehow a point lies on a line more than once whatever this may mean geometrically. Of course, the inner product condition has to be fulfilled, as in the case of symmetric designs In matrix and design theory (and in graph theory if you will) the results are comparable to symmetric designs, however there are more non-existence results, not only those by applying the theorem of Bruck-Ryser-Chowla (which also holds for orbital matrices). Altogether this talk is meant to make orbital matrices better known to the community of people working in graph theory. There will be a survey on known results as well as an idea how to go on with research in the future. A few special orbital matrices will be discussed in detail.

TURÁN NUMBERS FOR LINEAR 3-UNIFORM PATHS OF LENGTH 3

ELIZA JACKOWSKA, JOANNA POLCYN AND ANDRZEJ RUCIŃSKI

Adam Mickiewicz University

e-mail: elijac@amu.edu.pl, joaska@amu.edu.pl, rucinski@amu.edu.pl

In this talk I will sketch the proof of the exact formula for the Turán number $\mathrm{ex}_3(n; P_3^3)$ of the 3-uniform linear path of length 3, denoted by P_3^3, valid for all n.

Füredi, Jiang and Seiver [3] have determined $\mathrm{ex}_k(n; P_l^k)$ for all $k \geq 4$, $l \geq 1$, and sufficiently large n. In particular, their result for $l = 3$ states that $\mathrm{ex}_k(n; P_3^k) = \binom{n-1}{k-1}$. They conjectured that this formula remains valid in the case $k = 3$ too. It has to be note that case $k = 3$, $l \geq 4$, has also been solved, but again for large n only [4]. The sole remaining instance is $k = l = 3$ settled for all n. In this talk I confirm a conjecture of Füredi, Jiang and Seiver.

It turns out that the Turán number $\mathrm{ex}_3(n; P_3^3)$ coincides with the analogous formula for the 3-uniform triangle C_3^3, obtained earlier by Frankl and Füredi [2] for $n \geq 75$ and Csákány and Kahn [1] for all n.

Finally, in view of this coincidence, I will introduce the new notion of *conditional Turán number* defined as the maximum number of edges in a P_3^3-free 3-uniform hypergraph on n vertices which is not C_3^3-free.

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WORM COLORINGS OF PLANAR GRAPHS

Július Czap, Stanislav Jendrol', Juraj Valiska

Pavol Jozef Safárik University

e-mail: stanislav.jendrol@upjs.sk

Given three planar graphs F, H, and G. An (F, H)-WORM coloring of G is a vertex coloring such that no subgraph isomorphic to F is rainbow and no subgraph isomorphic to H is monochromatic. If G has at least one (F, H)-WORM coloring, then $W^-_{F,H}(G)$ denotes the minimum number of colors in an (F, H)-WORM coloring of G. We show that

a) $W^-_{F,H}(G) \leq 2$ if $|V(F)| \geq 3$ and H contains a cycle,

b) $W^-_{F,H}(G) \leq 3$ if $|V(F)| \geq 4$ and H is a forest with $\Delta(H) \geq 3$,

c) $W^-_{F,H}(G) \leq 4$ if $|V(F)| \geq 5$ and H is a forest with $1 \leq \Delta(H) \leq 2$.

We also discuss the remaining cases. The cases when both F and H are nontrivial paths are more complicated; therefore we consider a relaxation of the original problem. Among others, we prove that any 3-connected plane graph (resp. outerplane graph) admits a 2-coloring such that no facial path on five (resp. four) vertices is monochromatic.

ON-LINE COLORING AND L(2,1)-LABELING OF UNIT DISKS INTERSECTION GRAPHS

Konstanty Junosza-Szaniawski, Paweł Rzążewski, Joanna Sokół and Krzysztof Węsek

Warsaw University of Technology

e-mail: {k.szaniawski, p.rzazewski, j.sokol, k.wesek}@mini.pw.edu.pl

Graphs representing intersections of families of geometric objects are intensively studied for their practical applications and for their interesting theoretical properties. In particular, unit disk intersection graphs are interesting for applications in radio network modeling. We consider the problem of classical coloring, as well as the $L(2,1)$-labeling of such graphs.

Unit disk intersection graphs can be colored on-line with competitive ratio equal to 5. We improve this ratio using j-fold colorings of the so-called unit distance graph (see [2]). (The unit distance graph is an infinite graph, whose vertex set is $\mathbb{R}^2$, and two points are adjacent if their Euclidean distance is exactly 1).

Fiala, Fishkin and Fomin [1] presented an on-line algorithm for $L(2,1)$-labeling of unit disk intersection graphs with competitive ratio $50/3 \approx 16.66$. We improve this algorithm to the one with competitive ratio $40/3 \approx 13.33$. Moreover, using the j-fold coloring, we manage to improve this ratio for unit disks intersection graphs with a large clique number.

We also consider off-line $L(2,1)$-labeling. Shao *et al.* [3] proved that $\lambda(G) \leq \frac{4}{5}\Delta^2 + 2\Delta$ for unit disk intersection graph G with maximum degree Δ. We improve this result to $\lambda(G) \leq \frac{3}{4}\Delta^2 + 3\Delta - 3$. Moreover, from work of Fiala, Fishkin and Fomin [1], we derive a bound $\lambda \leq 18\Delta + 18$, which is significantly better for large Δ.

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TURAN NUMBERS FOR GRAPHS

Halina Bielak and Sebastian Kieliszek

Inst. Math., Faculty of Mathematics, Physics and Computer Science, UMCS
e-mail: hbiel@hektor.umcs.lublin.pl, sebastian.lukasz.kieliszek@gmail.com

The Turán number for the graph G denoted by $ex(n, G)$ is the maximum number of edges in a graph on n vertices which does not contain G as a subgraph. In 1941 Turán proved that the extremal graph without containing K_r as a subgraph is the Turán graph $T_{r-1}(n)$. Recently, Gorgol [5] studied the Turán number of disjoint copies of any connected graphs and she counted the Turán number for graphs $2P_3$ and $3P_3$. For the graph kP_3 Yuan and Zhang [7] determined the Turán number. We solved the Turán problem for graphs $2P_4, 3P_4$ and $2P_5$ (see [1],[2]). Morover we consider the Turán number for some linear forests. There are several results on the Turán numbers for forests, cycles, wheels, trees, bipartite graphs and other diffrent classes of graphs (see [3], [4], [6], et. al.).

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SECRETARY PROBLEM: GRAPHS, MATROIDS AND GREEDOIDS

Wojciech Kordecki

The Witelon State University of Applied Sciences in Legnica
e-mail: wojciech.kordecki@pwsz-legnica.eu

In the classical secretary problem there are n linearly ordered elements. They are being observed at a random order $\omega = (\omega_1, \omega_2, \ldots, \omega_n)$. At the moment $t = i$ the observer knows only the relative ranks of the elements examined so far. The aim of the observer is to choose the currently examined object in such a way that the probability $\Pr(\omega_r = n)$ is the maximal possible. Whether $\tau(\omega) = i$ depends only on $(\omega_1, \omega_2, \ldots, \omega_i)$. This problem is well known and solved.

Let us assume, that in the set E an independence structure $\mathcal{I}$ is introduced, then $(E, \mathcal{I})$ forms a matroid. If a new element is dependent on the previously rejected ones, also such an element is rejected. If the element is not dependent, then as a result of comparison we can reject or accept it. Such a problem was introduced in [1] and considered among others in the recent papers [2, 4]. The aim of the report is a further generalisation, when independence in matroids is replaced by the condition that a new element belongs to a feasible set in a fixed greedoid (see [3]).

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DIRECT PRODUCT OF AUTOMORPHISM GROUPS OF DIGRAPHS

Mariusz Grech, Anna Krystek and Łukasz Wojakowski

University of Wrocław

e-mail: mgrec@math.uni.wroc.pl, krystek@math.uni.wroc.pl,
wojak@math.uni.wroc.pl

The problem of representability of a permutation group A as the full automorphism group of a digraph $G = (V, E)$ was first studied for regular permutation groups by many authors, the solution of the problem for undirected graphs was first completed by Godsil [2] in 1979. For digraphs, L. Babai [1] in 1980 proved that, except for the groups S_2^2, S_2^3, S_2^4, C_3^2 and the eight element quaternion group Q, each regular permutation group is the automorphism group of a digraph. Later on, in [3] the direct product of automorphism groups of graphs was studied.

It was shown that, except for an infinite family of groups $S_n \times S_n, n \geq 2$, and three other groups $D_4 \times S_2$, $D_4 \times D_4$, and $S_4 \times S_2 \times S_2$, the direct product of automorphism groups of two graphs is, itself, an automorphism group of a graph.

We study the direct product of automorphism groups of digraphs. We show that, except for the infinite family of permutation groups $S_n \times S_n$, $n \geq 2$ and four other permutation groups $D_4 \times S_2$, $D_4 \times D_4$, $S_4 \times S_2 \times S_2$, and $C_3 \times C_3$, the direct product of automorphism groups of two digraphs is itself the automorphism group of a digraph.

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ON SEQUENCES COVERING ALL EDGES OF A GRAPH

Zbigniew Lonc

Warsaw University of Technology
e-mail: Z.Lonc@mini.pw..edu.pl

Let V be the set of vertices of a graph G and let k be a fixed positive integer. We say that a sequence (with possible repetitions) of elements of V is a k-radius sequence for the graph G if the ends of every edge of G appear at distance at most k somewhere in the sequence. The problem of finding, for a given graph, such a sequence of a possibly short length arose in connection with large data transfer. In the talk we shall show a few constructions of short k-radius sequences for some special graphs, present bounds for the lengths of shortest k-radius sequences for some graphs, consider complexity questions and discuss some relationships to other combinatorial problems.

ON TOURNAMENTS WITH THE POSSIBILITY OF A DRAW

Robert Malona

University of Opole
e-mail: ms11014@student.math.uni.opole.pl

The talk will be devoted to the topic of digraphs called tournaments and score sequences. At the beginning, the basic definitions, properties and theorems concerning digraphs will be given. After that the notions of the tournament and score sequences will be given, and the basic theorems concerning tournaments will be presented. The aim of the talk is to consider some problems for tournaments with the possibility of a draw. There will be also formulated a result analogous to Landau Theorem on score sequences and proven.

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HANGABLE GRAPHS

Mateusz Miotk

Faculty of Mathematics, Physics and Informatics University of Gdańsk
e-mail: mmiotk@inf.ug.edu.pl

Jerzy Topp

Faculty of Mathematics, Physics and Informatics University of Gdańsk
e-mail: jtopp@inf.ug.edu.pl

Let $G = (V_G, E_G)$ be a connected graph. The distance $d_G(u, v)$ between vertices u and v in G is the length of a shortest $u - v$ path in G. The eccentricity of a vertex v in G is the integer $e_G(v) = \max\{d_G(v, u) \colon u \in V_G\}$. The diameter of G is the integer $d(G) = \max\{e_G(v) \colon v \in V_G\}$. The periphery of a vertex v of G is the set $P_G(v) = \{u \in V_G \colon d_G(v, u) = e_G(v)\}$, while the periphery of G is the set $P(G) = \{v \in V_G \colon e_G(v) = d(G)\}$. We say that graph G is hangable if $P_G(v) \subseteq P(G)$ for every vertex v of G. In this paper we prove that every block graph is hangable and discuss the hangability of products of graphs.

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GENERAL BOUNDS ON LIMITED BROADCAST DOMINATION

JOSÉ CÁCERES AND MARÍA LUZ PUERTAS

Universidad de Almería

e-mail: {jcaceres, mpuertas}@ual.es

CARMEN HERNANDO, MERCÈ MORA AND IGNACIO M. PELAYO

Universitat Politècnica de Catalunya

e-mail: {carmen.hernando, merce.mora, ignacio.m.pelayo}@upc.edu

A *broadcast* on a graph G is a function $f : V(G) \to \{0, 1, \ldots, D\}$ such that $f(u) \leq e(u)$ for every vertex $u \in V(G)$, where $e(u)$ denotes the eccentricity of vertex u and D denotes the diameter of G. The *cost* of the broadcast f is $\omega(f) = \sum_{u \in V(G)} f(u)$. A broadcast on G is *dominating* if for every vertex $u \in V(G)$ there exists a vertex $v \in V(G)$ such that $f(v) \geq 1$ and $d(u, v) \leq f(v)$. For every integer $k \geq 1$, we say that a broadcast f is *k-limited* if $f(u) \leq k$ for every $u \in V$. The *k-limited broadcast domination number* is the minimum cost of a k-limited dominating broadcast. In this work we study k-limited dominating broadcasts. Our main result is a general upper bound on the k-limited broadcast domination number in terms of both k and the order of the graph. For the specific case of $k = 2$, we show that this bound is tight for graphs of order as great as desired.

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BROADCAST DOMINATION, INDEPENDENCE AND IRREDUNDANCE

Kieka Mynhardt

University of Victoria

e-mail: kmynhardt@gmail.com

A *broadcast* on a nontrivial connected graph $G = (V, E)$ is a function $f : V \to \{0, 1, \ldots, \operatorname{diam} G\}$ such that $f(v) \leq e(v)$ (the eccentricity of v) for all $v \in V$. The *cost* of f is $\sigma(f) = \sum_{v \in V} f(v)$. A broadcast f is a *dominating broadcast* if every vertex of G is within distance $f(v)$ from a vertex v with $f(v) > 0$. A dominating broadcast f is a *minimal dominating broadcast* if no broadcast $g < f$ is dominating. The *lower and upper broadcast numbers* of G are defined by

$$\gamma_b(G) = \min\{\sigma(f) : f \text{ is a dominating broadcast of } G\} \text{ and}$$

$$\Gamma_b(G) = \max\{\sigma(f) : f \text{ is a minimal dominating broadcast of } G\}.$$

A dominating broadcast f is minimal dominating if and only if it satisfies

P: For each v such that $f(v) > 0$ there exists $u \in V$ that is not dominated by the broadcast $f' = (f - \{(v, f(v))\}) \cup \{(v, f(v) - 1)\}$.

There exists an equivalent formulation of **P** in terms of broadcast neighbourhoods, boundaries and private boundaries, which will be discussed in the presentation.

Similar to classical domination and irredundance, a broadcast that satisfies **P** is an *irredundant broadcast*, and may or may not also be dominating. An irredundant broadcast f is *maximal irredundant* if no broadcast $g > f$ is irredundant. The *lower and upper broadcast irredundant numbers* of G are

$$\operatorname{ir}_b(G) = \min\{\sigma(f) : f \text{ is a maximal irredundant broadcast of } G\} \text{ and}$$

$$\operatorname{IR}_b(G) = \max\{\sigma(f) : f \text{ is an irredundant broadcast of } G\}.$$

Broadcast independence has been defined in the literature but this definition is unsatisfactory for several reasons. We mention alternative definitions and present an overview of these concepts, their properties and the relationships between the associated parameters.

INCIDENTOR COLORING OF GRAPHS

Michał Małafiejski, Krzysztof Pastuszak

Gdańsk University of Technology

e-mail: michal@animima.org, krzysztof_pastuszak@yahoo.com

The incidentor model of graph coloring has been introduced by A.A. Zykov in the 60s, but little research had been done until the 90s when A.V. Vizing and A. Pyatkin focused their research on this model and it's applications in the scheduling theory. The incidentor coloring model is a relaxation of the classical incidence coloring model. It finds applications mainly in the job shop and open shop scheduling problems.

During our talk we will present the overview of the model and the recent advances. We will present the model in relation to the classical graph theory problems such as finding the maximum matching. We will present our own results in the graphs of bounded degree. We also highlight the applications of our results in the scheduling theory.

GRASSHOPPER AVOIDANCE OF PATTERNS

Michał Dębski, Urszula Pastwa and Krzysztof Węsek

Warsaw University of Technology

e-mail: urszula@pastwa.pl

Motivated by a geometrical Thue-type problem, we define a new variant of the classical pattern avoidance in words, where jumping over a letter in the pattern occurence is allowed.

We say that pattern $p \in E^+$ occurs with jumps in a word $w = a_1 a_2 \ldots a_k \in A^+$, if there exist a non-erasing morphism f from E^* to A^* and a sequence $(i_1, i_2, \ldots, i_l)$ satisfying $i_{j+1} \in \{i_j + 1, i_j + 2\}$ for $j = 1, 2, \ldots, l-1$, such that $f(p) = a_{i_1} a_{i_2} \ldots a_{i_l}$.

For example, a pattern xx occurs with jumps in a word *abdcadbc* (for $x \mapsto abc$). A pattern p is *grasshopper k-avoidable* if there exists an alphabet A of k elements, such that there exist arbitrarily long words over A in which p does not occur with jumps. The minimal such k is the *grasshopper avoidability index* of p. It appears that this notion is related to two other problems: pattern avoidance on graphs and pattern-free colorings of the Euclidean plane. In particular, a sequence avoiding a pattern p with jumps can be a tool to construct a line p-free coloring of $\mathbb{R}^2$.

We almost completely determine the grasshopper avoidability index of patterns α^n. Using entropy compression method, we obtain results for more general classes of patterns: every doubled pattern is grasshopper (2^7+1)-avoidable, every pattern on k variables of length at least 2^k is grasshopper 37-avoidable, and there exists a constant c such that every pattern of length at least c on 2 variables is grasshopper 3-avoidable.

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THE HOMOGENEOUS DENSITY TURÁN PROBLEM FOR SOME CLASSES OF GRAPHS

HALINA BIELAK AND KAMIL POWROŹNIK

Maria Curie-Skłodowska University in Lublin

e-mail: hbiel@hektor.umcs.lublin.pl, kamil.pawel.powroznik@gmail.com

Let H be a simple, connected graph and let $B[H]$ be a blow-up graph of H. We define the edge density between any two clusters A_i and A_j in $B[H]$ by formula

$$d(A_i, A_j) = \frac{e(A_i, A_j)}{|A_i||A_j|},$$

where $e(A_i, A_j)$ denotes the number of edges between A_i and A_j.

We want to determine the critical edge density d_{crit} which ensures the existence of the subgraph H of $B[H]$ as a transversal. On the other words, we want to find the value of d_{crit} such that $d(A_i, A_j) > d_{crit}$ for all $e = (v_i, v_j) \in E(H)$, where $v_i, v_j \in V(H)$. Then, no matter how we construct $B[H]$, it contains the graph H as a transversal.

We present some results presented in papers [1]-[2] for trees and cycles. For example, by [2], the critical density for trees is given as follows

$$d_{crit}(T) = 1 - \frac{1}{\lambda^2_{max}(T)},$$

where $\lambda_{max}(T)$ denotes the maximal eigenvalue of the adjacency matrix of the tree.

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ON THE K-METRIC DIMENSION OF GRAPHS

JUAN ALBERT RODRIGUEZ- VELÁZQUEZ

Rovira i Virgili University

e-mail: juanalberto.rodriguez@urv.cat

The metric dimension of a general metric space was introduced in 1953 but attracted little attention until, about twenty years later, it was applied to the distances between vertices of a graph. Since then it has been frequently used in graph theory, chemistry, biology, robotics and many other disciplines. The theory was developed further in 2013 for general metric spaces. More recently, the theory of metric dimension has been generalised, again in the context of graph theory, to the notion of a k-metric dimension, where k is any positive integer, and where the case $k = 1$ corresponds to the original theory. Here we develop the idea of the k-metric dimension both in graph theory and in metric spaces.

A PROOF OF THE UNIVERSAL FIXER CONJECTURE

Monika Rosicka

University of Gdańsk

e-mail: mrosicka@inf.ug.edu.pl

For a given graph $G = (V, E)$ and permutation $\pi : V \mapsto V$ the prism πG of G is defined as follows: $V(\pi G) = V(G) \cup V(G')$, where G' is a copy of G, and $E(\pi G) = E(G) \cup E(G') \cup M_\pi$, where $M_\pi = \{uv' : u \in V(G), v = \pi(u)\}$ and v' denotes the copy of v in G'. The graph G is called a universal fixer if $\gamma(\pi G) = \gamma(G)$ for every permutation π. The idea of universal fixers was introduced by Burger, Mynhardt and Weakley in 2004. In this work we prove that the edgeless graphs $\overline{K_n}$ are the only universal fixers.

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DOMINATION CRITICALITY WITH RESPECT TO MULTIPLE EDGE SUBDIVISION

RIANA ROUX

Stellenbosch University

e-mail: rianaroux@sun.ac.za

A graph G is called domination critical with respect to edge subdivision, or γ_{sd}-*critical*, if the domination number of G increases with the subdivision of any edge of G. Rad [1] showed that the subdivision of an edge can increase the domination number of a graph by at most one and that a graph is γ_{sd}-critical if and only if every γ-set of G is a 2-packing.

In this talk we will consider how the domination number changes with the removal of any q edges. The criticality of some basic graph classes will be discussed and a characterization of γ_{sd}^{qe}-critical will be presented.

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LOCALIZATION GAMES ON GRAPHS

Jarosław Grytczuk, Joanna Sokół, Małgorzata Śleszyńska-Nowak

Warsaw University of Technology

e-mail: j.sokol@mini.pw.edu.pl

We present game version of metric and centroidal bases of graphs, inspired by localization problems in wireless networks. Given the network as a graph of wi-fi access points, we try to localize a person walking with a cell phone solely by wi-fi signals. The strength of the signals measured by the cell phone is proportional to the distances from access points. In our approach Robber is walking on the graph and Cop tries to catch him. In each round Cop chooses which access points will be active in this round. Then Robber moves to an adjacent vertex or stays where he is. After that Cop receives some information about the distances between Robber and active access points. Cop wins the game if able to determine the exact location of Robber in finite number of rounds. The question is how many access points Cop activates in each round in order to win. This parameter is bounded by the cardinality of metric and centroidal basis respectively for two variants of the game. We determine the number of active access points for some classes of graphs, such as trees, outerplanar graphs and unit distance graph on the plane. We ask whether there exists a constant bound on the parameter for planar graphs and speculate on possible relation to classic Cops and Robbers game.

AN ERDÖS- GALLAI TYPE THEOREM FOR HYPERGRAPHS

Casey Tompkins

Renyi Institute, Hungarian Academy of Sciences
e-mail: ctompkins496@gmail.com

Given an r-uniform hypergraph, define a Berge path of length k to be a set of k hyperedges $e_1, \ldots, e_k$ and $k+1$ vertices $v_1, \ldots, v_{k+1}$ such that $v_i, v_{i+1} \in h_i$. A well-known result of Erdős and Gallai determines the maximum number of edges possible in an n vertex graph without a path of length k. Győri, Katona and Lemons extended this theorem determining the extremal number of a Berge path of length k in an r-uniform hypegergraph for all pairs (r, k) except $k = r + 1$. In joint work with Davoodi, Győri and Methuku, we settle the remaining case.

DISTRIBUTED SEARCHING OF ARBITRARY GRAPHS BY MOBILE AGENTS

Dorota Urbańska

Gdańsk University of Technology
e-mail: dorurban@student.pg.gda.pl

A team of mobile agents starting from a *homebase* need to visit and clean all nodes of the network. A goal is to find a strategy, which would be optimal in sense of number of needed entities, moves performed by them or a total time of an algorithm. Currently, the field of distributed graph searching by a team of mobile agents is rapidly expending and many new approaches and models are being presented in order to better describe real life problems like decontaminating danger areas by a group of robots or cleaning networks from viruses.

An offline case, when a topology of a graph is known in advance is well studied, especially for one searcher. This survey presents recent results focusing mainly on an issue of decontaminating an arbitrary graph with none or some *a priori* knowledge about its topology, but also some background of an offline case is given. We introduce a bibliography for various models, which differ on i.e. knowledge about a graph, properties of agents, time clock, way of communication or size of available memory.

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DESTROYING LONGEST CYCLES IN DIGRAPHS

Rita Zuazua

Science Faculty, Universidad Nacional Autónoma de México, Mexico
e-mail: ritazuazua@ciencias.unam.mx

In 1978, C. Thomassen proved that in any graph one can destroy all the longest cycles by deleting at most one third of the vertices. We show [1], that for graphs with circumference $k \leq 8$ it suffices to remove at most 1/k of the vertices. In this talk, we consider the analogous problem for digraphs.

Joint work with: Susan A. van Aardt, Alewyn P. Burger, Jean E. Dunbar, Marietjie Frick, , Bernardo Llano and Carsten Thomassen.

References

[1] van Aardt, Susan A.; Burger, Alewyn P.; Dunbar, Jean E.; Frick, Marietjie; Llano, Bernardo; Thomassen, Carsten; Zuazua, Rita, Destroying longest cycles in graphs and digraphs. *Discrete Appl. Math.*, 186 (2015), 251-259.