Final Program and Abstracts

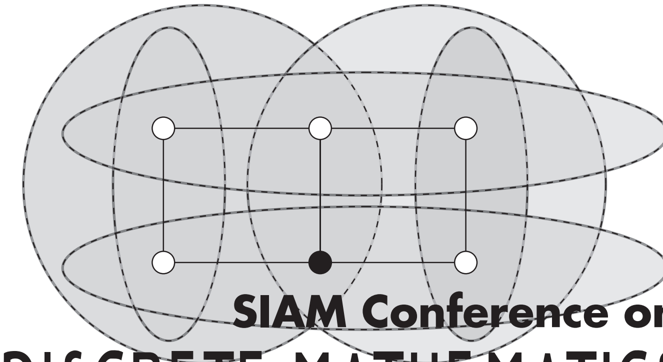

Figure courtesy Victor Chepoi, Hans-Juergen Bandelt, David Eppstein from SIDMA 24-4

SIAM Conference on DISCRETE MATHEMATICS

June 18-21, 2012
Dalhousie University
Halifax, Nova Scotia, Canada

Sponsored by the SIAM Activity Group on Discrete Mathematics

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University Information

All sessions will take place on Dalhousie University's campus in the Marion McCain, Kenneth C. Rowe and the Henry Hicks Buildings. The website for the university is *www.dal.ca/.*

Registration Desk

Conference registration will be located in the Marion McCain Arts & Science Building Lobby on the Dalhousie University campus. Registration is open during the following times:

Monday, June 18
7:00 AM – 7:30 PM

Tuesday, June 19
7:30 AM – 4:00 PM

Wednesday, June 19
7:30 AM – 4:00 PM

Thursday, June 20
7:30 AM – 4:00 PM

University Address

Dalhousie University

Marion McCain Arts and Social Sciences Building

6135 University Ave

Hailfax, Nova Scotia, Canada B3H 4R2

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Check the registration desk for additional information.

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- Admission to all technical sessions
- Business Meeting (open to SIAG/DM members)
- Coffee breaks daily
- Room set-ups and audio/visual equipment
- Welcome Reception

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Table Top Displays

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Sven Leyffer, SIAM Vice President for Programs (*vpp@siam.org*)

Get-togethers

- **Welcome Reception**
  Monday, June 18
  7:00 PM – 9:00 PM
  Sculpture Court

- **Business Meeting (open to SIAG/DM members)**
  Tuesday, June 19
  6:00 PM – 7:00 PM
  Chase 119
  Complimentary refreshments will be served.

Please Note

SIAM is not responsible for the safety and security of attendees' computers. Do not leave your laptop computers unattended. Please remember to turn off your cell phones, pagers, etc. during sessions.

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Invited Plenary Speakers

All Invited Plenary Presentations will take place in Marion McCain Ondaatje Auditorium.

Monday, June 18

8:15 AM – 9:00 AM

IP1 Cell Complexes in Combinatorics

Anders Björner, *Royal Institute of Technology, Sweden*

2:00 PM – 2:45 PM

IP2 On Sidorenko's Conjecture

Balázs Szegedy, *University of Toronto, Canada*

6:00 PM – 6:45 PM

Dénes König Prize Lecture: The Finite Field Kakeya Problem

Zeev Dvir, *Princeton University*

Tuesday, June 19

8:15 AM – 9:00 AM

IP3 Forcing Large Transitive Subtournamets

Maria Chudnovsky, *Columbia University, USA*

2:00 PM – 2:45 PM

IP4 Adding and Counting

Ken Ono, *Emory University, USA*

Invited Plenary Speakers

Wednesday, June 20

8:15 AM – 9:00 AM

IP5 Coloring 3-colorable Graphs; Graph Theory Finally Strikes Back!

Ken-ichi Kawarabayashi, *National Institute of Informatics, Japan*

2:00 PM – 2:45 PM

IP6 Computational Analysis of Cellular Interaction Networks

Mona Singh, *Princeton University, USA*

Thursday, June 21

8:15 AM – 9:00 AM

IP7 The Hub Labeling Algorithm

Andrew Goldberg, *Microsoft Research Silicon Valley, USA*

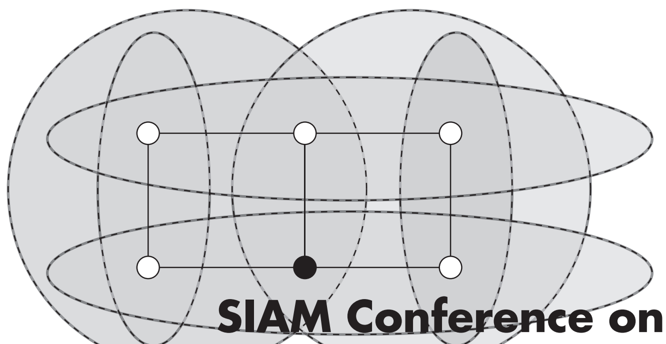
2:00 PM – 2:45 PM

IP8 Algorithms, Graph Theory, and the Solution of Laplacian Linear Equations

Daniel Spielman, *Yale University, USA*

Notes

DM12 Program



SIAM Conference on

DISCRETE MATHEMATICS

June 18-21, 2012

Dalhousie University

Halifax, Nova Scotia, Canada

Figure courtesy Victor Chepoi, Hans-Juergen Bandelt, David Eppstein from SIDMA 24-4

Monday, June 18

Registration

7:00 AM-7:30 PM

Room:Marion McCain Lobby

Welcome Remarks

8:00 AM-8:15 AM

Room:Marion McCain Ondaatje Auditorium

IP1

Cell Complexes in Combinatorics

8:15 AM-9:00 AM

Room:Marion McCain Ondaatje Auditorium

Chair: Jason Brown, Dalhousie University, Canada

Cell complexes of various kinds have been invented in topology to help analyze manifolds and other spaces. By introducing a combinatorial structure they make algorithms for computing topological invariants possible. Simplicial complexes are well-known examples. In the other direction, several structures studied in combinatorics naturally suggest associated cell complexes. Can the link to topology provided by these cell complexes be of use for dealing with purely combinatorial questions, or are they just idle curiosities? The answer is definitely "yes" in the simplicial case, as testified by several successes of what has come to be called "topological combinatorics". But what about more general cell complexes? In the talk this question will be discussed. Examples, old and new, arising in graph, group and number theory will be reviewed.

Anders Björner
Royal Institute of Technology, Sweden

Coffee Break

9:00 AM-9:30 AM

Room:Marion McCain Lobby

Monday, June 18

MS1

Combinatorics and Partially Ordered Sets - Part I of IV

9:30 AM-12:00 PM

Room:Henry Hicks 212

For Part 2 see MS8

Organizer: William T. Trotter
Georgia Institute of Technology, USA

9:30-9:55 Title Not Available at Time of Publication

William T. Trotter, Georgia Institute of Technology, USA

10:00-10:25 Variations on the Majorization Order

Curtis Greene, Haverford College, USA

10:30-10:55 Forbidden Structures for Efficient First-Fit Chain Partitioning

Bartlomiej E. Bosek, *Tomasz Krawczyk*, and Grzegorz Matecki, Jagiellonian University, Poland

11:00-11:25 Forbidden Induced Posets in the Boolean Lattice

Linyuan Lu and *Kevin Milans*, University of South Carolina, USA

11:30-11:55 Linear Extension Diameter and Reversal Ratio

Mitchel T. Keller, London School of Economics and Political Science, United Kingdom; Graham Brightwell, London School of Economics, United Kingdom

Monday, June 18

MS2

Algebraic Combinatorics - Part I of III

9:30 AM-12:00 PM

Room:Kenneth C. Rowe 1009

For Part 2 see MS16

This minisymposium focuses on combinatorial problems and results that are closely connected with topics in abstract algebra, including representation theory, commutative algebra, and algebraic geometry.

Organizer: Tom Roby
University of Connecticut and Massachusetts Institute of Technology, USA

Organizer: Richard Stanley
Massachusetts Institute of Technology, USA

9:30-9:55 Tesler Matrices, Parking Functions, and Diagonal Harmonics

Jim Haglund, University of Pennsylvania, USA

10:00-10:25 Classical and Quasi Symmetric Hall-Littlewood Polynomials and Transition Matrices

Nicholas Loehr, Virginia Polytechnic Institute & State University, USA; *Luis Serrano*, Universite du Quebec a Montreal, Canada; Gregory Warrington, University of Vermont, USA

10:30-10:55 Lie Theory for Hyperplane Arrangements

Marcelo Aguiar, Texas A&M University, USA; Swapneel Mahajan, IIT Mumbai, India

11:00-11:25 Combinatorial Ergodicity in Products of Chains

Tom Roby, University of Connecticut and Massachusetts Institute of Technology, USA; James Propp, University of Massachusetts, Lowell, USA

11:30-11:55 Demazure Crystals, Kirillov-Reshetikhin Crystals, and the Energy Function

Peter Tingley, Massachusetts Institute of Technology, USA

Monday, June 18

MS3

Graph Coloring Minisymposium - Part I of II

9:30 AM-12:00 PM

Room:Kenneth C. Rowe 1011

For Part 2 see MS30

Graph coloring is a central area of discrete mathematics, with connections to many seemingly unrelated fields. This minisymposium will consider a wide range of problems related to graph coloring.

Organizer: Daniel Cranston
Virginia Commonwealth University, USA

9:30-9:55 Conjectures Equivalent to the Borodin-Kostochka Conjecture that a Priori Seem Weaker

Daniel Cranston, Virginia Commonwealth University, USA

10:00-10:25 List-coloring on Surfaces with Some Small Lists

Alice M. Dean, Skidmore College, USA; *Joan P. Hutchinson*, Macalester College, USA

10:30-10:55 4-critical Graphs on Surfaces without Contractible Cycles of Length at Most 4

Zdenek Dvorak, Charles University, Czech Republic; *Bernard Lidicky*, University of Illinois, Urbana, USA

11:00-11:25 Fractional Colorings of Cubic Graphs

David Ferguson, London School of Economics, United Kingdom; Tomas Kaiser, University of West Bohemia, Pilsen, Czech Republic; Frantisek Kardos, INRIA Sophia Antipolis, France; *Daniel Kral* and Jan Volec, Charles University, Czech Republic

11:30-11:55 Extending Graph Choosability Results to Paintability

James Carraher, University of Nebraska, USA; Sarah Loeb, Thomas Mahoney, Gregory Puleo, and Mu-Tsun Tsai, University of Illinois, USA; *Douglas B. West*, University of Illinois, Urbana, USA

Monday, June 18

MS4

Extremal Graph Theory

9:30 AM-12:00 PM

Room:Henry Hicks 217

Extremal graph theory can be described as the study of how global properties of a graph can guarantee the existence of local substructures. A classical example is the Turan problem, which is to determine the maximum number of edges in a graph with n vertices, that does not contain a given graph H as a subgraph. Many natural questions can be formulated as extremal graph problems, and the subject has developed into a rich theory. Applications abound in many fields, including number theory, optimization, theoretical computer science, economics, and hardware design.

Organizer: Penny Haxell
University of Waterloo, Canada

9:30-9:55 On a Problem of Erdös and Rothschild on Edges in Triangles

Jacob Fox, Massachusetts Institute of Technology, USA; *Po-Shen Loh*, Carnegie Mellon University, USA

10:00-10:25 Turan's Brickyard Problem and Flag Algebras

Sergey Norin, McGill University, Canada

10:30-10:55 Extremal Results in Sparse Pseudorandom Graphs

David Conlon, University of Oxford, United Kingdom; Jacob Fox and *Yufei Zhao*, Massachusetts Institute of Technology, USA

11:00-11:25 Title Not Available at Time of Publication

Hamed Hatami, Princeton University, USA

11:30-11:55 Turán Densities of Hypergraphs Related to $K^{k}/_{k+1}$

Yi Zhao, Georgia State University, USA; József Balogh, University of Illinois, USA; Tom Bohman, Carnegie Mellon University, USA; Béla Bollobás, University of Memphis, USA

Monday, June 18

MS5

Design Theory - Part I of IV

9:30 AM-12:00 PM

Room:Marion McCain 2017

For Part 2 see MS19

This session will focus on combinatorial designs and related concepts.

Organizer: David Pike
Memorial University, Newfoundland, Canada

9:30-9:55 Defining Sets in Combinatorial Arrays

Nicholas Cavenagh, University of Waikato, New Zealand

10:00-10:25 On the Directed Oberwolfach Problem

Andrea Burgess, Ryerson University, Canada; Patrick Niesink and Mateja Sajna, University of Ottawa, Canada

10:30-10:55 Trinal Decompositions of Steiner Triple Systems

Mariusz Meszka, AGH University of Science and Technology, Poland; Charles C. Lindner, Auburn University, USA; Alexander Rosa, McMaster University, Canada

11:00-11:25 Extending the Bruck-Ryser-Chowla Theorem to Coverings

Daniel Horsley, Monash University, Australia; Darryn Bryant, Melinda Buchanan, Barbara Maenhaut, and Victor Scharaschkin, University of Queensland, Australia

11:30-11:55 Graph Decompositions and Convexity

Kseniya Garaschuk and Peter Dukes, University of Victoria, Canada

Monday, June 18

MS6

Computational Methods for RNA Structure Analysis

9:30 AM-11:30 AM

Room:Marion McCain 2021

The central role of RNA in organisms as well as for recombinant technology and therapeutics, demands for highly specialized and efficient computational methods. Despite recent significant advances, the high complexity of RNA-related problems and their intricate biology still challenges Bioinformatics. Experimental methods have now reached a level that facilitates the testing and verification of computational methods to study RNA sequence, structure and interaction. Therefore, now there is a high demand for working on RNA bioinformatics. This minisymposium will provide a great chance to bring together researchers to discuss new algorithms and software tools to study RNA.

Organizer: Raheleh Salari
Stanford University, USA

9:30-9:55 Detecting SNP-Induced Structural Changes in RNA: Application to Disease Studies

Raheleh Salari, Stanford University, USA; Teresa Przytycka, National Center for Biotechnology Information, USA

10:00-10:25 Structural Requirements for RNA Elements

Rolf Backofen, University of Freiburg, Germany

10:30-10:55 Understanding SHAPE-directed RNA Secondary Structure Prediction

Zsuzsanna Sukosd, Aarhus University, Denmark; *Christine E. Heitsch*, Georgia Institute of Technology, USA

11:00-11:25 Efficient Algorithms to Explore the RNA Mutational Landscape

Jerome Waldispuhl, McGill University, Canada; Bonnie Berger and Srinivas Devadas, Massachusetts Institute of Technology, USA; Peter Clote, Boston College, USA; Yann Ponty, Ecole Polytechnique, France

Monday, June 18

MS7

Graph Algorithms

9:30 AM-12:00 PM

Room:Marion McCain 2102

Often graphs arising in applications have special structure, which can sometimes be used to design efficient algorithms for problems that are hard in general. In this minisymposium, we look at instances of main topics in graph algorithms including constructing graph models, characterizing and recognizing classes of graphs, finding efficient combinatorial algorithms and min-max theorems or, alternatively, NP-hardness results for optimization problems on classes of graphs, and extending the results to matroids.

Organizer: Kathie Cameron
Wilfrid Laurier University, Canada

9:30-9:55 Algorithms for Unipolar and Generalized Split Graphs

Elaine M. Eschen and Xiaoqiang Wang, West Virginia University, USA

10:00-10:25 Path Graphs, PR-trees, and Split Decomposition

Steven Chaplick, University of Toronto, Canada

10:30-10:55 Induced and Distance-k Matchings and Some Related Min-Max Relations

R Sritharan and Arthur Busch, University of Dayton, USA; Feodor F. Dragan, Kent State University, USA

11:00-11:25 Fixed Weight De Bruijn Graphs

Joe Sawada, University of Guelph, Canada

11:30-11:55 Recognizing Even-Cycle Matroids

Bertrand Guenin, University of Waterloo, Canada; Irene Pivotto, Simon Fraser University, Canada; Paul Wollan, University of Hamburg, Germany

Monday, June 18

CP1

Graph Theory - Part I

9:30 AM-11:10 AM

Room:Marion McCain 2190

Chair: Akhlaq Bhatti, National University of Computer and Emerging Sciences, Pakistan

9:30-9:50 Distingushing with Nordhaus Gaddum graphs

Karen Collins, Wesleyan University, USA; Ann N. Trenk, Wellesley College, USA

9:55-10:15 On Antimagic Vertex Labeling Of Hypergraphs

Akhlaq Bhatti and Muhammad Javaid, National University of Computer and Emerging Sciences, Pakistan

10:20-10:40 On Super (a,d)-Edge Antimagic Total Labeling of Subdivided Caterpillar

Muhammad Javaid and Akhlaq Bhatti, National University of Computer and Emerging Sciences, Pakistan

10:45-11:05 On Two Conjectures About Graceful Digraphs

Shivaraj Kumar and Suresh Hegde, National Institute of Technology Karnataka , Surathkal, India

Monday, June 18

CP2

Graphs and Games

9:30 AM-11:10 AM

Room:Marion McCain 2198

Chair: Silvia Heubach, California State University, Los Angeles, USA

9:30-9:50 Structure of Weighted Graphs with Forbidden Subdivision and Graph Sharing Games

Piotr Micek, Jagiellonian University, Poland; Adam Gagol, Maria Curie-Sklodowska University, Poland; Bartosz Walczak, Jagiellonian University, Poland

9:55-10:15 A Game on Zero Forcing Sets

Kara Greenfield and Alyssa Gottshall, Worcester Polytechnic Institute, USA; Steve Butler, University of California, Los Angeles, USA; Young Michael, Iowa State University, USA

10:20-10:40 A Generalization of the Nim and Wythoff Games

Silvia Heubach, California State University, Los Angeles, USA; Matthieu Dufour, University of Quebec, Montreal, Canada

10:45-11:05 Saving Sets of Vertices in the Firefighter Problem

Christopher Duffy and Gary MacGillivrary, University of Victoria, Canada

Lunch Break

12:00 PM-2:00 PM

Attendees on their own

Monday, June 18

IP2

On Sidorenko's Conjecture

2:00 PM-2:45 PM

Room:Marion McCain Ondaatje Auditorium

Chair: Jeannette Janssen, Dalhousie University, Canada

The Erdos-Simonovits-Sidorenko conjecture is well-known in combinatorics but it has equivalent formulations in analysis and probability theory. The shortest formulation is an integral inequality related to Mayer integrals in statistical mechanics and Feynman integrals in quantum field theory. We present new progress in the area. Part of the talk is based on joint results with J.L. Xiang Li. In particular we present a type of calculus (based on logarithmic functions) which can be used to prove inequalities between subgraph densities.

Balázs Szegedy
University of Toronto, Canada

Coffee Break

2:45 PM-3:15 PM

Room:Marion McCain Lobby

Monday, June 18

MS8

Combinatorics and Partially Ordered Sets - Part II of IV

3:15 PM-5:45 PM

Room:Henry Hicks 212

For Part 1 see MS1
For Part 3 see MS28

Organizer: William T. Trotter
Georgia Institute of Technology, USA

3:15-3:40 Dimension and Height for Posets with Planar Cover Graphs

Noah Streib, and William T. Trotter, Georgia Institute of Technology, USA

3:45-4:10 The Dimension of Posets with Planar Cover Graphs

Stefan Felsner, Technical University Berlin, Germany; William T. Trotter, Georgia Institute of Technology, USA; *Veit Wiechert*, TU Berlin, Germany

4:15-4:40 Q_2-Free Families in the Boolean Lattice

Lucas J. Kramer, Ryan R. Martin, and Michael Young, Iowa State University, USA

4:45-5:10 First-Fit Coloring of Ladder-Free Posets

Matt E. Smith and H. A. Kierstead, Arizona State University, USA

5:15-5:40 The Width of the Family of Maximum Antichains

Michał Lason and Piotr Micek, Jagiellonian University, Poland; Noah Streib, Georgia Institute of Technology, USA; William T. Trotter, Georgia Institute of Technology, USA; *Bartosz Walczak*, Jagiellonian University, Poland

Monday, June 18

MS9

Combinatorial and Tropical Algebraic Geometry

3:15 PM-5:45 PM

Room:Kenneth C. Rowe 1009

Combinatorial algebraic geometry uses algebraic geometric techniques to shed light on combinatorial questions. Tropical geometry is a technique for associating a polyhedral object to certain algebraic varieties. The purpose of this minisymposium is to explore the relation between the algebraic geometric and combinatorial properties of the relevant mathematical objects.

Organizer: Eric Katz
University of Waterloo, Canada

3:15-3:40 Log-concavity of Characteristic Polynomials and Tropical Intersection Theory
Eric Katz, University of Waterloo, Canada

3:45-4:10 Tropical Torelli Space and Tropical Period Mapping
Farbod Shokrieh, Georgia Institute of Technology, USA

4:15-4:40 Divisors on Tropical Varieties
Dustin Cartwright, Yale University, USA

4:45-5:10 Orbits of Projective Point Configurations
Alex Fink, North Carolina State University, USA; Andrew Berget, University of California, Davis, USA

5:15-5:40 Tropisms, Surfaces and the Puiseux Series
Danko Adrovic and Jan Verschelde, University of Illinois, Chicago, USA

Monday, June 18

MS10

Matchings with Preferences

3:15 PM-5:15 PM

Room:Kenneth C. Rowe 1011

Matching problems with preferences arise in numerous real-world settings, involving sets of agents, where each agent may express preferences over a subset of the other agents. Examples include matching medical residents to hospital programs, college students to dormitories, papers to reviewers, and kidneys to patients. The goal is to find a matching of the agents that takes their preferences into account in an appropriate way. This session will survey some of the current work and describe open problems in this area.

Organizer: Christine T. Cheng
University of Wisconsin, Milwaukee, USA

3:15-3:40 Globally Fair Stable Matchings
Christine T. Cheng, University of Wisconsin, Milwaukee, USA

3:45-4:10 Stable Matching as a Heuristic for Cost-Based Matching Problems
Brian C. Dean and John Dabney, Clemson University, USA

4:15-4:40 A Unified Approach to Equivalence Results in Object Allocation
Jay Sethuraman and Thiam Lee, Columbia University, USA

4:45-5:10 Some Open Problems in Matchings with Preferences
David F. Manlove, University of Glasgow, Scotland, UK

Monday, June 18

MS11

Extremal Graph Theory II

3:15 PM-5:45 PM

Room:Henry Hicks 217

Extremal graph theory is one of the most important and best developed areas of graph theory. It investigates the extrema of the parameters of graphs with given properties. In the past years extremal graph theory is characterized by an increased use of complex analytical and algebraic techniques, together with further development of classical combinatorial methods.

Organizer: Vladimir Nikiforov
University of Memphis, USA

3:15-3:40 Homeomorphically Irreducible Spanning Trees
Guantao Chen and Songling Shan, Georgia State University, USA

3:45-4:10 Multipartite Version of the Alon-Yuster Theorem
Ryan R. Martin, Iowa State University, USA; Jozef Skokan, London School of Economics, United Kingdom

4:15-4:40 On Independent Sets in Steiner Systems
Jacques Verstraete, University of California, San Diego, USA

4:45-5:10 Decompositions of (Hyper) Graphs into Cliques or Bicliques
Sebastian Cioaba, University of Delaware, USA

5:15-5:40 An Erdos-Stone Theorem for Hypergraphs
Vladimir Nikiforov, University of Memphis, USA

Monday, June 18

MS12

Colourings and Homomorphisms

3:15 PM-5:45 PM

Room:Marion McCain 2017

Graph colouring problems can usually be formulated in terms of a homomorphism model. In this sense, homomorphisms generalize colourings. We present talks on five different aspects of colourings and homomorphisms.

Organizer: Gary Macgillivray
University of Victoria, Canada

3:15-3:40 Distinguishing Edge Colourings of Graphs

Karen Seyffarth, University of Calgary, Canada; Richard Brewster, Thompson Rivers University, Canada; Stacey Lamont, University of Calgary, Canada

3:45-4:10 Obstructions to Homomorphisms Involving the Graft Extension

Jacobus Swarts, Vancouver Island University, Canada; Gary Macgillivray, University of Victoria, Canada

4:15-4:40 Kempe-equivalence Classes for 3-edge-colored Cubic Graphs

Ruth Haas and Sarah-Marie Belcastro, Smith College, USA

4:45-5:10 Graph Homomorphisms: Mixing and Homotopies

Richard Brewster, Thompson Rivers University, Canada; Jon Noel, McGill University, Canada

5:15-5:40 Defective Colorings and Colorings that Avoid Large Monochromatic Components

John Gimbel, University of Alaska, Fairbanks, USA

Monday, June 18

MS13

Sequence Analysis

3:15 PM-5:45 PM

Room:Marion McCain 2021

We will explore applications of algorithms for sequence analysis in genomics. High through sequencing applications will be of particular interest.

Organizer: Cenk Sahinalp
Simon Fraser University, Canada

3:15-3:40 De Bruijn Graph Based Genome Assembly for Single Cells

Hamidreza Chitsaz, Wayne State University, USA

3:45-4:10 Combinatorial Designs for Sequencing Pooled Samples

Wenhui Wang, Xiaolin Yin, Matthew Hayes, Yoon Soo Pyon, and *Jing Li*, Case Western Reserve University, USA

4:15-4:40 TBD on Genome Assembly Algorithms

Max Alekseyev, University of South Carolina, USA

4:45-5:10 Quantifying Uniformity of Mapped Reads

Valerie Hower, University of Miami, USA; Richard Starfield, Adam Roberts, and Lior Pachter, University of California, Berkeley, USA

5:15-5:40 Spaced Seeds and their Application in Next Generation Sequencing

Bin Ma, University of Waterloo, Canada

Monday, June 18

MS14

Graph Pebbling

3:15 PM-5:45 PM

Room:Marion McCain 2102

The area of graph pebbling is over 20 years old and was born from fundamental research in number theory. Since then it has also been used to prove results in combinatorial group theory. The subject is rapidly growing as more researchers become aware of its allure, challenging problems, and potential applicability. In this minisymposium we will discuss a wide range of interesting variations of pebbling, using tools from algebra, probability, network optimization, and algorithms. Based on these newly developed methods of attack, we will also share new results and conjectures.

Organizer: Glenn Hurlbert
Arizona State University, USA

Organizer: Carl Yerger
Davidson College, USA

3:15-3:40 Graph Pebbling: Past, Present, Future

Glenn Hurlbert, Arizona State University, USA

3:45-4:10 Pebbling Graphs of Diameter Three and Four

Carl Yerger, Davidson College, USA; Noah Streib and Luke Postle, Georgia Institute of Technology, USA

4:15-4:40 Complexity of Diameter Two Graph Pebbling

Charles Cusack, Timothy Lewis, and Daniel Simpson, Hope College, USA; Samuel Taggart, Oberlin College, USA

4:45-5:10 Graph Rubbling

Nandor Sieben, Northern Arizona University, USA

5:15-5:40 The Pebbling Threshold of Graph Sequences

Airat Bekmetjev, Hope College, USA

Monday, June 18

CP3

Graph Theory - Part II

3:15 PM-5:45 PM

Room:Marion McCain 2190

Chair: Terry McKee, Wright State University, USA

3:15-3:35 Dual-Chordal and Strongly Dual-Chordal Graphs

Terry McKee, Wright State University, USA

3:40-4:00 On the 2-Edge Clique Cover Numbers of Graphs

Jung Yeun Lee, National Institute of Mathematical Science, Korea; Suh-Ryung Kim, Seoul National University, Korea; Boram Park, Rutgers University, USA; Yoshio Sano, National Institute of Informatics, Japan

4:05-4:25 2-Switches and Isomorphism Classes

Michael Barrus, Black Hills State University, USA

4:30-4:50 Well-Covered Graphs Without C_4,C_5,C_6

David Tankus and Vadim E. Levit, Ariel University Center of Samaria, Israel

4:55-5:15 The Number of Spanning Trees in Self-Similar Graphs

Francesc Comellas, Universitat Politecnica de Catalunya, Spain; Zhongzhi Zhang, Fudan University, China

5:20-5:40 Another Proof for Lovász's Cathedral Theorem

Nanao Kita, Keio University, Japan

Monday, June 18

CP4

Miscellaneous

3:15 PM-5:20 PM

Room:Marion McCain 2198

Chair: Andrew Vince, University of Florida, USA

3:15-3:35 Binary Sequences, Fractals, and Primes

Andrew Vince, University of Florida, USA; Michael Barnsley, Australian National University, Australia

3:40-4:00 Fixed Points Of a Fuzzy Semantics Function

Fairouz Tchier, King Saoud University, Saudia Arabia

4:05-4:25 On the Structure of Some Groups Containing $L_2(13)\ wrl_2(17)$

Basmah Shafee, Umm Al-Qura University, Iraq

4:30-4:50 Application of New Variational Method Using Hamiltonian for Nonlinear Oscillators with Discontinuities

Waseem A. Khan, CIIT, Pakistan

4:55-5:15 A Comparison of Conventional and Fuzzy Methods in Performance Appraisal Process

Idowu A. Osinuga, Federal University of Agriculture, Abeokuta, Nig; Adegboyega Adekoya, Olabisi Onabanjo University, Ago-Iwoye, Nigeria

Intermission

5:45 PM-6:00 PM

Monday, June 18

Dénes König Prize Lecture

The Finite Field Kakeya Problem

6:00 PM-6:45 PM

Room:Marion McCain Ondaatje Auditorium

The finite field Kakeya problem asks what is the size of the smallest set in Fn, where F is a finite field, that contains a line in every direction. In 1996, Wolff conjectured that such sets must have size >c|F|n, with c a constant depending only on n. In this talk I will describe the proof of this conjecture, which uses the Polynomial Method, as well as connections to other problems in Mathematics and Computer Science.

Zeev Dvir

Princeton University, USA

Welcome Reception

7:00 PM-9:00 PM

Room:Sculpture Court

Tuesday, June 19

Registration

7:30 AM-4:00 PM

Room:Marion McCain Lobby

Remarks

8:10 AM-8:15 AM

Room:Marion McCain Ondaatje Auditorium

IP3

Forcing Large Transitive Subtournamets

8:15 AM-9:00 AM

Room:Marion McCain Ondaatje Auditorium

Chair: Mike Molloy, University of Toronto, Canada

The Erdos Hajnal Conjecture states roughly that a graph with some induced subgraph excluded has a large clique or a large stable set. A similar statement can be formulated for tournaments (a tournament is an orientation of a complete graph), replacing cliques and stable sets by transitive subtournaments; and the two conjectures turn out to be equivalent. This talk will survey a number of recent results related to the latter conjecture. In particular, we will discuss a new infinite class of tournaments excluding which forces large transitive subtournaments; to the best of our knowledge this is the first such class not obtained by the so-called substitution operation.

Maria Chudnovsky
Columbia University, USA

Coffee Break

9:00 AM-9:30 AM

Room:Marion McCain Lobby

Tuesday, June 19

MS15

Probabilistic Combinatorics - Part I of II

9:30 AM-12:00 PM

Room:Henry Hicks 212

For Part 2 see MS22

Probabilistic Combinatorics began with Paul Erdos, with what is often called Erdos Magic. To prove the existence of a combinatorial object an appropriate random object is defined and one needs only to show that the probability that the random object has the desired properties is positive. Very closely aligned is the study of random objects per se, most notable the Erdos-Renyi random graph G(n,p). Of particular interest is percolation phenomenon, as the parameter changes we study closely the region in which the object undergoes a macroscopic change

Organizer: Joel Spencer
Courant Institute of Mathematical Sciences, New York University, USA

9:30-9:55 Phase Transition in Random Graph Processes through the Lens of PDE and Singularity Analysis

Mihyun Kang, Technische Universität, Graz, Austria

10:00-10:25 Achlioptas Processes: Recent Results and New Problems

Will Perkins, Georgia Institute of Technology, USA; Mihyun Kang, Technische Universität, Graz, Austria; Joel Spencer, Courant Institute of Mathematical Sciences, New York University, USA

10:30-10:55 The Fractal Nature of the Abelian Sandpile

Wesley Pegden, Courant Institute of Mathematical Sciences, USA; Charles Smart, Massachusetts Institute of Technology, USA; Lionel Levine, Cornell University, USA

11:00-11:25 Hunting the k-SAT Threshold

Konstantinos Panagiotou, ETH Zürich, Switzerland; Amin Coja-Oghlan, University of Warwick, United Kingdom

11:30-11:55 Self-similarity of Graphs

Choongbum Lee, University of California, Los Angeles, USA; *Po-Shen Loh*, Carnegie Mellon University, USA; Benny Sudakov, University of California, Los Angeles, USA

Tuesday, June 19

MS16

Algebraic Combinatorics - Part II of III

9:30 AM-12:00 PM

Room:Kenneth C. Rowe 1009

For Part 1 see MS2
For Part 3 see MS23

This minisymposium focuses on combinatorial problems and results that are closely connected with topics in abstract algebra, including representation theory, commutative algebra, and algebraic geometry.

Organizer: Tom Roby
University of Connecticut and Massachusetts Institute of Technology, USA

Organizer: Richard Stanley
Massachusetts Institute of Technology, USA

9:30-9:55 Rational Noncrossing Partitions

Drew Armstrong, University of Miami, USA; Nathan Williams, University of Minnesota, USA

10:00-10:25 Separation Probabilities for Products of Permutations

Olivier Bernardi, Massachusetts Institute of Technology, USA; Rosena Du, East China Normal University, China; Alejandro Morales and Richard Stanley, Massachusetts Institute of Technology, USA

10:30-10:55 Bijections for Lattice Paths Between Two Boundaries

Sergi Elizalde, Dartmouth College, USA; Martin Rubey, University of Hannover, Germany

11:00-11:25 The Möbius Function of Generalized Subword Order

Bruce Sagan, Michigan State University and the National Science Foundation, USA

11:30-11:55 Tableaux and Plane Partitions of Truncated Shapes

Greta Panova, University of California, Los Angeles, USA

Tuesday, June 19

MS17

Graphs on Surfaces - Part I of II

9:30 AM-12:00 PM

Room:Kenneth C. Rowe 1011

For Part 2 see MS38

Speakers in this minisymposium will present their recent work in topological graph theory. The topics range from considerations of planar graphs, to graphs on surfaces of higher genus, and properties of random maps.

Organizer: Bojan Mohar

Simon Fraser University, Canada

9:30-9:55 Genus Distribution of Path-like Graphs: Transfer Matrix Method

Bojan Mohar, Simon Fraser University, Canada

10:00-10:25 Closed 2-cell Embeddings Under Partial Duality

Mark Ellingham, Vanderbilt University, USA; Xiaoya Zha, Middle Tennessee State University, USA

10:30-10:55 Polychromatic Coloring of Graphs on Surfaces

Atsuhiro Nakamoto, Yokohama National University, Japan

11:00-11:25 Obstructions for Embeddings of Graphs in Surfaces

Bojan Mohar, and *Petr Skoda*, Simon Fraser University, Canada

11:30-11:55 Biembedding Designs and Minimum Genus Embeddings

Tom McCourt, University of Bristol, United Kingdom

Tuesday, June 19

MS18

Distance in Graphs Part I of II: Distance Labelings and Variations of the Channel Assignment Problem

9:30 AM-12:00 PM

Room:Henry Hicks 217

For Part 2 see MS24

"Distance" in graphs plays a broad role in graph theory research. This mini-symposium aims to cover recent advances on distance labelings (Part I) and metric graph theory (Part II). Part I: Motivated by the channel assignment problem, distance labelings are a type of graph coloring that restricts the labels (colors) that can be assigned to vertices based on the separation (distance) of the vertices in the graph. For instance, the widely studied distance two labeling restricts the allowed labels for vertices within distance two. Due to different aspects and requirements of the channels, variations arose. This section covers recent results on distance two and three labelings, and backbone colorings.

Organizer: Daphne D. Liu

California State University, Los Angeles, USA

9:30-9:55 The Δ^2 Conjecture for Graph Labellings with Separation Conditions

Jerry Griggs, University of South Carolina, USA

10:00-10:25 Distance Three Labellings of Graphs

Sanmaing Zhou, University of Melbourne, Australia

10:30-10:55 L(2,1,1)-Labeling Is NP-complete for Trees

Petr A. Golovach, Durham University, United Kingdom; *Bernard Lidicky*, University of Illinois, Urbana, USA; Daniel Paulusma, Durham University, United Kingdom

continued in next column

11:00-11:25 Backbone Colorings of Graphs with Large Girths

Yuehua Bu, Zhejiang Normal University, China; *Daphne D. Liu*, California State University, Los Angeles, USA; Xuding Zhu, Zhejiang Normal University, China

11:30-11:55 Backbone Coloring: Tree Backbone in Planar Graphs

Victor Campos, Unversidade Federal do Ceara, Brazil; *Frederic Havet,* INRIA, France; Rudini Sampaio and Ana Shirley Ferreira Silva, Universidade Federal do Ceara, Brazil

Tuesday, June 19

MS19

Design Theory - Part II of IV

9:30 AM-12:00 PM

Room:Marion McCain 2017

For Part 1 see MS5
For Part 3 see MS32

This session will focus on combinatorial designs and related concepts.

Organizer: David Pike
Memorial University, Newfoundland, Canada

9:30-9:55 Decompositions of Complete Graphs into Cycles and Related Problems
Darryn Bryant, University of Queensland, Australia

10:00-10:25 Broadcast Systems
Matthew Walsh, Indiana University and Purdue University, USA

10:30-10:55 Cycle Extension Property in BIBD Block-Intersection Graphs
Atif Abueida, The University of Dayton, USA; David Pike, Memorial University, Newfoundland, Canada

11:00-11:25 Friendship 3-hypergraphs
Ben Li, University of Manitoba, Canada

11:30-11:55 Schröder Quasigroups and Related Combinatorial Designs
Frank Bennett, Mount Saint Vincent University, Canada

Tuesday, June 19

MS20

Biological Self-Assembly

9:30 AM-12:00 PM

Room:Marion McCain 2021

Self-assembly is a process by which collections of independent components under appropriate conditions spontaneously assemble into organized structures or machines. Self-assembly is ubiquitous in biology, where complexes of molecules, cells, or even whole organisms are constantly assembled and disassembled to perform various tasks. Biological self-assembly has inspired the use of similar principles and materials in synthetic biology and nanotechnology. A rich mathematical literature has arise from self-assembly studies, directed at understanding how self-assembly functions in nature, what design principles allow it to work effectively, and how these principles can be harnessed for practical applications in artificial systems.

Organizer: Russell Schwartz
Carnegie Mellon University, USA

9:30-9:55 Inferring Physical Parameters and Assembly Pathways from Indirect Measures of Viral Self-assembly
Russell Schwartz, Lu Xie, Gregory Smith, and Xian Feng, Carnegie Mellon University, USA

10:00-10:25 Graph Theoretical Design Strategies for DNA Self-assembly
Joanna Ellis-Monaghan, Saint Michael's College, USA

10:30-10:55 Specification and Optimization of Synthetic Multi-cell Behaviors
Eric Klavins, University of Washington, USA

11:00-11:25 Fluid Models for Self-organized Microtubule Arrays
Ezgi Eren and Natarajan Gautam, Texas A&M University, USA; Ram Dixit, Washington Univeristy, St. Louis, USA

11:30-11:55 Modelling the Co-operative Roles of Genomic RNA during Virus Assembly
Reidun Twarock, Eric Dykeman, and Nick Grayson, University of York, United Kingdom; Peter Stockley, University of Leeds, United Kingdom

Tuesday, June 19

MS21

König-Egerváry Graphs and Their Relatives

9:30 AM-11:30 AM

Room:Marion McCain 2102

König-Egerváry graphs were introduced a generation ago as a generalization of bipartite graphs. Characterizations were given by the originators, Deming and Sterboul (both 1979), and by Lovász (1983), among others. These graphs have also attracted more recent attention, due in part to their intimate connections, simultaneously, with the matching, vertex covering, and stability theory of graphs. Computer-generated conjectures have been confirmed, new characterizations have been established, and ties with other central graph classes have been cinched. This session will briefly survey the basics, highlight the newest results, and culminate with a presentation by a true pioneer of matching theory, combinatorial optimization, and polyhedral combinatorics.

Organizer: Mark Kayll
University of Montana, USA

Organizer: Craig E. Larson
Virginia Commonwealth University, USA

9:30-9:55 König-Egerváry Graphs: Introduction and a Warm-up Result
Mark Kayll, University of Montana, USA

10:00-10:25 Fractional Independence Number and König-Egerváry Graphs
Craig E. Larson, Virginia Commonwealth University, USA

10:30-10:55 Independent Sets in almost König-Egerváry Graphs
Vadim E. Levit, Ariel University Center of Samaria, Israel; Eugen Mandrescu, Holon Institute of Technology, Israel

11:00-11:25 Egerváry LPs and Fractional Vertex Packing
Jack Edmonds

Tuesday, June 19

CP5

Ordered Sets

9:30 AM-12:00 PM

Room:Marion McCain 2190

Chair: Clifford D. Smyth, University of North Carolina at Greensboro, USA

9:30-9:50 The Largest Size Versus the Largest Weight of Families of Sets Without a Poset *P*

Jerry Griggs, University of South Carolina, USA; *Wei-Tian Li*, Academia Sinica, Taiwan

9:55-10:15 The Bkr Inequality on Finite Distributive Lattices

Clifford D. Smyth, University of North Carolina at Greensboro, USA

10:20-10:40 Order Dimension and Coloring of Planar Point Sets

Jonathan E. Beagley, George Mason University, USA

10:45-11:05 Searching Algorithms in Partially Ordered Set

Abdurashid R. Mamadolimov, Malaysian Institute of Microelectronic Systems, Malaysia

11:10-11:30 Universal Cycles for Weak Orders and a Problem of Knuth

Victoria Horan and Glenn Hurlbert, Arizona State University, USA

11:35-11:55 Zeta Polynomials for Shellable Posets and Their Applications

Joon Yop Lee, ASARC,KAIST, Korea

Tuesday, June 19

CP6

Graph Theory - Part III

9:30 AM-12:00 PM

Room:Marion McCain 2198

Chair: Gary Macgillivray, University of Victoria, Canada

9:30-9:50 On Signed Star Domination and Domatic Numbers of Complete Multipartite Graphs

Wu-Hsiung Lin, Chiuyuan Chen, Well Y. Chiu, and Allen Y. Wang, National Chiao Tung University, Taiwan

9:55-10:15 Decompositions of Complete Multipartite Graphs into Gregarious Long Cycles

Jeongmi Park and Jung Rae Cho, Pusan National University, Busan (Pusan), Republic of Korea; Yoshio Sano, National Institute of Informatics, Japan

10:20-10:40 Some Unsolved Problems on Cycles

Chunhui Lai, Zhangzhou Teachers College and Academy of Mathematics and Systems Science, China; Mingjing Liu, Zhangzhou Normal University, People's Republic of China

10:45-11:05 On the Locating-Chromatic Number of a Corona Product of Two Graphs

Edy T. Baskoro and Ira Purwasih, Bandung Institute of Technology, Indonesia

11:10-11:30 A New Upper Bound for the Broadcast Domination Number of a Graph

Laura E. Teshima and Christina Mynhardt, University of Victoria, Canada

11:35-11:55 On The Structure Of The γ-Graph Of A Tree

Michelle Edwards and Gary Macgillivray, University of Victoria, Canada

Lunch Break

12:00 PM-2:00 PM

Attendees on their own

Tuesday, June 19

IP4

Adding and Counting

2:00 PM-2:45 PM

Room:Marion McCain Ondaatje Auditorium

Chair: Lenore Cowen, Tufts University, USA

In mathematics, the stuff of partitions seems like mere child's play. The speaker will explain how the simple task of adding and counting has fascinated many of the world's leading mathematicians: Euler, Ramanujan, Hardy, Rademacher, Dyson, to name a few. And as is typical in number theory, many of the most fundamental (and simple to state) questions have remained open. In 2010, the speaker, with the support of the American Institute for Mathematics and the National Science Foundation, assembled an international team of researchers to attack some of these problems. Come hear Professor Ono speak about their findings: new theories which solve some of the famous old questions.

Ken Ono

Emory University, USA

Coffee Break

2:45 PM-3:15 PM

Room:Marion McCain Lobby

Tuesday, June 19

MS22

Probabilistic Combinatorics- Part II of II

3:15 PM-5:15 PM

Room:Henry Hicks 212

For Part 1 see MS15

Probabilistic Combinatorics began with Paul Erdos, with what is often called Erdos Magic. To prove the existence of a combinatorial object an appropriate random object is defined and one needs only to show that the probability that the random object has the desired properties is positive. Very closely aligned is the study of random objects per se, most notable the Erdos-Renyi random graph G(n,p). Of particular interest is percolation phenomenon, as the parameter changes we study closely the region in which the object undergoes a macroscopic change

Organizer: Joel Spencer
Courant Institute of Mathematical Sciences, New York University, USA

3:15-3:40 Connectivity and Giant Components in Stochastic Kronecker Graphs
Mary Radcliffe, University of California, San Diego, USA

3:45-4:10 Phase Transition in Random Integer Programs
Karthekeyan Chandrasekaran, Georgia Institute of Technology, USA

4:15-4:40 The Power and Weakness of Two Choices: Unbalanced Allocations
Amanda Redlich, Rutgers University, USA

4:45-5:10 The Game Chromatic Number of Sparse Random Graphs
Simi Haber, Tel Aviv University, Israel; Alan Frieze and Mikhail Lavrov, Carnegie Mellon University, USA

Tuesday, June 19

MS23

Algebraic Combinatorics - Part III of III

3:15 PM-5:45 PM

Room:Kenneth C. Rowe 1009

For Part 2 see MS16

This minisymposium focuses on combinatorial problems and results that are closely connected with topics in abstract algebra, including representation theory, commutative algebra, and algebraic geometry.

Organizer: Tom Roby
University of Connecticut and Massachusetts Institute of Technology, USA

Organizer: Richard Stanley
Massachusetts Institute of Technology, USA

3:15-3:40 Perturbation of Transportation Polytopes
Fu Liu, University of California, Davis, USA

3:45-4:10 Orientations, Semiorders, Arrangements, and Parking Functions
David Perkinson, Reed College, USA

4:15-4:40 Symmetric Chain Decomposition for Necklace Posets and Relation to Cyclic Crystals
Patricia L. Hersh, North Carolina State University, USA

4:45-5:10 Monotone Hurwitz Numbers: Polynomiality and Explicit Forms
Jonathan I. Novak, Massachusetts Institute of Technology, USA

Tuesday, June 19

MS24

Distance in Graphs Part II of II: Distance-like Parameters and Graph Structure

3:15 PM-5:45 PM

Room:Kenneth C. Rowe 1011

For Part 1 see MS18

“Distance” in graphs plays a broad role in graph theory research. This mini-symposium aims to cover recent advances on distance labelings (Part I) and topics in metric graph theory (Part II). Part II: Many aspects of a graph are related to or even determined by some distance-like parameters, say the number of walks of a fixed length or some fixed lengths between vertices, the Wiener index, the Gromov hyperbolicity, the intersection array of distance regular graphs, etc. Some famous early results illustrating this line of connections include the Friendship Theorem, the Hoffman-Singleton Theorem and the Four Point Condition characterization of tree metrics.

Organizer: Yaokun Wu
Shanghai Jiaotong University, China

Organizer: Yaokun Wu
Shanghai Jiaotong University, China

Organizer: Daphne D. Liu
California State University, Los Angeles, USA

3:15-3:40 Distances Between Evolutionary Trees
Stefan Gruenewald, PICB, China

3:45-4:10 Greedy Trees and the Extremal Distances
Nina Schmuck, Technische Universität, Graz, Austria; Stephan Wagner, Stellenbosch University, South Africa; *Hua Wang*, Georgia Southern University, USA

4:15-4:40 Switchings, Extensions, and Reductions in Central Digraphs
Andre Kundgen, California State University, San Marcos, USA; Gregor Leander and Carsten Thomassen, Technical University of Denmark, Denmark

4:45-5:10 On *t*-Path Closed Graphs
Jacobus Koolen, Korea Advanced Institute of Science and Technology, Korea; Hwang Rae Lee, POSTECH, Korea; Stefan Gruenewald, PICB, China

5:15-5:40 Walks and Homomorphisms of Digraphs
Yaokun Wu, Shanghai Jiaotong University, China

Tuesday, June 19

MS25

Structural Graph Theory

3:15 PM-5:45 PM

Room:Henry Hicks 217

In this minisymposium we consider graph classes determined by certain graph properties. Efficient recognition algorithms and/or structural properties of such graph classes will be discussed.

Organizer: Ortrud R. Oellermann
The University of Winnipeg, Canada

Organizer: Andreas Brandstädt
University of Rostock, Germany

3:15-3:40 Atomic Structure, Hyperbolicity, and Recognition of AT-free Graphs with no Induced 4-cycles

Derek Corneil, University of Toronto, Canada; *Juraj Stacho*, University of Warwick, United Kingdom

3:45-4:10 Polygon Numbers of Circle Graphs

Lorna Stewart and Richard Valenzano, University of Alberta, Canada

4:15-4:40 Title Not Available at TIme of Publication

Andreas Brandstädt, University of Rostock, Germany

4:45-5:10 Convexity and Graph Classes

Ortrud R. Oellermann, The University of Winnipeg, Canada

5:15-5:40 Unit Interval Graphs of Mixed Intervals

Ann N. Trenk, Alan Shuchat, Randy Shull, and Lee West, Wellesley College, USA

Tuesday, June 19

MS26

Graphs and Groups - Part I of II

3:15 PM-5:45 PM

Room:Marion McCain 2017

For Part 2 see MS39

The automorphism group contains useful information about a graph. Such groups show up both as tools for examining graphs, and as objects of study on their own. This mini-symposium will focus on various topics involving graphs and groups.

Organizer: Debra L. Boutin
Hamilton College, USA

3:15-3:40 The Cost of 2-Distinguishing Cartesian Powers

Debra L. Boutin, Hamilton College, USA

3:45-4:10 Decomposing Hypergraphs on Finite Fields

Shonda Gosselin, University of Winnipeg, Canada

4:15-4:40 Finite Subgraphs of d-Distinguishable, Locally Finite Graphs

Mark E. Watkins and Simon Smith, Syracuse University, USA

4:45-5:10 Infinite Motion and Distinguishing Number 2

Thomas Tucker, Colgate University, USA; Wilfriied Imrich, University of Leoben, Austria; Simon Smith and Mark E. Watkins, Syracuse University, USA

5:15-5:40 Groups That Are Transitive on All Partitions of a Finite Set

Ted Dobson, Mississippi State University, USA; Aleksander Malnic, University of Ljubljana, Slovenia

Tuesday, June 19

MS27

Algorithms to Study Biological Evolution: Theory and Practice

3:15 PM-5:45 PM

Room:Marion McCain 2021

This minisymposium focuses on computational and algorithmic problems in biological evolution. While some of these are classical questions, a focus of current work is on making practical algorithms for very large-scale data. Talks will range from traditional problems, such as evolutionary tree reconstruction from DNA sequences of currently living species, to more recent problems, such as integrating a number of different inferred evolutionary trees for overlapping sets of species into a single tree, or studying large-scale genome rearrangements and using information about these events as a source of signal in the tree reconstruction process.

Organizer: Dan Brown
University of Waterloo, Canada

3:15-3:40 Fast Algorithms for Phylogenetic Reconstruction

Dan Brown, University of Waterloo, Canada

3:45-4:10 Tree Compatibility, Character Compatibility, and Graph Triangulation

David F. Fernandez-Baca and Sudheer Vakati, Iowa State University, USA

4:15-4:40 Gene Family Evolution by Duplication and Loss - Reconciliation and Species Tree Inference

Nadia S. El-Mabrouk, Université de Montréal, Canada

4:45-5:10 Aspects of Fractionation; A Fundamental Evolutionary Process

David Sankoff and Chunfang Zheng, University of Ottawa, Canada

5:15-5:40 Reconstruction of Certain Phylogenetic Networks from the Tree-Additive Distances Between Their Leaves

Stephen J. Willson, Iowa State University, USA

Tuesday, June 19

CP7

Extremal Graph Theory

3:15 PM-5:20 PM

Room:Marion McCain 2102

Chair: Stanislaw P. Radziszowski, Rochester Institute of Technology, USA

3:15-3:35 Embedding Spanning Bipartite Graphs of Small Bandwidth

Andrew Treglown, Charles University, Czech Republic; Fiachra Knox, University of Birmingham, United Kingdom

3:40-4:00 On the Density of Nearly Regular Graphs with a Good Edge-Labelling

Abbas Mehrabian, University of Waterloo, Canada

4:05-4:25 Bounds on Shannon Capacity and Ramsey Numbers from Product of Graphs

Xiaodong Xu, Guangxi Academy of Sciences, Guangxi, China; *Stanislaw P. Radziszowski*, Rochester Institute of Technology, USA

4:30-4:50 The Edge Density of Critical Digraphs

Richard Hoshino and Ken-Ichi Kawarabayashi, National Institute of Informatics, Japan

4:55-5:15 Colorings of Uniform Hypergraphs with Large Girth

Dmitry A. Shabanov, Moscow State University, Russia; Andrei Kapavskii, Moscow Institute of Physics and Technology, Russia

Tuesday, June 19

CP8

Matroids and Matrices

3:15 PM-5:20 PM

Room:Marion McCain 2190

Chair: Richard P. Anstee, University of British Columbia, Canada

3:15-3:35 Intertwining Connectivities in Matroids Representable over a Finite Field

Tony Huynh, KAIST, Korea; Bert Gerards, CWI, Amsterdam, Netherlands; Stefan van Zwam, Princeton University, USA

3:40-4:00 The Supertail of a Subspace Partition

Esmeralda L. Nastase, Xavier University, USA; Olof Heden, KTH Stockholm, Sweden; Julianne Lehmann, University of Bremen, Germany; Papa Sissokho, Illinois State University, USA

4:05-4:25 The Minimum Rank of Universal Adjacency Matrices

Shahla Nasserasr, Bahman Ahmadi, Fatemeh Alinaghipour, and Shaun M. Fallat, University of Regina, Canada; Yi-Zheng Fan, Anhui University, China; Karen Meagher, University of Regina, Canada

4:30-4:50 Rank-Width and Well-Quasi-Ordering of Skew-Symmetric Or Symmetric Matrices

Sang-Il Oum, KAIST, Korea

4:55-5:15 Forbidden Submatrices

Richard P. Anstee, and Ruiyuan Chen, University of British Columbia, Canada; Attila Sali, Alfréd Rényi Institute of Mathematics, Hungary

Tuesday, June 19

CP9

Discrete Algorithms

3:15 PM-4:55 PM

Room:Marion McCain 2198

Chair: Sheldon Jacobson, University of Illinois, USA

3:15-3:35 A Branch, Bound, and Remember Algorithm for the Simple Assembly Line Balancing Problem

Sheldon H. Jacobson, University of Illinois at Urbana-Champaign, USA; Edward Sewell, Southern Illinois University, Edwardsville, USA

3:40-4:00 An Approximation Algorithm for the Multilevel Bottleneck Assignment Problem

Yuusaku Kamura and Mario Nakamori, Tokyo A&T University, Japan

4:05-4:25 Greedy Is Good to Approximate Minimum Rainbow Subgraphs

Ingo Schiermeyer, Technische Universitaet Bergakademie Freiberg, Germany

4:30-4:50 Applications of the Traveling Salesman Problem and Perfect B-Matching for Finding Genomic Medians

Maryam Haghighi and Sylvia Boyd, University of Ottawa, Canada

Intermission

5:45 PM-6:00 PM

SIAG/DM Business Meeting

6:00 PM-7:00 PM

Room:Chase 119

Complimentary refreshments will be served.

Wednesday, June 20

Registration
7:30 AM-4:00 PM

Room:Marion McCain Lobby

Remarks
8:10 AM-8:15 AM

Room:Marion McCain Ondaatje Auditorium

IP5
Coloring 3-colorable Graphs; Graph Theory Finally Strikes Back!
8:15 AM-9:00 AM

Room:Marion McCain Ondaatje Auditorium

Chair: Daniel Kral, Charles University, Czech Republic

We consider the problem of coloring a 3-colorable graph in polynomial time using as few colors as possible. Starting with Wigderson in 1982 ($O(n^{1/2})$ colors), Blum in 1990 came with the first polynomial improvements ($O(n^{3/8}$ colors). His improvement is based on graph theoretical approach. Karger, Motwani, Sudan in 1994 is the first to use semi-definite programming (SDP) to give improvement, and then Karger and Blum in 1997 combines Blum's method with the SDP improvement to show that $O(n^{0.2142})$ colors suffices.

Since then, the only improvements in semi-definite programming have been made (Arora, Chlamtac, and Charikar in 2006 ($O(n^{0.2111})$ colors), and Chlamtac in 2007 ($O(n^{0.2072})$ colors)). We present the first improvement on the graph theory side since Blum in 1990. With a purely graph theoretical approach, we get down to $O(n^{4/11})$ colors (over Blum's $O(n^{3/8})$ colors). Combining it with SDP, we get down to $O(n^{0.2038})$ colors. Joint work with Mikkel Thorup (AT&T Research)

Ken-ichi Kawarabayashi
National Institute of Informatics, Japan

Wednesday, June 20

Coffee Break
9:00 AM-9:30 AM

Room:Marion McCain Lobby

MS28
Combinatorics and Partially Ordered Sets - Part III of IV
9:30 AM-12:00 PM

Room:Henry Hicks 212

For Part 2 see MS8
For Part 4 see MS35

Organizer: William T. Trotter
Georgia Institute of Technology, USA

9:30-9:55 Poset-free Families of Sets
Jerry Griggs, University of South Carolina, USA; Wei-Tian Li, Academia Sinica, Taiwan; Linyuan Lu, University of South Carolina, USA

10:00-10:25 Linear Discrepancy of Partially Ordered Sets
Jeong Ok Choi, Gwangju Institute of Science and Technology, Korea; Kevin Milans, University of South Carolina, USA; *Douglas B. West*, University of Illinois, Urbana, USA

10:30-10:55 Diamond-Free Collections of Subspaces
Shahriar Shahriari, Pomona College, USA

11:00-11:25 Quotients of the Boolean Lattice by Wreath Products
Dwight Duffus, and Kyle Thayer, Emory University, USA

11:30-11:55 Chopping Celery and the Lattice of Integer Partitions
Bill Sands, and Thao Do, University of Calgary, Canada

Wednesday, June 20

MS29
Combinatorial Polynomials
9:30 AM-12:00 PM

Room:Kenneth C. Rowe 1009

Polynomials arise in combinatorics various contexts, both pure and applied. This minisymposium will concentrate the links to graphs, simplicial complexes, greedoids, and other discrete structures, with particular focus on the analytical and algebraic properties of combinatorial polynomials.

Organizer: Jason Brown
Dalhousie University, Canada

Organizer: Bruce Sagan
Michigan State University and the National Science Foundation, USA

9:30-9:55 Roots of Combinatorial Polynomials
Jason Brown, Dalhousie University, Canada

10:00-10:25 Peck Orders and LYM Orders
David Wagner, University of Waterloo, Canada

10:30-10:55 Some Recent Results on Chromatic and Tutte Polynomials for Families of Graphs
Robert Shrock, State University of New York, Stony Brook, USA

11:00-11:25 Matroids, Greedoids and the Tutte Polynomial
Gary Gordon, Lafayette College, USA

11:30-11:55 Graph Colouring and the Topological Penrose Polynomial
Joanna Ellis-Monaghan, Saint Michael's College, USA; Iain Moffatt, University of South Alabama, USA

Wednesday, June 20

MS30

Graph Coloring Minisymposium - Part II of II

9:30 AM-12:00 PM

Room:Kenneth C. Rowe 1011

For Part 1 see MS3

Graph coloring is a central area of discrete mathematics, with connections to many seemingly unrelated fields. This minisymposium will consider a wide range of problems related to graph coloring.

Organizer: Daniel Cranston
Virginia Commonwealth University, USA

9:30-9:55 Edge-coloring *8*-regular Planar Graphs

Maria Chudnovsky, Columbia University, USA; Katherine Edwards, and Paul Seymour, Princeton University, USA

10:00-10:25 Multicolor and Directed Edit Distance

Ryan R. Martin and Maria Axenovich, Iowa State University, USA

10:30-10:55 Graph Stirling Numbers

David J. Galvin, and Do Trong Thanh, University of Notre Dame, USA

11:00-11:25 Recent Results on Grundy number

H. A. Kierstead, Arizona State University, USA

11:30-11:55 Bounding the Fractional Chromatic Number of K_Δ-free Graphs

Andrew D. King, Columbia University, USA; Linyuan Lu and Xing Peng, University of South Carolina, USA

Wednesday, June 20

MS31

Ramsey Theory - Part I of II

9:30 AM-11:30 PM

Room:Henry Hicks 217

For Part 2 see MS43

Ramsey theory studies the guaranteed emergence of ordered substructures in large structures. This field has seen a resurgence in recent years and many advances have been made. These include improvements on many long-standing bounds for graph and hypergraph Ramsey numbers and a hugely improved understanding of Ramsey properties of random and pseudorandom graphs. The talks in this minisymposium will explore a broad cross-section of these advances and point out directions for future research.

Organizer: David Conlon
University of Oxford, United Kingdom

9:30-9:55 Two Extensions of Ramsey's Theorem

David Conlon, University of Oxford, United Kingdom; Jacob Fox, Massachusetts Institute of Technology, USA; Benny Sudakov, University of California, Los Angeles, USA

10:00-10:25 Ramsey Problems on Non-Complete Graphs

Jozef Skokan, London School of Economics, United Kingdom

10:30-10:55 On Restricted Ramsey Numbers

Andrzej Dudek, Western Michigan University, USA

11:00-11:25 Diagonal Forms for Incidence Matrices and Zero-Sum (mod 2) Ramsey Theory

Wing Hong Tony Wong and Richard Wilson, California Institute of Technology, USA

Wednesday, June 20

MS32

Design Theory - Part III of IV

9:30 AM-11:30 PM

Room:Marion McCain 2017

For Part 2 see MS19
For Part 4 see MS46

This session will focus on combinatorial designs and related concepts.

Organizer: David Pike
Memorial University, Newfoundland, Canada

9:30-9:55 Skolem and Rosa Rectangles and Related Designs

Nabil Shalaby, Memorial University, Newfoundland, Canada; Vaclav Linek, University of Winnipeg, Canada

10:00-10:25 Block Colourings of Designs Revisited

Alexander Rosa, McMaster University, Canada

10:30-10:55 Non-extendible Latin Cuboids

Darryn Bryant, University of Queensland, Australia; Nicholas Cavenagh, University of Waikato, New Zealand; *Barbara Maenhaut*, University of Queensland, Australia; Kyle Pula, University of Colorado, Denver, USA; Ian Wanless, Monash University, Australia

11:00-11:25 Cyclic Block Designs with Block Size 3 from Skolem-Type Sequences

Daniela Silvesan and Nabil Shalaby, Memorial University, Newfoundland, Canada

Wednesday, June 20

MS33

Discrete Mathematical Biology - Part I of II

9:30 AM-12:00 PM

Room:Marion McCain 2021

For Part 2 see MS47

This minisymposium will focus on the importance of discrete models and methods across a spectrum of subfields in mathematical biology. Our goal is to highlight common mathematical challenges motivated by different biological applications.

Organizer: Christine E. Heitsch
Georgia Institute of Technology, USA

Organizer: Svetlana Poznanovikj
Georgia Institute of Technology, USA

9:30-9:55 Asymptotic Distribution of Substructures in a Stochastic Context-free Grammar Model of RNA Folding
Svetlana Poznanovikj, and Christine E. Heitsch, Georgia Institute of Technology, USA

10:00-10:25 Bayesian Centroid Estimation for Genome-Wide Association Studies
Luis Carvalho, Boston University, USA

10:30-10:55 Assembling Helices in RNA Junctions by Using 3D Graphs
Christian Laing, Wilkes University, USA

11:00-11:25 Combinatorics of Splice Graphcs
Dustin Cartwright, Yale University, USA

11:30-11:55 Encoding Memories in Neuronal Networks
Carina Curto, University of Nebraska, Lincoln, USA

Wednesday, June 20

MS34

Approximation Algorithms - Part I of II

9:30 AM-12:00 PM

Room:Marion McCain 2102

For Part 2 see MS50

Approximation algorithms for NP-hard optimization problems constitute a deep and central aspect of the theory of algorithms and computational complexity. Their study has rich connections to discrete mathematics, geometry, and probability, and applications of approximation algorithms are pervasive in computer science, operations research, computational biology, and quantitative social sciences, among other areas. This minisymposium highlights key recent developments in the field, including advances on the analysis of linear and semidefinite relaxations of combinatorial optimization problems.

Organizer: Robert Kleinberg
Cornell University, USA

9:30-9:55 Improving Christofides' Algorithm for the Metric s-t Path Traveling Salesman Problem
Hyung-Chan An, R*obert Kleinberg*, and David Shmoys, Cornell University, USA

10:00-10:25 Electrical Flows, Laplacian Systems, and Faster Approximation of Maximum Flow in Undirected Graphs
Paul Christiano, Jonathan Kelner, and *Aleksander Madry*, Microsoft Research New England, USA; Daniel Spielman, Yale University, USA

10:30-10:55 The Entropy Rounding Method in Approximation Algorithms
Thomas Rothvoss, Massachusetts Institute of Technology, USA

11:00-11:25 Semidefinite Programming Hierarchies and the Unique Games Conjecture
David Steurer, Microsoft Research New England, USA

11:30-11:55 Title Not Available at TIme of Publication
Prasad Raghavendra, Georgia Institute of Technology, USA

Wednesday, June 20

CP10

Graph Theory - Part IV

9:30 AM-12:00 PM

Room:Marion McCain 2190

Chair: Lowell Adams, George Washington University, USA

9:30-9:50 Constructing Self-Dual Graph Embeddings in Surfaces
Lowell Abrams, George Washington University, USA; Daniel Slilaty, Wright State University, USA

9:55-10:15 Almost Empty Monochromatic Triangles in Planar Point Sets
Bhaswar B. Bhattacharya, Stanford University, USA; *Deepan Basu*, Indian Statistical Institute, India; Sandip Das, ISI, Calcutta, India

10:20-10:40 *k*-Metric Dimension of Graphs
Sooryanarayana B, Dr. B.R. Ambedkar N.I.T., India

10:45-11:05 Metric Dimension of Amalgamation of Graphs
Rinovia Simanjuntak, Saladdin Uttunggadewa, and Suhadi Wido Saputro, Bandung Institute of Technology, Indonesia

11:10-11:30 On The Metric Dimension Of Generalized Wheel And Other Graphs
Shreedhar K, KVG College of Engineering, Sullia, India; Sooryanarayana B, Dr. B.R. Ambedkar N.I.T., India

11:35-11:55 Latin Squares and Competition Numbers
Jaromy S. Kuhl, University of West Florida, USA

Wednesday, June 20

CP11

Discrete Mathematics and Applications

9:30 AM-11:35 AM

Room:Marion McCain 2198

Chair: Li-Da Tong, National Sun Yat-Sen University, Taiwan

9:30-9:50 Towards a De Bruijn-Erdos Theorem in the L_1-Metric

Ida Kantor, Charles University, Czech Republic; Balázs Patkós, Alfréd Rényi Institute of Mathematics, Hungary

9:55-10:15 Graphs with Minimum Identifying Code and Minimum Size

Li-Da Tong, National Sun Yat-sen University, Taiwan

10:20-10:40 Discrete Operators Applied to Further Generalize the Integral Image Algorithm

Amir Shachar, Hebrew University of Jerusalem, Israel

10:45-11:05 The Periodicity of Winning/Losing States in Subtraction Games

Nhan Bao Ho, La Trobe University, Australia

11:10-11:30 Radio Number of k^{th} Power of a Path

P. Devadas Rao, Srinivas Institute of Technology, Mangalore, India; Sooryanarayana B, Dr. B.R. Ambedkar N.I.T., India; Chandru Hegde, PES Institute of Technology, Bangalore, India

Lunch Break

12:00 PM-2:00 PM

Attendees on their own

Wednesday, June 20

IP6

Computational Analysis of Cellular Interaction Networks

2:00 PM-2:45 PM

Room:Marion McCain Ondaatje Auditorium

Chair: Teresa Przytycka, National Center for Biotechnology Information, USA

Complex networks are at the heart of biological functioning. In the past decade, high-throughput experimental and computational techniques have determined large-scale cellular networks for a wide range of organisms across the evolutionary spectrum.

In this talk, I will overview various types of biological networks, and show how graph-theoretic approaches have been, and will continue to be, essential for uncovering insights into cellular organization and functioning.

Mona Singh
Princeton University, USA

Coffee Break

2:45 PM-3:15 PM

Room:Marion McCain Lobby

Wednesday, June 20

MS35

Combinatorics and Partially Ordered Sets - Part IV of IV

3:15 PM-5:45 PM

Room:Henry Hicks 212

For Part 3 see MS28

Organizer: William T. Trotter
Georgia Institute of Technology, USA

3:15-3:40 An Improved Bound for First-Fit on Posets Without Two Long Incomparable Chains

Vida Dujmovic, Carleton University, Canada; *Gwenael Joret*, Université Libre de Bruxelles, Belgium; David R. Wood, University of Melbourne, Australia

3:45-4:10 Semiorders and Ascent Sequences

Stephen J. Young and Jeff Remmel, University of California, San Diego, USA

4:15-4:40 News About Semiantichains and Unichain Coverings

Bartlomiej E. Bosek, Jagiellonian University, Poland; Stefan Felsner, Technical University Berlin, Germany; Kolja Knauer, TU Berlin, Germany; Grzegorz Matecki, Jagiellonian University, Poland

4:45-5:10 Some Problems and Results on the On-line Chain Partitioning of Posets

Csaba Biro, University of Louisville, USA; Linyuan Lu, University of South Carolina, USA

5:15-5:40 First-Fit Coloring of Interval Graphs

Peng Li and *Yaokun Wu*, Shanghai Jiaotong University, China

Wednesday, June 20

MS36

My Favorite Graph Theory Conjectures - Part I of III

3:15 PM-5:15 PM

Room:Kenneth C. Rowe 1009

For Part 2 see MS42

Conjectures and conjecture-making are central to every discipline in mathematics. In this session leading graph theorists have been invited to discuss the conjectures that have most influenced their research. We expect these talks to be both biographical and to set an agenda for future research in graph theory. Talks will be (1) historical about the conjectures that have guided their research, or (2) about the future of our field, and talk about the conjectures that have most intrigued them or motivated them, and that they think are important.

Organizer: Craig E. Larson
Virginia Commonwealth University, USA

Organizer: Ralucca M. Gera
Naval Postgraduate School, USA

3:15-3:40 Some Graph Theory Problems I Would Like to See Solved
Ron Graham, University of California, San Diego, USA

3:45-4:10 Euler's Rigidity Conjecture
Jack Graver, Syracuse University, USA

4:15-4:40 Ringel and Kotzig after Fifty Years
Alexander Rosa, McMaster University, Canada

4:45-5:10 Algorithms and Existential Polytime?
Jack Edmonds

Wednesday, June 20

MS37

Cops and Robber Games on Graphs

3:15 PM-5:45 PM

Room:Kenneth C. Rowe 1011

The Game of Cops and Robbers, since its introduction in the early eighties, has gathered significant interest from those working in structural, probabilistic, and algorithmic graph theory. The last few years has seen a wealth of results, focusing on new variants of the game, random graphs, characterizations, and on bounds such as Meyniel's conjecture. This minisymposium will bring together leading researchers in the field to discuss state-of-the-art work on the subject.

Organizer: Anthony Bonato
Ryerson University, Canada

3:15-3:40 Cops and Robbers on Geometric Graphs
Andrew J. Beveridge, Macalester College, USA; Andrzej Dudek, Western Michigan University, USA; Alan Frieze, Carnegie Mellon University, USA; Tobias Mueller, CWI, Amsterdam, Netherlands

3:45-4:10 Seepage in Directed Acyclic Graphs
Anthony Bonato, Ryerson University, Canada

4:15-4:40 Ambush Cops and Robbers
Nancy E. Clarke, Acadia University, Canada

4:45-5:10 Cops and Scared Robber
Shannon L. Fitzpatrick, University of Prince Edward Island, Canada; Stephen Finbow, St. Francis Xavier University, Canada

5:15-5:40 Chasing Cops on Random Graphs
Pawel Pralat, Ryerson University, Canada; Nick Wormald, University of Waterloo, Canada

Wednesday, June 20

MS38

Graphs on Surfaces - Part II of II

3:15 PM-5:45 PM

Room:Henry Hicks 217

For Part 1 see MS17

Speakers in this minisymposium will present their recent work in topological graph theory. The topics range from considerations of planar graphs, to graphs on surfaces of higher genus, and properties of random maps.

Organizer: Bojan Mohar
Simon Fraser University, Canada

3:15-3:40 Coloring Graphs on Surfaces
Zdenek Dvorak, Charles University, Czech Republic

3:45-4:10 Hamiltonicity of Graphs on Surfaces
Ken-ichi Kawarabayashi and *Kenta Ozeki*, National Institute of Informatics, Japan

4:15-4:40 An Analogue of the Harer-Zagier Formula for General Surfaces
Olivier Bernardi, Massachusetts Institute of Technology, USA

4:45-5:10 Rooted $K_{2,4}$ Minors in Planar Graphs
Lino Demasi, Simon Fraser University, Canada

5:15-5:40 Clique Immersion in Digraphs
Jessica McDonald, Simon Fraser University, Canada

Wednesday, June 20

MS39

Graphs and Groups - Part II of II

3:15 PM-5:15 PM

Room:Marion McCain 2017

For Part 1 see MS26

The automorphism group contains useful information about a graph. Such groups show up both as tools for examining graphs, and as objects of study on their own. This mini-symposium will focus on various topics involving graphs and groups.

Organizer: Debra L. Boutin
Hamilton College, USA

3:15-3:40 Hamiltonian Cycles in Cayley Graphs
Joy Morris, University of Lethbridge, Canada

3:45-4:10 A Catalog of Self-Dual Plane Graphs with Max Degree 4
Elizabeth Hartung, Massachusetts College of Liberal Arts, USA; Jack Graver, Syracuse University, USA

4:15-4:40 Distinguishing Numbers and Regular Orbits
Robert Bailey, University of Regina, Canada

4:45-5:10 On the Orders of Symmetric Graphs
Marston Conder, University of Auckland, New Zealand

Wednesday, June 20

MS40

Biological Networks

3:15 PM-5:45 PM

Room:Marion McCain 2021

Computational techniques for the study of graphs that describe the physical or logical interactions between entities (proteins, genes, other molecules) in the cell. Typical biological networks of study encode protein-protein interactions, regulatory relationships, gene co-expression, the effect of pairs of gene deletions, or a combination of these links. Applications include modeling the evolution of interactions, comparing and aligning networks, and predicting gene function.

Organizer: Carl Kingsford
University of Maryland, College Park, USA

3:15-3:40 Network Archaeology: Uncovering Ancient Networks from Present-Day Interactions
Carl Kingsford, University of Maryland, College Park, USA

3:45-4:10 Sensitive Graph-theoretic Approaches for Extracting Function from Biological Networks
Tijana Milenkovic, University of Notre Dame, USA

4:15-4:40 Biological Networks in Three Dimensions
Yu (Brandon) Xia, Boston University, USA

4:45-5:10 Understanding Phenome-genome Association by Co-clustering and Graph Matching
Rui Kuang, University of Minnesota, USA

5:15-5:40 How Networks Change with Time
Joel S. Bader, Johns Hopkins University, USA

Wednesday, June 20

MS41

Interactions between Computer Algebra and Discrete Mathematics - Part I of III

3:15 PM-5:45 PM

Room:Marion McCain 2102

For Part 2 see MS48

Computer Algebra Systems (CAS), such as Axiom, Maple, Mathematica, are powerful software tools which support the work of mathematicians in many disciplines. Recent algorithmic developments in the context of hardware acceleration technologies are boosting the performances of CAS. This mini-symposium aims at exploring the application of computer algebra to discrete mathematics. We are interested in theoretical problems such as discrete optimization or the realization of discrete geometries as well as more practical problems in computer vision or program verification, to name a few, where techniques from discrete mathematics and computer algebra can successfully be combined.

Organizer: Rong Xiao
University of Western Ontario, Canada

Organizer: Marc Moreno Maza
University of Western Ontario, Canada

Organizer: Changbo Chen
University of Western Ontario, Canada

Organizer: Yuzhen Xie
Massachusetts Institute of Technology, USA

3:15-3:40 Advances on Quantifier Elimination and Applications
Changbo Chen and Marc Moreno Maza, University of Western Ontario, Canada

3:45-4:10 Automatic Quantifier Elimination Proves a Key Result in Submodular Function Minimization
Andrew Delong, University of Western Ontario, Canada

continued on next page

Wednesday, June 20

MS41

Interactions between Computer Algebra and Discrete Mathematics - Part I of III

3:15 PM-5:45 PM

continued

4:15-4:40 Algebraic Representations of Branches of Functions

David J. Wilson, Russell Bradford, and James Davenport, University of Bath, United Kingdom

4:45-5:10 On Newton Polytopes, Tropisms, and Puiseux Series to Solve Polynomial systems

Jan Verschelde and Danko Adrovic, University of Illinois, Chicago, USA

5:15-5:40 A Solver for Linear Algebraic Systems Resulting from Selecting Discrete Structures

Thomas Wolf, Brock University, Canada

Wednesday, June 20

CP12

Graph Theory - Part V

3:15 PM-5:45 PM

Room:Marion McCain 2190

Chair: Boram Park, Rutgers University, USA

3:15-3:35 Dynamic Coloring and List Dynamic Coloring of Planar Graphs

Seog-Jin Kim, Konkuk University, South Korea; Sang June Lee, Emory University, USA; Won-Jin Park, Seoul National University, Korea

3:40-4:00 Eulerian Circuits with No Monochromatic Transitions

James Carraher, and Stephen Hartke, University of Nebraska, Lincoln, USA

4:05-4:25 Labeled Embeddings of Graphs

Eric Duchene and Hamamache Kheddouci, Universite de Lyon 1, France; Richard Nowakowski, Dalhousie University, Canada; Amine Tahraoui, Universite de Lyon 1, France

4:30-4:50 Total Weight Choosability of Cartesian Product of Graphs

Jiaojiao Wu and Tsai-Lien Wong, National Sun Yat-Sen University, Taiwan; Xuding Zhu, Zhejiang Normal University, China

4:55-5:15 Flow-Continuous Mappings -- Influence of the Group

Robert Samal and Jaroslav Nesetril, Charles University, Czech Republic

5:20-5:40 The Competition Graphs of Powers of Digraphs

Boram Park, Rutgers University, USA; Woongbae Park and Suh-Ryung Kim, Seoul National University, Korea

Wednesday, June 20

CP13

Algebraic and Enumerative Combinatorics - Part I

3:15 PM-4:55 PM

Room:Marion McCain 2198

Chair: Laure Flapan, Yale University, USA

3:15-3:35 Counting Minimal Sturmian Words

Francine Blanchet-Sadri, University of North Carolina, USA; Sean Simmons, Massachusetts Institute of Technology, USA; *Bob Chen*, University of California, San Diego, USA

3:40-4:00 Unavoidable Sets

Francine Blanchet-Sadri, University of North Carolina, USA; *Laure Flapan*, Yale University, USA; Steven Ji, Massachusetts Institute of Technology, USA; Elizabeth Reiland, Harvey Mudd College, USA; Stephen Watkins, Vanderbilt University, USA

4:05-4:25 Recurrence in Infinite Partial Words

Francine Blanchet-Sadri, University of North Carolina, USA; *Bob Chen*, University of California, San Diego, USA; Sinziana Munteanu, Princeton University, USA

4:30-4:50 Solving Wilf's Sigma-Tau Problem

Aaron M. Williams, McGill University, Canada

Intermission

5:45 PM-6:00 PM

Wednesday, June 20

Forward Looking Session

6:00 PM-7:30 PM

Room:Marion McCain Ondaatje Auditorium

Chair: Joel Spencer, Courant Institute of Mathematical Sciences, New York University, USA

Panelists:

Christian Borgs
Microsoft Research, USA

Anders Björner
Royal Institute of Technology, Sweden

Maria Chudnovsky
Columbia University, USA

Lenore Cowen
Tufts University, USA

Thursday, June 21

Registration

7:30 AM-4:00 PM

Room:Marion McCain Lobby

Remarks

8:10 AM-8:15 AM

Room:Marion McCain Ondaatje Auditorium

Thursday, June 21

IP7

The Hub Labeling Algorithm

8:15 AM-9:00 AM

Room:Marion McCain Ondaatje Auditorium

Chair: Lenore Cowen, Tufts University, USA

This is a survey of Hub Labeling results for general and road networks. Given a weighted graph, a distance oracle takes as an input a pair of vertices and returns the distance between them. The labeling approach to distance oracle design is to precompute a label for every vertex so that distances can be computed from the corresponding labels. This approach has been introduced by [Gavoille et al. '01], who also introduced the Hub Labeling algorithm (HL). HL has been further studied by [Cohen et al. '02]. We study HL in the context of graphs with small highway dimension (e.g., road networks). We show that under this assumption HL labels are small and the queries are sublinear. We also give an approximation algorithm for computing small HL labels that uses the fact that shortest path set systems have small VC-dimension. Although polynomial-time, precomputation given by theory is too slow for continental-size road networks. However, heuristics guided by the theory are fast, and compute very small labels. This leads to the fastest currently known practical distance oracles for road networks. The simplicity of HL queries allows their implementation inside of a relational database (e.g., in SQL), and query efficiency assures real-time response. Furthermore, including HL data in the database allows efficient implementation of more sophisticated location-based queries. This approach brings the power of location-based services to SQL programmers

Andrew Goldberg
Microsoft Research Silicon Valley, USA

Coffee Break

9:00 AM-9:30 AM

Room:Marion McCain Lobby

Thursday, June 21

MS42

My Favorite Graph Theory Conjectures - Part II of III

9:30 AM-12:00 PM

Room:Henry Hicks 212

For Part 1 see MS36
For Part 3 see MS49

Conjectures and conjecture-making are central to every discipline in mathematics. In this session leading graph theorists have been invited to discuss the conjectures that have most influenced their research. We expect these talks to be both biographical and to set an agenda for future research in graph theory. Talks will be (1) historical about the conjectures that have guided their research, or (2) about the future of our field, and talk about the conjectures that have most intrigued them or motivated them, and that they think are important.

Organizer: Craig E. Larson
Virginia Commonwealth University, USA

Organizer: Ralucca M. Gera
Naval Postgraduate School, USA

9:30-9:55 How to Recognize a Good Conjecture
Bojan Mohar, Simon Fraser University, Canada

10:00-10:25 Matthews Sumner Conjecture on Claw-Free Graphs
Ralph Faudree, University of Memphis, USA

10:30-10:55 The Implicit Representation of Graphs Conjecture
Ed Scheinerman, Johns Hopkins University, USA

11:00-11:25 Some of my favorite Conjectures
Michael D. Plummer, Vanderbilt University, USA

11:30-11:55 A De Bruijn - Erdos Theorem in Connected Graphs?
Vasek Chvatal, Concordia University, Canada

Thursday, June 21

MS43

Ramsey Theory - Part II of II

9:30 AM-11:30 AM

Room:Kenneth C. Rowe 1009

For Part 1 see MS31

Ramsey theory studies the guaranteed emergence of ordered substructures in large structures. This field has seen a resurgence in recent years and many advances have been made. These include improvements on many long-standing bounds for graph and hypergraph Ramsey numbers and a hugely improved understanding of Ramsey properties of random and pseudorandom graphs. The talks in this minisymposium will explore a broad cross-section of these advances and point out directions for future research.

Organizer: David Conlon
University of Oxford, United Kingdom

9:30-9:55 Ramsey Classes Defined by Forbidden Homomorphisms
Jan Foniok, Queen's University, Canada

10:00-10:25 General Deletion Lemmas via the Harris Inequality
Reto Spöhel, Max Planck Institute for Informatics, Germany; Angelika Steger, ETH Zürich, Switzerland; Lutz Warnke, University of Oxford, United Kingdom

10:30-10:55 On Ramsey Multiplicities of Graphs Containing Triangles
Michael Young, Iowa State University, USA; James Cummings, Carnegie Mellon University, USA

11:00-11:25 A Randomized Version of Ramsey's Theorem
Luca Gugelmann, ETH Zürich, Switzerland; *Yury Person*, Freie Universitaet Berlin, Germany; Angelika Steger and Henning Thomas, ETH Zürich, Switzerland

Thursday, June 21

MS44

Algorithmic Mechanism Design

9:30 AM-12:00 PM

Room:Kenneth C. Rowe 1011

The field of algorithmic mechanism design uses mathematical insights from computer science and economics to study large systems of strategic agents, such as social networks and online auctions, from the perspective of an optimizing designer. The designer's goal is to develop a computationally efficient system in which individuals' selfish behavior leads to a globally optimal outcome at equilibrium. This minisymposium touches upon key problems in this domain, such as maximizing revenue in online auctions and aggregating individual preferences into socially optimal choices.

Organizer: Brendan Lucier
Microsoft Research New England, USA

9:30-9:55 Knightian Auctions
Silvio Micali, Alessandro Chiesa, and Zeyuan Zhu, Massachusetts Institute of Technology, USA

10:00-10:25 Combinatorial Walrasian Equilibria
Brendan Lucier, Microsoft Research New England, USA; Michal Feldman, Hebrew University of Jerusalem, Israel

10:30-10:55 Bayesian Multi-Parameter Scheduling
Balasubramanian Sivan and Shuchi Chawla, University of Wisconsin, Madison, USA; Jason Hartline, Northwestern University, USA; David Malec, University of Wisconsin, Madison, USA

11:00-11:25 Online Procurement
Yaron Singer, University of California, Berkeley, USA

11:30-11:55 Multidimensional Algorithmic Mechanism Design
Costis Daskalakis, Massachusetts Institute of Technology, USA

Thursday, June 21

MS45

Graph Homomorphisms - Part I of II

9:30 AM-12:00 PM

Room:Henry Hicks 217

For Part 2 see MS52

This minisymposium will focus on recent work dealing with or relating to graph homomorphisms, from graph colorings to graph partitions and constraint satisfaction problems.

Organizer: Pavol Hell

Simon Fraser University, Canada

9:30-9:55 Colorings and Homomorphisms of Sparse Graphs

Jaroslav Nesetril, Charles University, Czech Republic; Patrice Ossona de Mendez, CNRS, France

10:00-10:25 Fast Algorithms for Sparse Graphs

Patrice Ossona de Mendez, CNRS, France; Jaroslav Nesetril, Charles University, Czech Republic

10:30-10:55 Graph Homomorphism Counts Mod M

Swastik Kopparty, Rutgers University, USA

11:00-11:25 Semilattice and NU Polymorphisms on Reflexive Graphs

Mark Siggers, Kyungpook National University, Korea

11:30-11:55 Frozen Vertices in Colourings of a Random Graph

Michael Molloy, University of Toronto, Canada

Thursday, June 21

MS46

Design Theory - Part IV of IV

9:30 AM-12:00 PM

Room:Marion McCain 2017

For Part 3 see MS32

This session will focus on combinatorial designs and related concepts.

Organizer: David Pike

Memorial University, Newfoundland, Canada

9:30-9:55 New Areas in Covering Arrays

Brett C. Stevens, Carleton University, Canada

10:00-10:25 Bounds for Covering Arrays with Row Limit

Nevena Francetic, University of Toronto, Canada; Peter Danziger, Ryerson University, Canada; Eric Mendelsohn, University of Toronto, Canada

10:30-10:55 Near Factorisations of the Complete Graph

Peter Danziger and Andrea Burgess, Ryerson University, Canada

11:00-11:25 Nonincident Points and Blocks in Designs

Douglas R. Stinson, University of Waterloo, Canada

11:30-11:55 A New Construction of Strength-3 Covering Arrays Using Primitive Polynomials Over FInite Fields

Lucia Moura, and Sebastian Raaphorst, University of Ottawa, Canada; Brett C. Stevens, Carleton University, Canada

Thursday, June 21

MS47

Discrete Mathematical Biology - Part II of II

9:30 AM-12:00 PM

Room:Marion McCain 2021

For Part 1 see MS33

This minisymposium will focus on the importance of discrete models and methods across a spectrum of subfields in mathematical biology. Our goal is to highlight common mathematical challenges motivated by different biological applications.

Organizer: Christine E. Heitsch

Georgia Institute of Technology, USA

Organizer: Svetlana Poznanovikj

Georgia Institute of Technology, USA

9:30-9:55 Profiling RNA Secondary Structures

Emily Rogers, *M. Shel Swenson*, and Christine E. Heitsch, Georgia Institute of Technology, USA

10:00-10:25 Statistics and Applications of Tree Space

Megan Owen, Fields Institute for Research in Mathematical Sciences, Canada

10:30-10:55 Finding the Max Cut of the Genetic Interactions Graph in Yeast Finds Compensatory Pathways.

Benjamin Hescott, Tufts University, USA; Mark Leiserson, Brown University, USA; Andrew Gallant, Diana Tatar, and Lenore Cowen, Tufts University, USA

11:00-11:25 Comparing Biological and Mathematical Approaches to Modeling Tissue Development in *C. elegans*

Brandilyn Stigler, Southern Methodist University, USA

11:30-11:55 Optimality of the Neighbor Joining Algorithm and Faces of the Balanced Minimum Evolution Polytope

David Haws, University of Kentucky, USA; Terrell Hodge, Western Michigan University, USA; Ruriko Yoshida, University of Kentucky, USA

Thursday, June 21

MS48

Interactions between Computer Algebra and Discrete Mathematics - Part II of III

9:30 AM-12:00 PM

Room:Marion McCain 2102

For Part 1 see MS41
For Part 3 see MS54

Computer Algebra Systems (CAS), such as Axiom, Maple, Mathematica, are powerful software tools which support the work of mathematicians in many disciplines. Recent algorithmic developments in the context of hardware acceleration technologies are boosting the performances of CAS. This mini-symposium aims at exploring the application of computer algebra to discrete mathematics. We are interested in theoretical problems such as discrete optimization or the realization of discrete geometries as well as more practical problems in computer vision or program verification, to name a few, where techniques from discrete mathematics and computer algebra can successfully be combined.

Organizer: Changbo Chen
University of Western Ontario, Canada

Organizer: Marc Moreno Maza
University of Western Ontario, Canada

Organizer: Rong Xiao
University of Western Ontario, Canada

Organizer: Yuzhen Xie
Massachusetts Institute of Technology, USA

9:30-9:55 Generating Program Invariants via Interpolation
Rong Xiao and Marc Moreno Maza, University of Western Ontario, Canada

10:00-10:25 Program Analysis using Quantifier Elimination Heuristics
Deepak Kapur, University of New Mexico, USA

continued in next column

10:30-10:55 New Results on D-Optimal Matrices
Ilias S. Kotsireas, Wilfrid Laurier University, Canada

11:00-11:25 Matroid Base Polytope Decomposition and Applications
Jorge L. Ramirez Alfonsin, Universite de Montpellier II, France

11:30-11:55 Parallel Computation of the Minimal Elements of a Poset and Applications
Yuzhen Xie and Marc Moreno Maza, University of Western Ontario, Canada

Thursday, June 21

CP14

Discrete and Algebraic Geometry

9:30 AM-11:35 AM

Room:Marion McCain 2190

Chair: Kathie Cameron, Wilfrid Laurier University, Canada

9:30-9:50 A New Lower Bound Based on Gromov's Method of Selecting Heavily Covered Points
Lukas Mach and Daniel Král, Charles University, Czech Republic; Jean-Sébastien Sereni, CNRS, France

9:55-10:15 Lattice-point Generating Functions for Free Sums of Convex Sets
Pallavi Jayawant, Bates College, USA; Matthias Beck, San Francisco State University, USA; Tyrrell B. Mcallister, University of Wyoming, USA

10:20-10:40 Monotone Path Systems in Regions with Holes
Kathie Cameron and Katie Tsuji, Wilfrid Laurier University, Canada

10:45-11:05 On Structures of Geometrically Realizable Triangulations on the Möbius Band
Shoichi Tsuchiya, Yokohama National University, Japan

11:10-11:30 Grid Representation for the Triangulations of the Torus
Maryam Verdian Rizi, KAIST, Korea

Thursday, June 21

CP15

Graph Theory - Part VI

9:30 AM-12:00 PM

Room:Marion McCain 2198

Chair: Tyler Seacrest, The University of Montana Western

9:30-9:50 Finding 1-Factors in Realizations of Degree Sequences

Tyler Seacrest, The University of Montana Western

9:55-10:15 Immersions of Complete Graphs in Graphs with Minimum Degree *n - 1*

Megan Heenehan and Karen Collins, Wesleyan University, USA

10:20-10:40 *n*-Tournaments That Have *n*-Integer Signatures

Vasudeva Acharya, Srinivas Institute of Technology, Mangalore, India; Suresh M. Hegde, National Institute of Technology Karnataka , Surathkal, India

10:45-11:05 New Characterizations of Proper Interval Bigraphs

Ashok K. Das, University Of Calcutta, India

11:10-11:30 Fat Hoffman Graphs with Smallest Eigenvalue at Least-1-τ

Yoshio Sano, National Institute of Informatics, Japan; Akihiro Munemasa, Tohoku University, Japan; Tetsuji Taniguchi, Matsue College of Technology, Japan

11:35-11:55 House of Graphs: a Database of Interesting Graphs

Jan Goedgebeur, Gunnar Brinkmann, and Kris Coolsaet, Ghent University, Belgium; Hadrien Melot, Universite de Mons, Belgium

Lunch Break

12:00 PM-2:00 PM

Attendees on their own

Thursday, June 21

IP8

Algorithms, Graph Theory, and the Solution of Laplacian Linear Equations

2:00 PM-2:45 PM

Room:Marion McCain Ondaatje Auditorium

Chair: Adam Marcus, Yale University, USA

We survey several fascinating concepts and algorithms in graph theory that arise in the design of fast algorithms for solving linear equations in the Laplacian matrices of graphs. We will begin by explaning why linear equations in these matrices are so interesting. The problem of solving linear equations in these matrices motivates a new notion of what it means for one graph to approximate another. This leads to a problem of graph sparsification--the approximation of a graph by a sparser graph. Our algorithms for solving Laplacian linear equations will exploit surprisingly strong approximations of graphs by sparse graphs, and even by trees. We will survey the roles that spectral graph theory, random matrix theory, graph sparsification, low-stretch spanning trees and local clustering algorithms play in the design of fast algorithms for solving Laplacian linear equations.

Daniel Spielman

Yale University, USA

Coffee Break

2:45 PM-3:15 PM

Room:Marion McCain Lobby

Thursday, June 21

MS49

My Favorite Graph Theory Conjectures - Part III of III

3:15 PM-5:15 PM

Room:Henry Hicks 212

For Part 2 see MS42

Conjectures and conjecture-making are central to every discipline in mathematics. In this session leading graph theorists have been invited to discuss the conjectures that have most influenced their research. We expect these talks to be both biographical and to set an agenda for future research in graph theory. Talks will be (1) historical about the conjectures that have guided their research, or (2) about the future of our field, and talk about the conjectures that have most intrigued them or motivated them, and that they think are important.

Organizer: Craig E. Larson

Virginia Commonwealth University, USA

Organizer: Ralucca M. Gera

Naval Postgraduate School, USA

3:15-3:40 Conjectures on Thickness, Connectivity, and Other Things

Lowell Beineke, Indiana University - Purdue University Fort Wayne, USA

3:45-4:10 On Conjectures of Grafitti. pc

Ermelinda DeLaVina, University of Houston, USA

4:15-4:40 Open Problems on Graph Eigenvalues

Mustapha Aouchiche, Gilles Caporossi, and Pierre Hansen, GERAD and HEC Montreal, Canada

4:45-5:10 Title Not Available at Time of Publication

Fan Chung Graham, University of California, San Diego, USA

Thursday, June 21

MS50

Approximation Algorithms - Part II of II

3:15 PM-5:45 PM

Room:Kenneth C. Rowe 1009

CANCELLED

Thursday, June 21

MS51

Distance in Graphs

3:15 PM-5:15 PM

Room:Kenneth C. Rowe 1011

This session incorporates talks presenting results on different types of metrics in graphs as well as different measurements defined in terms of distance.

Organizer: Ralucca M. Gera
Naval Postgraduate School, USA

Organizer: Linda Eroh
University of Wisconsin, Oshkosh, USA

3:15-3:40 Closed K-Stop Distance in Graphs

Ralucca M. Gera, Naval Postgraduate School, USA; Grady Bullington, Linda Eroh, and Steve Winters, University of Wisconsin, Oshkosh, USA

3:45-4:10 Using Graphs for Facility Location Problems

Steven J. Winters, University of Wisconsin, Oshkosh, USA

4:15-4:40 Distance in Rainbow Connected Graphs

Garry L. Johns, Saginaw Valley State University, USA

4:45-5:10 On Metric Dimension of Functigraphs

Linda Eroh, University of Wisconsin, Oshkosh, USA; Cong Kang and Eunjeong Yi, Texas A&M University, Galveston, USA

Thursday, June 21

MS52

Graph Homomorphisms - Part II of II

3:15 PM-5:45 PM

Room:Henry Hicks 217

For Part 1 see MS45

This minisymposium will focus on recent work dealing with or relating to graph homomorphisms, from graph colorings to graph partitions and constraint satisfaction problems.

Organizer: Pavol Hell
Simon Fraser University, Canada

3:15-3:40 Adjoint Functors in Graph Theory

Claude Tardif, Royal Military College, Canada; Jan Foniok, Queen's University, Canada

3:45-4:10 Near-Unanimity Graphs and Absolute Retracts

Tomas Feder, Stanford University, USA; Pavol Hell, Simon Fraser University, Canada; *Benoit Larose*, Concordia University, Canada; Cynthia Loten, Fraser Valley, Canada; Mark Siggers, Kyungpook National University, Korea; Claude Tardif, Royal Military College, Canada

4:15-4:40 Graph Partitions

Gary Macgillivray, Peter Dukes, and Steve Lowdon, University of Victoria, Canada

4:45-5:10 Bipartite Graphs and Approximation of Minimum Cost Homomorphisms

Arash Rafiey, University of Bergen, Norway

5:15-5:40 Graph Partitions With Emphasis on $2K_2$-Partition

Pavol Hell, Simon Fraser University, Canada; Barnaby Martin and *Daniel Paulusma*, Durham University, United Kingdom

Thursday, June 21

MS53

Geometric Graphs

3:15 PM-5:45 PM

Room:Marion McCain 2017

Geometric graphs in the broadest sense are graphs where vertices are embedded in a metric space, and the existence of an edge between two vertices is influenced by their metric distance. Geometric graphs have long been used as models for ad-hoc networks. Lately, geometric graphs have been also used to model complex real-life networks such as on-line social networks. Here, the metric space is used to model the “feature space” that represents the individual characteristics of the vertices. This session will include talks on various aspects and applications of geometric graphs.

Organizer: Jeannette Janssen
Dalhousie University, Canada

Organizer: Lata Narayanan
Concordia University, Canada

3:15-3:40 Some Results about Disk Graphs and Pseudocircle Arrangements

Tobias Mueller, CWI, Amsterdam, Netherlands

3:45-4:10 New Results and Open Problems on Random Geometric Graphs

Josep Diaz, Universitat Politecnica de Catalunya, Spain

4:15-4:40 On the 2-Edge Connectivity of Geometric Planar Graphs With Bounded Edge Length

Oscar Morales Ponce, Carleton University, Canada

4:45-5:10 Modelling Interference in Wireless Networks using Geometric Graphs

Stephane Durocher, University of Manitoba, Canada

5:15-5:40 On the Treewidth of Random Geometric Graphs

Dieter Mitsche, Ryerson University, Canada; Guillem Perarnau, Universitat Politecnica de Catalunya, Spain

Thursday, June 21

MS54

Interactions between Computer Algebra and Discrete Mathematics - Part III of III

3:15 PM-5:45 PM

Room:Marion McCain 2021

For Part 2 see MS48

Computer Algebra Systems (CAS), such as Axiom, Maple, Mathematica, are powerful software tools which support the work of mathematicians in many disciplines. Recent algorithmic developments in the context of hardware acceleration technologies are boosting the performances of CAS. This mini-symposium aims at exploring the application of computer algebra to discrete mathematics. We are interested in theoretical problems such as discrete optimization or the realization of discrete geometries as well as more practical problems in computer vision or program verification, to name a few, where techniques from discrete mathematics and computer algebra can successfully be combined.

Organizer: Rong Xiao
University of Western Ontario, Canada

Organizer: Marc Moreno Maza
University of Western Ontario, Canada

Organizer: Changbo Chen
University of Western Ontario, Canada

Organizer: Yuzhen Xie
University of Western Ontario, Canada

3:15-3:40 What Computer Algebra Systems Can Offer to Tackle Realizability Problems of Matroids

Marc Moreno Maza, University of Western Ontario, Canada

3:45-4:10 The Interplay Between Finite Fields and Computer Algebra

David Thomson, Carleton University, Canada

continued in next column

4:15-4:40 Bijections Between Truncated Affine Arrangements and Valued Graphs

David Forge, Universite de Paris-Sud, France; Veronique Ventos, Universite Paris 11, France; Sylvie Corteel, Universite Paris 7-Denis Diderot, France

4:45-5:10 Generating Trees for Partitions and Permutations with No k-nestings

Sophie Burrill, Simon Fraser University, Canada; Sergi Elizalde, Dartmouth College, USA; Marni Mishna and Lily Yen, Simon Fraser University, Canada

5:15-5:40 Stochastic Pétri Nets and Symbolic Calculus

Michel Petitot, Universite des Sciences et Technologies de Lille, France

Thursday, June 21

MS55

Algebraic and Combinatorial Approaches to Neural Networks

3:15 PM-5:45 PM

Room:Marion McCain 2102

While the dynamics and function of neuronal networks in the brain has been an active area of research over the past 50 years, a rigorous mathematical theory relating network structure to function is still in its infancy. Recently, a diverse array of techniques such as algebraic combinatorics, Ramsey theory, graph theory, and probability has surfaced to facilitate the development of this theory. The combination of these ideas with more traditional approaches has the potential to significantly advance our understanding of the brain and artificial intelligence. The proposed minisymposium will bring together young researchers working in this emerging field.

Organizer: Christopher Hillar
University of California, Berkeley, USA

Organizer: Vladimir Itskov
University of Nebraska, Lincoln, USA

3:15-3:40 A Theoretical Foundation for Neural Sensor Networks
Christopher Hillar and Kilian Koepsell, University of California, Berkeley, USA

3:45-4:10 Neural Code Topology Imposes Constraints on the Network Architecture
Vladimir Itskov, University of Nebraska, Lincoln, USA

4:15-4:40 Noise-Induced Dynamics in Electricaly Coupled Neuronal Networks
Georgi S. Medvedev, Drexel University, USA

4:45-5:10 Simplex Packings of Marginal Polytopes and Mixtures of Exponential Families
Guido F. Montufar, Max Planck Institute for Mathematics in the Sciences, Germany

5:15-5:40 Stable Exponential Storage in Hopfield Networks
Kilian Koepsell, Ngoc Tran, and Christopher Hillar, University of California, Berkeley, USA

Thursday, June 21

CP16

Algebraic and Enuermative Combinatorics - Part II

3:15 PM-5:00 PM

Room:Marion McCain 2190

Chair: Christopher Raridan, Clayton State University, USA

3:15-3:35 On Iterated Functions, Directed Graphs, and Recursion
Christopher Raridan and Elliot Krop, Clayton State University, USA

3:40-4:00 Cayley Factorization and the Area Method
Susanne Apel, TU München, Germany

4:05-4:25 Variations on the Erdos Discrepancy Problem
Alexander Leong and Jeffrey Shallit, University of Waterloo, Canada

4:30-4:55 1½-Designs Arising from Group Rings
Oktay Olmez, Iowa State University, USA

Thursday, June 21

CP17

Graph Theory - Part VII

3:15 PM-5:20 PM

Room:Marion McCain 2198

Chair: Craig Tennenhouse, University of New England, USA

3:15-3:35 Graphs of Small Rank-Width Are Pivot-Minors of Graphs of Small Tree-Width
O-Joung Kwon and Sang-Il Oum, KAIST, Korea

3:40-4:00 Saturation Numbers for Families of Graph Subdivisions
Craig Tennenhouse, University of New England, USA; Michael Ferrara, and Michael Jacobson, University of Colorado at Denver, USA; Kevin Milans, University of South Carolina, USA; Paul Wenger, University of Colorado at Denver, USA

4:05-4:25 Universal *H*-Colourable Graphs
Izak Broere, University of Pretoria, South Africa; Johannes Heidema, University of South Africa, South Africa

4:30-4:50 A Generalization of Menger's Theorem
Guangyue Han, University of Hong Kong, China

DM12 Abstracts

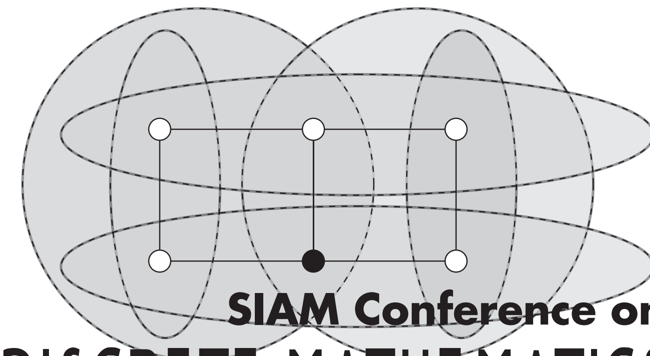


Figure courtesy Victor Chepoi, Hans-Juergen Bandelt, David Eppstein from SIDMA 24-4

SIAM Conference on

DISCRETE MATHEMATICS

June 18-21, 2012
Dalhousie University
Halifax, Nova Scotia, Canada

Abstracts are printed as submitted by the author.

IP0

Dnes Knig Prize Lecture: Talk Title TBD

Abstract not available at time of publication.

Zeev Dvir
Princeton University
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IP1

Cell Complexes in Combinatorics

Cell complexes of various kinds have been invented in topology to help analyze manifolds and other spaces. By introducing a combinatorial structure they make algorithms for computing topological invariants possible. Simplicial complexes are well-known examples. In the other direction, several structures studied in combinatorics naturally suggest associated cell complexes. Can the link to topology provided by these cell complexes be of use for dealing with purely combinatorial questions, or are they just idle curiosities? The answer is definitely "yes" in the simplicial case, as testified by several successes of what has come to be called "topological combinatorics". But what about more general cell complexes? In the talk this question will be discussed. Examples, old and new, arising in graph, group and number theory will be reviewed.

Anders Björner
Royal Institute of Technology (KTH)
bjorner@math.kth.se

IP2

On Sidorenko's Conjecture

The Erdos-Simonovits-Sidorenko conjecture is well-known in combinatorics but it has equivalent formulations in analysis and probability theory. The shortest formulation is an integral inequality related to Mayer integrals in statistical mechanics and Feynman integrals in quantum field theory. We present new progress in the area. Part of the talk is based on joint results with J.L. Xiang Li. In particular we present a type of calculus (based on logarithmic functions) which can be used to prove inequalities between subgraph densities.

Balázs Szegedy
University of Toronto
Department of Mathematics
szegedyb@gmail.com

IP3

Forcing Large Transitive Subtournamets

The Erdos Hajnal Conjecture states roughly that a graph with some induced subgraph excluded has a large clique or a large stable set. A similar statement can be formulated for tournaments (a tournament is an orientation of a complete graph), replacing cliques and stable sets by transitive subtournaments; and the two conjectures turn out to be equivalent. This talk will survey a number of recent results related to the latter conjecture. In particular, we will discuss a new infinite class of tournaments excluding which forces large transitive subtournaments; to the best of our knowledge this is the first such class not obtained by the so-called substitution operation.

Maria Chudnovsky
Columbia
mchudnov@columbia.edu

IP4

Adding and Counting

In mathematics, the stuff of partitions seems like mere child's play. The speaker will explain how the simple task of adding and counting has fascinated many of the world's leading mathematicians: Euler, Ramanujan, Hardy, Rademacher, Dyson, to name a few. And as is typical in number theory, many of the most fundamental (and simple to state) questions have remained open. In 2010, the speaker, with the support of the American Institute for Mathematics and the National Science Foundation, assembled an international team of researchers to attack some of these problems. Come hear Professor Ono speak about their findings: new theories which solve some of the famous old questions.

Ken Ono
Emory University
Department of Mathematics and Computer Science
ono@mathcs.emory.edu

IP5

Coloring 3-colorable Graphs; Graph Theory Finally Strikes Back!

We consider the problem of coloring a 3-colorable graph in polynomial time using as few colors as possible. Starting with Wigderson in 1982 ($O(n^{1/2})$ colors), Blum in 1990 came with the first polynomial improvements ($O(n^{3/8})$ colors). His improvement is based on graph theoretical approach. Karger, Motwani, Sudan in 1994 is the first to use semi-definite programming (SDP) to give improvement, and then Karger and Blum in 1997 combines Blum's method with the SDP improvement to show that $O(n^{0.2142})$ colors suffices. Since then, the only improvements in semidefinite programming have been made (Arora, Chlamtac, and Charikar in 2006 ($O(n^{0.2111})$ colors), and Chlamtac in 2007 ($O(n^{0.2072})$ colors)). We present the first improvement on the graph theory side since Blum in 1990. With a purely graph theoretical approach, we get down to $O(n^{4/11})$ colors (over Blum's $O(n^{3/8})$ colors). Combining it with SDP, we get down to $O(n^{0.2038})$ colors. Joint work with Mikkel Thorup (ATT Research)

Ken-ichi Kawarabayashi
National Institute of Informatics, Japan
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IP6

Talk Title TBA - Singh

Abstract not available at time of publication.

Mona Singh
Princeton University
msingh@cs.princeton.edu

IP7

The Hub Labeling Algorithm

This is a survey of Hub Labeling results for general and road networks. Given a weighted graph, a distance oracle takes as an input a pair of vertices and returns the distance between them. The labeling approach to distance oracle design is to precompute a label for every vertex so that distances can be computed from the corresponding labels. This approach has been introduced by [Gavoille et al. '01], who also introduced the Hub Labeling algorithm (HL). HL has been further studied by [Cohen et al. '02]. We study HL in the context of graphs with small highway dimension (e.g., road networks). We show that under this assumption HL labels are small and the queries are sublinear. We also give an approximation algorithm for computing small HL labels that uses the fact that shortest path set systems have small VC-dimension. Although polynomial-time, precomputation given by theory is too slow for continental-size road networks. However, heuristics guided by the theory are fast, and compute very small labels. This leads to the fastest currently known practical distance oracles for road networks. The simplicity of HL queries allows their implementation inside of a relational database (e.g., in SQL), and query efficiency assures real-time response. Furthermore, including HL data in the database allows efficient implementation of more sophisticated location-based queries. This approach brings the power of location-based services to SQL programmers

Andrew Goldberg
Microsoft Research Silicon Valley
goldberg@microsoft.com

IP8

Algorithms, Graph Theory, and the Solution of Laplacian Linear Equations

We survey several fascinating concepts and algorithms in graph theory that arise in the design of fast algorithms for solving linear equations in the Laplacian matrices of graphs. We will begin by explaning why linear equations in these matrices are so interesting. The problem of solving linear equations in these matrices motivates a new notion of what it means for one graph to approximate another. This leads to a problem of graph sparsification–the approximation of a graph by a sparser graph. Our algorithms for solving Laplacian linear equations will exploit surprisingly strong approximations of graphs by sparse graphs, and even by trees. We will survey the roles that spectral graph theory, random matrix theory, graph sparsification, low-stretch spanning trees and local clustering algorithms play in the design of fast algorithms for solving Laplacian linear equations.

Daniel Spielman
Yale University
spielman@cs.yale.edu

CP1

On Antimagic Vertex Labeling Of Hypergraphs

Let $H = (V, E)$ be a graph with vertex set $V(H)$ and edge set $E(H)$. Moreover suppose that $v = |V(H)|, e = |E(H)|$ and N denotes the set of non negative integers. An antimagic (magic) vertex labeling is a bijection "f" from $V(H)$ to the set of consecutive integers $1, 2, \ldots, v$ if the induced edge labeling "g" from $E(H)$ to the set of non negative integers N defined by g(e)=? f(v) for all v in $E(G)$ is injective (constant) function. A hypergraph H is called antimagic (magic) iff there exist an antimagic (magic) vertex labeling of H. In this paper we formulate antimagic vertex labeling on star and disjoint union of star hypergraph.

Akhlaq Bhatti
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Muhammad Javaid
FAST-National University of Computer and Emerging Sciences
Lahore Campus, Lahore, Pakistan
javaidmath@gmail.com

CP1

Distingushing with Nordhaus Gaddum graphs

Albertson and Collins introduced the distinguishing number in 1996 and Collins and Trenk introduced the distinguishing chromatic number of a graph which requires that the coloring be proper as well as distinguishing in 2006. We revisit the Nordhaus-Gaddum inequalities which give bounds on the sum and the product of $\chi(G)$ and $\chi(\overline{G})$ for any graph G, and give analogues of these inequalities for the distinguishing chromatic number. We provide a new characterization of those graphs that achieve equality for the upper bound in the sum Nordhaus-Gaddum inequality, which leads to a polynomial-time recognition algorithm for this class and efficient computation of their chromatic numbers.

Karen Collins
Wesleyan University
kcollins@wesleyan.edu

Ann N. Trenk
Wellesley College
atrenk@wellesley.edu

CP1

On Super (a,d)-Edge Antimagic Total Labeling of Subdivided Caterpillar

Let $G = (V, E)$ be a graph with $v = |V(G)|$ vertices and $e = |E(G)|$ edges. An(a, d)-edge antimagic total labeling is a bijection "f" from $V(G)UE(G)$to the set of consecutive integers $1, 2, .., v + e$, such that the weights of the edge $W = \{w(xy) : xy \text{ in } E(G)\}$ form an arithmetic progression with the initial term "a" and common difference "d" where $w(xy) = f(x) + f(y) + f(xy)$. "W" is called the set of edge-weights of the graph G. Additionally, if $f(V) = 1, 2, ..., |V(G)|$ then f is called super (a, d)-edge antimagic total labeling and G is called super(a, d)-edge antimagic total. In this paper we formulate, super (a, d)-edge antimagic total labeling on subdivided caterpillar for different integral values of d.

Muhammad Javaid
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CP1

On Two Conjectures About Graceful Digraphs

A digraph D with p vertices and q arcs is labeled by assigning a distinct integer value $g(v)$ from $\{0, 1, \ldots, q\}$ to each vertex v. The vertex values, in turn, induce a value $g(u, v)$ on each arc (u, v) where $g(u, v) = (g(v) - g(u))(mod\, q+1)$.

If the arc values are all distinct then the labeling is called a graceful labeling of digraph. In this talk we present the proofs of two conjectures namely, Bloom and Hsu's conjecture (1985) on graceful unicyclic wheels and Du and Sun's conjecture (1994) on the gracefulness of the digraph $n.\overrightarrow{C_m}$.

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CP2

Saving Sets of Vertices in the Firefighter Problem

The Firefighter Problem is a discrete-time model of the spread of a fire using a simple graph. At each time step a player has an opportunity to defend some vertex (or set of vertices) and then the fire spreads from all burning vertices to all of their undefended neighbours. Here we examine the decision problem that asks if a specified set of vertices can be saved from burning.

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CP2

A Game on Zero Forcing Sets

We consider the two player game on a graph where players alternate turns, with one player selecting a vertex to color black on each turn and the other player selecting a vertex to color white on each turn. The black player wins if after all of the vertices have been colored, the black vertices form a zero forcing set. This game will be discussed for several classes of graphs.

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CP2

A Generalization of the Nim and Wythoff Games

We define a two-player game $\mathcal{G}(\|, \backslash)$ (with $k \leq n$) as follows: each player chooses up to k stacks from a total of n stacks and removes an equal number of tokens from the selected stacks. The first player who cannot move loses. $\mathcal{G}(\infty, \backslash)$ is ordinary Nim and $\mathcal{G}(\in, \in)$ is Wythoff. We will present a conjecture on the structure of the losing positions of this class of games and prove a special case of the conjecture.

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CP2

Structure of Weighted Graphs with Forbidden Subdivision and Graph Sharing Games

We show that every weighted graph excluding subdivision of a fixed (small) graph contains one of the following structures:

- a connected subgraph separating the graph into heavy balanced components,
- a heavy set of vertices connected by paths as in a cycle.

This characterization yields a strategy for the first player to gather a positive fraction of the total weight in a variant of graph sharing game played on graphs with forbidden subdivision.

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CP3

2-Switches and Isomorphism Classes

A 2-switch is an operation that changes adjacencies in a graph while preserving vertex degrees. The resulting graph may or may not have the same isomorphism class; we show that if a 2-switch changes the isomorphism class of a graph, then it takes place in one of four configurations. We also present a sufficient condition for 2-switches to change graph isomorphism classes and examine consequences for graphs determined up to isomorphism by their degree sequences.

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CP3

The Number of Spanning Trees in Self-Similar Graphs.

The number of spanning trees of a graph is an important invariant related to its topological and dynamic properties (reliability, communication, synchronization,etc.) Its calculation remains a challenge, particularly for large networks. We describe a method to find an exact analytical expression for the number of spanning trees (and tree entropy) for several relevant graph families, including Hanoi graphs, Apollonian networks and some maximal outerplanar graphs. The method is based on the self-similarity of the graphs considered.

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CP3

On the 2-Edge Clique Cover Numbers of Graphs

Let $\mathcal{F}$ be a multifamily of subsets of the vertex set of a graph G. The multifamily $\mathcal{F}$ is called a 2-edge clique cover of G if for any two distinct I, $J \in \mathcal{F}$, $I \cap J$ is a clique of G, and the family $\{I \cap J \mid I, J \in \mathcal{F}, \mathcal{I} \neq \mathcal{J}\}$ is an edge clique cover of G. The minimum size of a 2-edge clique cover of G is called the 2-edge clique cover number of G. In general, it is hard to compute a 2-edge clique cover of a graph. In this talk, we study relationships between the 2-edge clique cover number and the edge clique cover number of a graph. Then we focus on the 2-edge clique cover numbers of a path and a cycle, and then give a bound for 2-edge clique cover number of a star $K_{1,n}$ by using a block design.

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CP3

Dual-Chordal and Strongly Dual-Chordal Graphs

If a subgraph is defined to be strength-k whenever it is in $\geq k$ maxcliques, then a graph is (strongly) chordal if and only if (for all $k \geq 1$) every cycle of (strength-k) edges either has a (strength-k) chord or is a (strength-k) triangle. A carefully crafted notion of dual strength (using cycle/cutset duality) allows parallel characterizations of (strongly) dual-chordal graphs and a listing of all 3-connected strongly dual-chordal graphs.

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CP3

Well-Covered Graphs Without C_4, C_5, C_6

Let $G = (V, E)$ be a graph and $w : V \longrightarrow R$ be a weight function. Then G is *w-well-covered* if all its maximal independent sets are of the same weight. The set of weight functions w such that G is w-well-covered is a *vector space*. Given an input graph G without cycles of length 4, 5, and 6 (not necessarily induced), we characterize polynomially the vector space of weight functions w for which G is w-well-covered.

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CP4

Construction of nonuniform p-wavelet packets

A generalization of Mallat's classical multiresolution analysis for which the translation set is a discrete set which is not a group, was defined by Gabardo and Nashed. In this talk, we introduce nonuniform multiresolution p-analysis on $L^2(R^+)$, analogy of Gabardo-Nashed definition and then we will construct the associated p-wavelet packets for such an multiresolution p-analysis on $L^2(R^+)$.

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CP4

Application of New Variational Method Using Hamiltonian for Nonlinear Oscillators with Discontinuities

In this paper, we used Hamiltonian for nonlinear oscillators with discontinuities. The maximal relative error for the frequency obtained by new variational method compared with the exact solution indicates the remarkable precision of this method. Some examples are given to illustrate the effectiveness and convenience of the method

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CP4

A Comparison of Conventional and Fuzzy Methods in Performance Appraisal Process

The purpose of this paper is to address the performance appraisal process via conventional and Fuzzy satisfied methods.Conventional methods for solving performance appraisal decision making problem are by using statistical methods(chi-square, correlation etc)on the measurement of performance based on specific appraisal criteria.This research shows that the Fuzzy satisfied method is an easy to understand and realistic technique as it enables us to understand the relative strengths and weaknesses of employees,thus providing useful information for improving competitive advantage.

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CP4

On the Structure of Some Groups Containing $L_2(13)wrl_2(17)$

In this paper, we will show the structure of some groups containing the wreath product $L_2(13)wrL_2(17)$.Some symmetric and alternating groups are constructed in view of such wreath product. Some other related cases are also included.

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CP4

Fixed Points Of a Fuzzy Semantics Function

The meaning of a program is given by specifying the function (from input to output) that corresponds to the program. The denotational semantic definition, thus maps syntactical things into functions. A fuzzy relational semantics is a mapping of programs to relations. We consider that the input-output semantics of a program is given by a fuzzy relation on its set of states. In a nondeterministic context, this relation is calculated by considering the worst behavior of the program (*demonic fuzzy relational semantics*). In this paper, we concentrate on while loops. We will present some interesting results about the fixed points of the while fuzzy semantics function; $f(X) = Q \cup_f uzP_f uzX$ where $PQ =$, by taking $P := tB$ and $Q := t$, one gets the demonic semantics we have assigned to while loops in previous papers. We will show that the least angelic fixed point is equal to the greatest demonic fixed point of the fuzzy semantics function.

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CP4

Binary Sequences, Fractals, and Primes

The concept of a fractal transformation is discussed. A 1-dimensional example leads to connections between the topics in the title.

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CP5

Order Dimension and Coloring of Planar Point Sets

The Erdős-Szekeres Conjecture of planar point sets in general position will be discussed using convex geometries or anti-matroids. We study this problem with two graphs, one based on the lattice of closed sets and the other from the copoints of the convex geometry. We use these graphs to show that any point set in general position with at least $2^{n-2} + 1$ has order dimension at least n.

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CP5

Universal Cycles for Weak Orders and a Problem of Knuth

A weak order on $[n] = \{1, 2, ..., n\}$ is a string $w_1w_2...w_n$ such that $\{w_1, w_2, ..., w_n\} = [h]$, for some height $h \leq n$. Knuth asked: For which n does there exist a Gray code for all weak orders on $[n]$ using operations of the form $w_i \leftrightarrow w_{i+1}$ and $w_i \leftarrow w_{i+1}$? We prove such existence for a class of weak orders with the additional operation $w_i \leftrightarrow w_{i+2}$ and discuss open problems for fixed height weak orders that are related to solving the original problem. Furthermore, we present constructions of universal cycles for weak orders, as well as for weak orders of fixed height or weight.

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CP5

Zeta Polynomials for Shellable Posets and Their Applications

The zeta polynomial $Z(P, n)$ for a poset P is the number of multichains in P of length $n-2$, and a shellable poset P is a graded poset whose maximal chains explain the structure of chains in P. Using shellability, we establish theorems on computations of zeta polynomials for shellable posets. Applying these theorem, we also derive new resluts on multidimensional partitions, multidimensional Young tableaux, lattice paths, and multiset permutations.

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CP5

The Largest Size Versus the Largest Weight of Families of Sets Without a Poset P

We are interested in how large a family of subsets of $[n] := \{1, 2 \ldots, n\}$ not containing a given poset P as a subposet can be. Such a family is called a P-free family and the largest size of a P-free family is denoted by $\mathrm{La}(n, P)$. Griggs and Lu conjectured that $\pi(P) := \lim_{n\to\infty} \mathrm{La}(n, P)/\binom{n}{\lfloor \frac{n}{2} \rfloor}$ exists and is an integer for any finite P. The Lubell function of a family $\mathcal{F}$ of subsets of $[n]$ is $\bar{h}_n(\mathcal{F}) := \sum_{\mathcal{E}\in\mathcal{F}} \binom{\setminus}{|\mathcal{E}|}^{-\infty}$ which can be viewed as the weighted sum of sets in $\mathcal{F}$. It gives an upper bound of $|\mathcal{F}|$, which is crucial in solving the forbidden subposet problem above. We will study the limit of $\lambda_n(P) := \max_{\mathcal{F}} \bar{h}_n(\mathcal{F})$ over all P-free families $\mathcal{F}$ as n increases and demonstrate a class of posets satisfying $\pi(P) = \lim_n \lambda_n(P)$. We will also show that for many posets $\lim_n \lambda_n(P)$ exists and can be evaluated, although $\pi(P)$ is unknown.

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CP5

Searching Algorithms in Partially Ordered Set

Using conceptual graphs and graph homomorphism it is possible to build a basic query-answering mechanism based on semantic search. Because graph homomorphism is NP-Complete, the main requirement for conceptual graph database building and managing algorithms is to reduce the homomorphism checks. Graph homomorphism defines a partial order over conceptual graphs. Searching is a basic operation for building and managing operations as ordering, updating, and retrieval. We propose two new searching algorithms in a poset.

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CP5

The Bkr Inequality on Finite Distributive Lattices

The van den Berg-Kesten-Reimer inequality, or BKR inequality, is a well-known result in combinatorial probability with applications in percolation. The BKR inequality applies to product spaces X equipped with product probability measures. For events A and B, the box product of A and B is the set of tuples x in X that lie in A and B disjointly, i.e. x lies in A due to the values of one set of x's coordinates and in B due to a disjoint set of coordinates. The BKR inequality states that for any two events A and B of any finite product probability space the measure of the box product of A and B is less than or equal to the product of the measures of A and B. We extend the box product and the BKR inequality to finite distributive lattices with log modular measures, analogues of product measures. A product space can be made into a distributive lattice by linearly ordering each member of the product. The new box product of A and B will then contain the old box product. Furthermore the containment is often strict, improving the BKR inequality.

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CP6

On the Locating-Chromatic Number of a Corona Product of Two Graphs

The problem of determining the locating-chromatic number for a general graph is an NP-hard problem. Therefore, there is no efficient algorithm to determine this number of arbitrary graph. Some heuristics have been developed and some studies were done to find the locating-chromatic number for certain graphs. In this paper, we investigate the locating-chromatic number for a corona product $G \odot H$. Some upper bound will be derived. We also determine the locating-chromatic number of certain graphs.

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CP6

On The Structure Of The γ-Graph Of A Tree

The γ-graph of a graph G has vertex set comprised of all minimum dominating sets of G. There are two ways to define adjacency in the γ-graph: where dominating sets are adjacent if they agree in all but one vertex, or where dominating sets are adjacent if they agree in all but one vertex and the differing vertices are adjacent. Here we answer open questions on maximum degree, diameter, and order of γ-graphs for trees.

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CP6

Some Unsolved Problems on Cycles

Hajos' conjecture that every simple even graph on n vertices can be decomposed into at most $(n-1)/2$ cycles. Let $f(n)$ be the maximum number of edges in a graph on n vertices in which no two cycles have the same length. P. Erdos raised the problem of determining $f(n)$. P. Erdos conjectured that there exists a positive constant c such that $ex(n, C_{2k}) \geq cn^{1+1/k}$. This talk summarizes some results on these problems and the conjectures that relate to these. It seems to me that Hajós conjecture is false.

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CP6

On Signed Star Domination and Domatic Numbers of Complete Multipartite Graphs

The signed star domination and domatic numbers of a graph G, $\gamma_{SS}(G)$ and $d_{SS}(G)$, were first introduced in [B. Xu, On edge domination numbers of graphs, Discrete Mathematics, 294 (2005), 311–316.] and [M. Atapour, S. M. Sheikholeslami, A. N. Ghameshlou and L. Volkmann, Signed star domatic number of a graph, Discrete Applied Mathematics, 158 (2010), 213–218.]. We give new constructions to complete the proofs of $\gamma_{SS}(K_{m,n})$ and $d_{SS}(K_{m,n})$. We also obtain $\gamma_{SS}(K_{m(n)})$ and $d_{SS}(K_{m(n)})$.

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CP6

Decompositions of Complete Multipartite Graphs

into Gregarious Long Cycles

The notion of gregarious cycles in complete multipartite graphs was introduced by Billington and Hoffman in 2003 and was modified by Billington, Smith, and Hoffman in 2007. In this talk, we propose more general definition of "gregarious" cycles which is a common generalization of both the definitions. With our definition, we can consider the problem to characterize complete multipartite graphs which are decomposable into gregarious long cycles, and we give some results on this problem.

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CP6

A New Upper Bound for the Broadcast Domination Number of a Graph

The *broadcast domination number* of a graph G, denoted $\gamma_b(G)$, is the minimum cost of a dominating broadcast on G. We present an improvement to the well-known Bollobás-Cockayne bound from $\gamma_b(G) \leq \min\{rad(G), \gamma(G)\} \leq 2\ \mathrm{ir}(G) - 1$, to $\gamma_b(G) \leq \frac{3}{2}\ \mathrm{ir}(G)$. We also show the existence of a graph G with $\gamma_b(G) - \mathrm{ir}(G) = k$ for any positive integer k.

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CP7

The Edge Density of Critical Digraphs

Let $\chi(G)$ denote the chromatic number of a graph G. We say that G is k-critical if $\chi(G) = k$ and $\chi(H) < k$ for every proper subgraph $H \subset G$. Over the years, many properties of k-critical graphs have been discovered, including improved upper and lower bounds for $||G||$, the number of edges in a k-critical graph, as a function of $|G|$, the number of vertices. In this note, we analyze this edge density problem for directed graphs, where the chromatic number $\chi(D)$ of a digraph D is defined to be the fewest number of colours needed to colour the vertices of D so that each colour class induces an acyclic subgraph. For each $k \geq 3$, we construct an infinite family of sparse k-critical digraphs for which $||D|| < (\frac{k^2-k+1}{2})|D|$ and an infinite family of dense k-critical digraphs for which $||D|| > \left(\frac{1}{2} - \frac{1}{2^{k-1}}\right)|D|^2$. One corollary of our results is an explicit construction of an infinite family of k-critical digraphs of digirth l, for any pair of integers $k, l \geq 3$. This extends a result by Bokal et. al. who used a probabilistic approach to demonstrate the existence of one such digraph.

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CP7

On the Density of Nearly Regular Graphs with a Good Edge-Labelling

A good edge-labelling of a simple graph is a labelling of its edges with real numbers such that, for any ordered pair of vertices (u, v), there is at most one non-decreasing path from u to v. Say a graph is good if it admits a good edge-labelling, and is bad otherwise. Our main result is that any good n-vertex graph whose maximum degree is within a constant factor of its average degree (in particular, any good regular graph) has at most $n^{1+o(1)}$ edges. As a corollary, we show that there are bad graphs with arbitrarily large girth, answering a question of Bode, Farzad and Theis. We also prove that for any Δ, there is a g such that any graph with maximum degree at most Δ and girth at least g is good.

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CP7

Bounds on Shannon Capacity and Ramsey Numbers from Product of Graphs

We study Shannon capacity of channels in the context of Ramsey numbers. We overview some of the results on channel capacity, and how Ramsey-type constructions may enhance them. A new lower bound for a special type of multicolor Ramsey numbers is presented, which implies that the supremum of the Shannon capacity over all graphs with independence 2 cannot be achieved by any finite graph power. This generalizes to graphs with any bounded independence number.

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CP7

Colorings of Uniform Hypergraphs with Large Girth

The talk deals with a combinatorial problem concerning colorings of uniform hypergraphs with large girth. Let H be a hypergraph and $\Delta(H)$ denote the maximum vertex degree of H. By using a continuous-time random recoloring process we prove that if H is an n-uniform non-r-colorable hypergraph with girth at least 6 then

$$\Delta(H) \geq c\,\frac{r^{n-1}}{\ln n},$$

where $c > 0$ is an absolute constant.

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CP7

Embedding Spanning Bipartite Graphs of Small Bandwidth

Böttcher, Schacht and Taraz gave a condition on the minimum degree of a graph G on n vertices that ensures G contains every r-chromatic graph H on n vertices of bounded degree and of bandwidth $o(n)$, thereby proving a conjecture of Bollobás and Komlós. We strengthen this result in the case when H is bipartite by relaxing the condition on G to a condition on the degree sequence of G.

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CP8

Forbidden Submatrices

We consider an extremal hypergraph problem, where the order of the elements and of the hyperedges matter. In matrix terms, let F be a given (0,1)-matrix. Among all m-rowed (0,1)-matrices with no repeated columns and no submatrix F, what is the maximum number of columns? We call this $fs(m, F)$. It was conjectured by Anstee, Frankl, Furedi, Pach that if F has k rows then $fs(m, F)$ is $O(m^k)$. We give results for 2-rowed F.

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CP8

Intertwining Connectivities in Matroids Representable over a Finite Field

Let N_1 and N_2 be matroids. An *intertwine* of N_1 and N_2 is a matroid that has both an N_1- and N_2-minor, and is minor-minimal with this property. Bonin proved that there exist matroids N_1 and N_2 with infinitely many intertwines. We prove that if we instead intertwine "connectivities" instead of minors, then are a finite number of $\mathbf{F}$-representable intertwines, for $\mathbf{F}$ finite.

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CP8

The Minimum Rank of Universal Adjacency Matrices

For a simple graph G on n vertices, a matrix of the form

$$U(\alpha, \beta, \gamma, \delta) = \alpha A + \beta I + \gamma J + \delta D$$

where A is the 0,1-adjacency matrix of G, J is the all ones matrix of size n, I is the identity matrix of size n, and D is the diagonal matrix with the degrees of the vertices in the main diagonal, and $\alpha \neq 0, \beta, \gamma, \delta$ are scalars, is called a *universal adjacency matrix* of G. An analogous parameter to the minimum rank of a given graph G is the minimum rank over all matrices in the set of universal adjacency matrices of G. This parameter is called the *minimum universal rank* of G, and is denoted by mur(G). Graphs with mur(G) equal to zero and one are characterized. The minimum universal rank of some families of graphs such as complete graphs, complete bipartite graphs, paths and cycles are presented. A formula for the minimum universal rank of a regular graph is given. Finally, it is shown that mur(G) is not monotone on induced subgraphs.
This is joint work with Discrete Mathematics Research Group at the University of Regina.

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CP8

The Supertail of a Subspace Partition

Let $V = V(n, q)$ be a vector space of dimension n over the finite field with q elements, and let $d_1 < d_2 < \ldots < d_m$ be the dimensions that occur in a subspace partition $\mathcal{P}$ of V. Let $\sigma_q(n, t)$ denote the minimum size of a subspace partition of V in which t is the largest dimension of a subspace. For any integer s, with $1 < s \leq m$, the set of subspaces in $\mathcal{P}$ of dimension less than d_s is called the s-supertail of $\mathcal{P}$. We show that the number of subspaces in an s-supertail is at least $\sigma_q(d_s, d_{s-1})$.

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CP8

Rank-Width and Well-Quasi-Ordering of Skew-Symmetric Or Symmetric Matrices

We prove that every infinite sequence of skew-symmetric or symmetric matrices M_1, M_2, ... over a fixed finite field must have a pair M_i, M_j $(i < j)$ such that M_i is isomorphic to a principal submatrix of the Schur complement of a nonsingular principal submatrix in M_j, if those matrices have bounded rank-width. This generalizes three theorems on well-quasi-ordering of graphs or matroids admitting good tree-like decompositions; (1) Robertson and Seymour's theorem for graphs of bounded tree-width, (2) Geelen, Gerards, and Whittle's theorem for matroids representable over a fixed finite field having bounded branch-width, and (3) Oum's theorem for graphs of bounded rank-width with respect to pivot-minors.

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CP9

Applications of the Traveling Salesman Problem and Perfect B-Matching for Finding Genomic Medians

Genomic medians model an ancestor of several species. There has been extensive research on finding medians. We study the Breakpoint Median Problem (BMP) and present a novel and successful approach in which the NP-hard problem of BMP for linear multichromosomal genomes is transformed into a variation of the Traveling Salesman Problem. We also use prefect b-matchings to show, for the first time, that BMP for circular or mixed unsigned genomes is solvable in polynomial time.

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CP9

A Branch, Bound, and Remember Algorithm for the Simple Assembly Line Balancing Problem

A new exact algorithm is presented for the assembly line balancing problem, which finds and verifies the optimal solution for every problem in the benchmarks of Hoffmann, Talbot, and Scholl one-half second per problem, on average, including one problem that has remained open for over ten years. The previous best known algorithm solved 257 of the 269 benchmarks. The new algorithm is based on a branch and bound method using memory to eliminate redundant subproblems.

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CP9

An Approximation Algorithm for the Multilevel Bottleneck Assignment Problem

We deal with the multilevel bottleneck assignment problem. The multilevel bottleneck assignment problem is NP-complete, and some approximation algorithms have been proposed. We propose an approximation algorithm that uses the element's rank in each set sorted in the ascending order. We show the effectiveness of our algorithm by numerical experiments for the case that elements' values follow the normal distribution. Also we present the idea of our algorithm's extension to multidimensional case.

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CP9

Greedy Is Good to Approximate Minimum Rainbow Subgraphs

We consider the Minimum Rainbow Subgraph problem (MRS): Given a graph G, whose edges are coloured with p colours. Find a subgraph $F \subseteq G$ of minimum order and with p edges such that each colour occurs exactly once. In this talk we will show that the Greedy algorithm for the MRS problem has an approximation ratio of $\frac{\Delta}{2} + \frac{\ln \Delta + 1}{2}$ for graphs with maximum degree Δ. If the average degree d of a minimum rainbow subgraph is known, then the approximation ratio is $\frac{d}{2} + \frac{\ln \lceil d \rceil + 1}{2}$.

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CP10

Constructing Self-Dual Graph Embeddings in Surfaces

A cellular automorphism of a surface S is a 2-cell graph embedding G in S together with an automorphism of the cellular structure given by G. We detail methods which allow one, given a catalog of all cellular automorphisms in any particular surface S (such as we have produced for five surfaces), to construct all self-dual graph embeddings in S. Our methods account for all free and all non-free automorphisms, of all possible orders.

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CP10

k-Metric Dimension of Graphs

Let $G(V, E)$ be a connected graph. A subset S of V is said

to be *k-resolving set* of G, if for every pair of distinct vertices $u, v \in V - S$, there exists a vertex $w \in S$ such that $|d(u, w) - d(v, w)| \geq k$, for some $k \in Z^+$. Among all k-resolving sets of G, the set having minimum cardinality is called a *k-metric basis* of G and its cardinality is called the *k-metric dimension* of G, denoted by $\beta_k(G)$. In this paper, we characterize the graphs with prescribed k-metric dimensions and also extend some of the earlier known results on metric dimension of graphs.

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CP10
Almost Empty Monochromatic Triangles in Planar Point Sets

For positive integers $c, s \geq 1$, let $M_\triangle(c, s)$ be the least integer such that any set of at least $M_\triangle(c, s)$ points in the plane, no three on a line and colored with c colors, contains a monochromatic triangle with at most s interior points. The case $s = 0$, which corresponds to empty monochromatic triangles, has been studied extensively over the last few years. In particular, it is known that $M_\triangle(1, 0) = 3$, $M_\triangle(2, 0) = 9$ and $M_\triangle(c, 0) = \infty$, for $c \geq 3$. In this paper we extend these results when $c \geq 4$ and $s \geq 1$. We prove that the least integer $\lambda(c)$ such that $M_\triangle(c, \lambda(c)) < \infty$ satisfies:

$$\frac{\lfloor c \rfloor_p - 1}{2} \leq \lambda(c) \leq c - 2,$$

where $c \geq 2$ and $\lfloor c \rfloor_p$ is the largest prime number less than or equal to c. We also show that $M_\triangle(c, c-2) \leq (c+1)^2$, for $c \geq 2$. Finally, we determine the exact values of $M_\triangle(c, s)$ for several small values of c and s, and discuss related problems for general convex polygons.

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CP10
On The Metric Dimension Of Generalized Wheel And Other Graphs

For an ordered set $W = \{w_1, w_2, ..., w_k\}$ of vertices and a vertex v in a connected graph G, the representation of v with respect to W is the ordered k-tuple $r(v \mid W) = (d(v, w_1), d(v, w_2), ..., d(v, w_k))$, where $d(x, y)$ represents the distance between the vertices x and y. The set W is called a resolving set for G if every two vertices of G have distinct representations. A resolving set containing a minimum number of vertices is called a basis for G. The elements of a metric basis are called land marks and the metric dimension of G, denoted by $\beta(G)$, is the number of vertices in a basis of G.
A generalized wheel graph is $W_{mn} = C_m + \overline{K_n}$. In this Paper we determine the metric dimensions of Generalized Wheel graphs. We also obtain the metric dimension of some cellular network graphs and their dual graphs.

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CP10
Latin Squares and Competition Numbers

In this talk we show how latin squares are used to find bounds on the competition numbers of complete multipartite graphs. Let G be a graph and let I_k denote the graph on k isolated vertices. The minimum k such that $G \cup I_k$ is the competition graph of an acyclic digraph is called the competition number of G. We show that if $n \geq 5$ is odd, then $k(K_n^4) \in \{n^2 - 4n + 7, n^2 - 4n + 8\}$. For the general case, we show that if n is a prime integer and $m \leq n$, then $k(K_n^m) \leq n^2 - 2n + 3$.

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CP10
Metric Dimension of Amalgamation of Graphs

A set of vertices S resolves a graph G if every vertex is uniquely determined by its vector of distances to the vertices in S. The metric dimension of G is the minimum cardinality of resolving set of G. Let $\{G_1, G_2, \ldots, G_n\}$ be a finite collection of graphs and each G_i has a fixed vertex v_{0_i} called a terminal. The amalgamation $Amal\{G_i; v_{0_i}\}$ is formed by taking all the G_i's and identifying their terminals. Here we study the metric dimension of $Amal\{G_i; v_{0_i}\}$ for $\{G_1, G_2, \ldots, G_n\}$ a finite collection of arbitrary graphs. We give lower and upper bounds for the dimension, show that the bounds are tight, and construct infinitely many graphs for each possible value of dimensions.

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CP11
The Periodicity of Winning/Losing States in Subtraction Games

A subtraction game is a game involving a pile of tokens and a finite set S of positive integers. Two players move alternately, each removing some m tokens provided that m is an element in S. The player who makes the last move wins. We introduce an observation on the periodicity of the winning/losing positions of subtraction games which have a connection to the periodicity of the nim-sequences.

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CP11
Towards a De Bruijn-Erdos Theorem in the L_1-

Metric

In 1948, de Bruijn and Erdős proved that every set of n points in the plane is either collinear, or it induces at least n lines. The notion of a line can be extended in a natural way to an arbitrary metric space as follows. If δ is a metric, we say that the point x is *between* the points a and b if $\delta(a,b) = \delta(a,x) + \delta(x,b)$. The *line* induced by the points a and b consists of the points a, b, and all points x such that one of a, b, x is between the other two. With the usual Euclidean, or L_2, metric, this is equivalent to the usual definition of a line. Chen and Chvátal conjectured in 2006 that a statement analogous to the de Bruijn–Erdős theorem holds in any finite metric space. Despite several partial results, this question is still open. We prove that with the L_1 (also called Manhattan) metric, every set of n points in the plane is either collinear, or it induces at least $\Omega(n^{6/7-o(1)})$ lines.

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CP11

Radio Number of k^{th} Power of a Path

Let G be a connected graph. For any two vertices u and v, let $d(u,v)$ denotes the distance between u and v in G. The maximum distance between any pair of vertices is called the *diameter* of G and is denoted by $diam(G)$. A radio labeling of a connected graph G is an assignment of distinct positive integers to the vertices of G, with $x \in V(G)$ labeled $f(x)$, such that $|f(u)-f(v)|+d(u,v) \geq 1+diam(G)$ for all $u, v \in V, u \neq v$. The radio number $rn(f)$ of a radio labeling f of G is the maximum label assigned by f to a vertex of G. The radio number $rn(G)$ of G is the $min\{rn(f)\}$ over all radio labeling f of G. The k^{th} power of a graph G, denoted by G^k, is the graph on the vertices of G with two vertices u and v are adjacent in G^k, whenever $d(u,v) \leq k$ in G. In this paper, we completely determine the radio number of the graph P_n^k for positive integers n, k with $k \geq 2$.

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CP11

Discrete Operators Applied to Further Generalize the Integral Image Algorithm

The "Integral Image" algorithm was extended to continuous and more general domains by Wang, Doretto et al in 2007. Their theorem will be abbreviated the "Antiderivative Formula" in this talk. The main results are: (1) a more rigorous formulation (via a discretization of the derivative) to a parameter at the antiderivative formula, and (2) an extension of the antiderivative formula to more general types of domains, via a (novel) discrete integration method over curves in the plane.

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CP11

Graphs with Minimum Identifying Code and Minimum Size

In a graph G, let $B(u)$ be the set of u with all its neighbors in G. A subset S of vertices is called an identifying code of G if, for every pair of distinct vertices u and v, both $B(u) \cap S$ and $B(v) \cap S$ are nonempty and distinct. A minimum identifying code of a graph G is an identifying code of G with minimum cardinality and $M(G)$ is the cardinality of a minimum identifying code for G. A minimum identifying code graph G of order n is a graph with $M(G) = \lceil \log_2(n+1) \rceil$ having the minimum number of edges. Moncel constructed minimum identifying code graphs of order $2^m - 1$ for $m \geq 2$ and left the same problem, for arbitrary order, to be open. In this talk, we purposed the construction of connected minimum identifying code graphs to solve this problem.

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CP12

Eulerian Circuits with No Monochromatic Transitions.

Let G be an eulerian digraph with a fixed edge coloring (not necessarily a proper edge coloring). A compatible circuit T is an eulerian circuit of G such that no consecutive edges in the circuit have the same color. We provide sufficient conditions for the existence of a compatible circuit, strengthening results of Fleischner and Isaak. We also show several examples of digraphs that do not have compatible circuits.

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CP12

Labeled Embeddings of Graphs

We present a recent variant of the graph embedding problem on labeled graphs. Given a graph $G = (V, E)$, a k-labeled embedding of G is a labeling $f : V \to \{1..k\}$ such that there exists an edge-disjoint placement of two copies of G into the complete graph $K_{|V|}$ preserving f. The objective consists in maximizing the number of labels k. We give upper bounds in the general case, exact values for some families of graphs, and extensions for the placement

of more than two copies of G.

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CP12

Dynamic Coloring and List Dynamic Coloring of Planar Graphs

A *dynamic chromatic number* $\chi_d(G)$ of a graph G is the least number k such that G has a proper k-coloring of the vertex set $V(G)$ so that for each vertex of degree at least 2, its neighbors receive at least two distinct colors. We show that $\chi_d(G) \leq 4$ for every planar graph except C_5. The *list dynamic chromatic number* $ch_d(G)$ of G is the least number k such that for any assignment of k-element lists to the vertices of G, there is a dynamic coloring of G where the color on each vertex is chosen from its list. Based on Thomassen's result that every planar graph is 5-choosable, an interesting question is whether the list dynamic chromatic number of every planar graph is at most 5 or not. We answer this question by showing that $ch_d(G) \leq 5$ for every planar graph.

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CP12

The Competition Graphs of Powers of Digraphs

The *competition graph* $C(D)$ of a digraph D has the same vertex set as D and has an edge between vertices u and v if and only if there exists a common prey of u and v in D. Given a digraph D, the convergence of the sequence $\{C(D^m)\}_{m=1}^{\infty}$ has been studied by several researches that are related to the notion of competition index. In this paper, given a digraph D, we focus on the limit graph of the sequence $\{C(D^m)\}_{m=1}^{\infty}$ if it converges. We find the limit graph of $\{C(D^m)\}_{m=1}^{\infty}$ when D has at most two strongly connected components, and then we give a sufficient and necessary condition for its limit graph consisting of only complete connected components.

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CP12

Flow-Continuous Mappings – Influence of the Group

Mapping $f : E(G) \to E(H)$ is M-flow-continuous if for every flow ϕ on H using values in M the composition $\phi \circ f$ is a flow on G. This notion was introduced by Jaeger to approach flow-related conjectures (like CDC). We discuss the influence of the group on flow-continuous mappings. On one hand, groups for which this mapping exists exhibit nice structure. On the other hand, in the important case of snarks we can restrict to Z_2, Z_3 or Z.

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CP12

Total Weight Choosability of Cartesian Product of Graphs

A graph $G = (V, E)$ is called (k, k')-choosable if the following is true: For any total list assignment L which assigns to each vertex x a set $L(x)$ of k real numbers, and assigns to each edge e a set $L(e)$ of k' real numbers, there is a mapping $f : V \cup E \to \mathbf{R}$ such that $f(y) \in L(y)$ for any $y \in V \cup E$ and for any two adjacent vertices x, x', $\sum_{e\in E(x)} f(e) + f(x) \neq \sum_{e\in E(x')} f(e) + f(x')$. In this talk, we will show that if G is the Cartesian product of an even number of even cycles, or the Cartesian product of an odd number of even cycles and at least one of the cycles has length $4n$ for some positive integer n, then G is $(1, 3)$-choosable.

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CP13

Counting Minimal Sturmian Words

The subword complexity $p_w(n)$ of a word w is the number of distinct subwords of length n of w. We call a word w *Sturmian of order* N, if $p_w(n) = n + 1$ for $n = 1, \ldots, N$. It is *minimal* if it has minimal length among all Sturmian words of order N. Equivalently, it is minimal if it has length $2N$. Recently, Blanchet-Sadri and Lensmire considered such words and provided an algorithm for generating all of them using techniques from graph theory. In this paper, we exploit their approach in order to count the number of minimal Sturmian words of order N and we show that this number is connected to Euler's totient function from number theory. We also present some other results that come from applying this graph theoretical framework to subword complexity.

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CP13
Recurrence in Infinite Partial Words

The *recurrence function* $R_w(n)$ of an infinite word w was introduced by Morse and Hedlund in relation to symbolic dynamics. It is the size of the smallest window such that, wherever its position on w, all length n subwords of w will appear at least once inside that window. The *recurrence quotient* $\rho(w)$ of w, defined as limsup of the quotient of $R_w(n)$ and n, is useful for studying the growth rate of $R_w(n)$. It is known that if w is periodic, then $\rho(w) = 1$, while if w is not, then $\rho(w) \geq 3$. A long standing conjecture from Rauzy states that the latter can be improved to $\rho(w) \geq (2.5+.5\sqrt{5}) \sim 3.618$, this bound being true for each Sturmian word and being reached by the Fibonacci word. In this paper, we study in particular the spectrum of values taken by the recurrence quotients of infinite partial words, which are sequences that may have some undefined positions. In this case, we determine exactly the spectrum of values, which turns out to be 1, every real number greater than or equal to 2, and ∞. More precisely, if an infinite partial word w is "ultimately factor periodic", then $\rho(w) = 1$, while if w is not, then $\rho(w) \geq 2$, and we give constructions of infinite partial words achieving each value.

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CP13
Unavoidable Sets

Partial words are sequences over a finite alphabet that may contain some undefined positions called holes. We first consider unavoidable sets of partial words of equal length. We compute the minimum number of holes in sets satisfying some conditions (summed over all partial words in the sets). We also construct sets that achieve this minimum. This is a step towards the difficult problem of fully characterizing all unavoidable sets of partial words. We are next concerned with the complexity of deciding the avoidability of sets of partial words over an arbitrary alphabet. Towards this, we investigate the minimum size of unavoidable sets of partial words with a fixed number of holes. Additionally, we analyze the complexity of variations on the decision problem when placing restrictions on the number of holes and length of the words.

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CP13
Solving Wilf's Sigma-Tau Problem

We honor Herb Wilf (1931-2012) by solving Exercise 6 from his textbook *Combinatorial Algorithms* with Albert Nijenhuis (1975). The symmetric group S_n is generated by $\sigma = (1\ 2\ \cdots\ n)$ and $\tau = (1\ 2)$, and Wilf asks if S_n can be sequenced "so that each is obtained from its predecessor" by σ or τ. We settle Wilf's open problem with a cyclic sequence when n is odd, and a non-cyclic sequence when n is even.

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CP14
Monotone Path Systems in Regions with Holes

A monotone path system (MPS) is a finite set of pairwise disjoint paths (polygonal arcs) in the plane such that every horizontal line intersects each of the paths in at most one point. Consider a simple polygon in the xy-plane which bounds the polygonal region D. Let T and B be two finite, disjoint, equicardinal sets of points of D. Cameron and Sachs gave a polytime algorithm for finding a MPS joining T with B. We consider polygonal regions with holes.

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CP14
Lattice-point Generating Functions for Free Sums of Convex Sets

The join of two convex sets in Euclidean space is the convex hull of their union. This join is called a free sum under certain conditions on the convex sets. We present a multivariate generating function that gives information about the lattice points in the free sum. This work is motivated by

(and recovers) a product formula of Braun for the Ehrhart series of the free sum of certain lattice polytopes.

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CP14

A New Lower Bound Based on Gromovs Method of Selecting Heavily Covered Points

Classical theorem of Bárány states that there exists $c_d > 0$ such that for every n-set P of points in $\mathbf{R}^\mathbf{d}$ in general position, there exists a point of $\mathbf{R}^\mathbf{d}$ contained in at least $c_d\binom{n}{d+1}$ $(d+1)$-simplices with vertices at the points of P. Gromov improved the known lower bound on c_d by topological means. Using methods from extremal combinatorics, we improve one of the quantities appearing in Gromov's approach and thereby provide a new stronger lower bound on c_d for arbitrary d.

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CP14

On Structures of Geometrically Realizable Triangulations on the Möbius Band

Let G be a graph embedded in to a surface F^2. A geometric realization of G is an embedding of F^2 into a Euclidian 3-space with no self-intersection such that each face of G is a flat polygon. In 1983, Brehm found a Möbius triangulation (i.e., a triangulation on the on the Möbius band) which has no geometric realization. In this talk, we characterize geometrically realizable Möbius triangulations.

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CP14

Grid Representation for the Triangulations of the Torus

William Thurston describes all triangulations of the sphere such that each vertex has degree six or less. In this talk, we present a grid representation for the triangulations of the torus with at most two odd vertices where each vertex has degree five or more. We also discuss the motivation behind studying this family, and some applications of our description. This is a joint work with Luis Goddyn.

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CP15

n-Tournaments That Have n-Integer Signatures

A compact representation for many digraphs is defined in a "labeled graph" context. Each positive integer of an n-element subset S (called the signature of the digraph) of $Z_m\backslash\{0\}$, is assigned to a vertex of a digraph with n vertices. An arc from a vertex x to another vertex y exists if and only if $(y-x)$ mod m is an element of the signature. A digraph defined by such a signature is called a *mod difference digraph*. In this presentation, we discuss the n-Tournaments T_n having uniquely defined n-Integer signatures.

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CP15

New Characterizations of Proper Interval Bigraphs

The class of proper interval bigraphs was introduced and characterized by Sen and Sanyal in terms of monotone consecutive arrangement of adjacency matrix.In this paper we define astral triple of edges in a bigraph and characterize proper interval bigraph in terms of this and other notions.Tucker characterized proper circular arc graphs in terms of circularly compatible 1's of adjacency matrices.We have shown an inter-relation between monotone consecutive arrangement and circularly compatible 1's.

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CP15

House of Graphs: a Database of Interesting Graphs

In this talk we will present a new searchable database of graphs. Next to complete lists of some graph classes (such as fullerenes or snarks), also a list of graphs that already turned out to be *interesting* and *relevant* in the study of graph theoretic problems is offered. We will demonstrate how users can perform queries on this database and how they can add new *interesting* graphs to it. House of Graphs is accessible at http://hog.grinvin.org

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CP15

Immersions of Complete Graphs in Graphs with Minimum Degree $n-1$

In 2003, F. Abu-Khzam and M. Langston conjectured that an n-chromatic graph contains an immersion of a complete graph on n vertices. We will look at an attempt to prove this by looking at a stronger statement involving minimum degree. We will consider examples that show a graph with minimum degree $n-1$ need not contain an immersion of a complete graph on n vertices for n greater than or equal to 8.

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CP15

Fat Hoffman Graphs with Smallest Eigenvalue at Least $-1-\tau$

In this talk, we show that all fat Hoffman graphs with smallest eigenvalue at least $-1-\tau$, where τ is the golden ratio, can be described by a finite set of fat $(-1-\tau)$-irreducible Hoffman graphs. In the terminology of Woo and Neumaier, we mean that every fat Hoffman graph with smallest eigenvalue at least $-1-\tau$ is an $\mathcal{H}$-line graph, where $\mathcal{H}$ is the set of isomorphism classes of maximal fat $(-1-\tau)$-irreducible Hoffman graphs.

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CP15

Finding 1-Factors in Realizations of Degree Sequences

Kundu proved a necessary and sufficient condition for a degree sequence to have a realization containing a k-factor. Brualdi and independently Busch, Ferrara, Hartke, Jacobson, Kaul and West conjectured that the same condition could yield much more: a realization of the sequence containing k edge-disjoint 1-factors. In this talk, we describe two results making partial progress towards this conjecture.

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CP16

Cayley Factorization and the Area Method

Given a bracket polynomial B, i.e. a polynomial in formal determinants. Assume B is homogenous and has integer coefficients. Let $e(B,C)$ be the evaluation of B for a point configuration C. The Cayley factorization problem asks for a synthetic construction for testing $e(B,C)=0$. We give an explicit algorithm that generates a bracket monomial M and a construction which tests $e(M\cdot B,C)=0$. This construction is more geometrically motivated and compact than the one of Sturmfels and Whiteley. M has lower degree.

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CP16

Variations on the Erdos Discrepancy Problem

The Erdos Discrepancy Problem asks if there exists a sequence $\{t_i\}_{i>0}$ over $\{-1,1\}$ and a constant c such that $|\sum_{i=1}^{k} t_{id}| < c$ for all $k,d\in\mathbf{N}$. We examine variations on this problem where the values of d are restricted to certain subsets of N and certain values of c are fixed. We count the number of sequences satisfying these conditions, find the lexicographically least such sequence, and present a number theory conjecture that arises.

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CP16

$1\frac{1}{2}$-Designs Arising from Group Rings

Let $T=(\mathcal{P},\mathcal{B},\mathcal{I})$ be a tactical configuration with parameters (v,b,k,r). For every point $x\in\mathcal{P}$ and every block $B\in\mathcal{B}$, let $\phi(x,B)$ be the number of flags $(y,C)\in\mathcal{I}$ such that $y\in B\setminus\{x\}$, $x\in C$ and $C\neq B$. A $1\frac{1}{2}$-design with parameters $(v,b,k,r;\alpha,\beta)$ is a tactical configuration T such that

$$\phi(x,B)=\begin{cases}\alpha, & x\notin B;\\ \beta, & x\in B.\end{cases}$$

Examples of $1\frac{1}{2}$-designs include 2-designs, complete bipartite graphs $K_{n,n}$, transversal designs, and partial geometries. In this talk, we introduce a method which can be viewed as a generalization of difference sets to construct symmetric $1\frac{1}{2}$-designs. We also give non-existence results on symmetric $1\frac{1}{2}$-designs in connection to directed strongly regular graphs.

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CP16

On Iterated Functions, Directed Graphs, and Re-

cursion

In this presentation, we show how enumerations of the backwards iterates of certain piecewise defined functions lead to general second order linear recurrence relations. In particular, for each integer $k \geq 2$, we provide a piecewise function f_k that acts on k equal subdivisions of the unit interval $[0, 1]$, and the recurrence relation that results from counting the solutions of $f_k(x) = \psi$ for some ψ in $(0, 1)$.

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CP17
Universal H-Colourable Graphs

Rado constructed a (simple) denumerable graph R with the positive integers as vertex set with the following edges: For given m and n with $m < n$, m is adjacent to n if n has a 1 in the m'th position of its binary expansion. It is well known that R is a universal graph in the set $\mathcal{I}_c$ of all countable graphs (since every graph in $\mathcal{I}_c$ is isomorphic to an induced subgraph of R) and that it is a homogeneous graph (since every isomorphism between two finite induced subgraphs of R extends to an automorphism of R). In this talk we discuss a graph $U(H)$ which is H-universal in $\rightarrow H_c$, the induced-hereditary hom-property of H-colourable graphs consisting of all (countable) graphs which have a homomorphism into a given (countable) graph H. If H is the (finite) complete graph K_k, then $\rightarrow H_c$ is the property of k-colourable graphs. The universal graph $U(H)$ is characterised by showing that it is, up to isomorphism, the unique denumerable, H-universal graph in $\rightarrow H_c$ which is H-homogeneous in $\rightarrow H_c$. The graphs H for which $U(H) \cong R$ are also characterised.

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CP17
A Generalization of Menger's Theorem

Consider an acyclic directed network G with sources $S_1, S_2, \cdots, S_l$ and distinct sinks $R_1, R_2, \cdots, R_l$. For $i = 1, 2, \cdots, l$, let c_i denote the min-cut between S_i and R_i. Then, by Menger's theorem, there exists a group of c_i edge-disjoint paths from S_i to R_i, which will be referred to as a group of Menger's paths from S_i to R_i in this paper. Although within the same group they are edge-disjoint, the Menger's paths from different groups may have to merge with each other. In this paper, we prove that by choosing Menger's paths appropriately, the number of mergings among different groups of Menger's paths is always bounded by a constant, which is independent of the size and the topology of G. The tightest such constant for the all the above-mentioned networks is denoted by $\mathcal{M}(\rfloor_\infty, \rfloor_\in, \cdots, \rfloor_\in)$ when all S_i's are distinct, and by $\mathcal{M}^*(\rfloor_\infty, \rfloor_\in, \cdots, \rfloor_\in)$ when all S_i's are in fact identical. It turns out that $\mathcal{M}$ and $\mathcal{M}^*$ are closely related to the network encoding complexity for a variety of networks. Computation of these two functions, however, appears to be rather difficult; so far there are no explicit formulas for $\mathcal{M}(\rfloor_\infty, \rfloor_\in, \cdots, \rfloor_\in)$ and $\mathcal{M}^*(\rfloor_\infty, \rfloor_\in, \cdots, \rfloor_\in)$ for a generic parameter $c_1, c_2, \cdots, c_l$. We also derive exact values of and tighter bounds on $\mathcal{M}$ and $\mathcal{M}^*$ for some parameters. See http://arxiv.org/abs/0805.4059 for the full manuscript.

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CP17
Another Proof for Lovász's Cathedral Theorem

A graph with perfect matchings is satuated if addition of any complement edges creates new perfect matchings. Cathedral theorem, which is originally investigated by Lovász (1986) and later given another proof by Szigeti (1993), is a constructive charactrization of saturated graphs and appears in proving the theorem on toatally-k-covered graphs. Here, we gave the third proof for Lovász's Cathedral theorem by revealing the ordered structure of graphs with perfect matchings.

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CP17
Graphs of Small Rank-Width Are Pivot-Minors of Graphs of Small Tree-Width

We prove that every graph of rank-width k is a pivot-minor of a graph of tree-width at most 2k. We also prove that graphs of rank-width at most 1, equivalently distance-hereditary graphs, are exactly vertex-minors of trees, and graphs of linear rank-width at most 1 are exactly vertex-minors of paths.

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CP17
Saturation Numbers for Families of Graph Subdivisions

For a family $\mathcal{F}$ of graphs, a graph G is $\mathcal{F}$-saturated if G contains no member of $\mathcal{F}$ but the addition of any edge in $\overline{G}$ results in one. The minimum number of edges in an $\mathcal{F}$-saturated graph of order n is denoted $sat(n, \mathcal{F})$. For a graph H, $\mathcal{S}(\mathcal{H})$ denotes the family of graphs resulting from replacing the edges of H with internally disjoint paths. We determine $sat(n, \mathcal{S}(\mathcal{C}_\sqcup))$ for small t, and provide a bound when t is arbitrarily large. We also examine $sat(n, \mathcal{S}(\mathcal{K}_\sqcup))$ in light of a result of Wagner's on minors.

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MS1

Variations on the Majorization Order

The key role played by the majorization (aka dominance) order on integer partitions as a tool in both pure and applied mathematics has been widely recognized and documented. Recently, variants of the classical majorization order have appeared in the study of posets defined by certain symmetric function inequalities. We will describe these variants, focusing on differences and similarities between these posets and the classical majorization order.

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MS1

Linear Extension Diameter and Reversal Ratio

Define the distance between two linear extensions L_1 and L_2 of a poset $\mathbf{P}$ as the number of incomparable pairs x, y with $x <_{L_1} y$ and $y <_{L_2} x$. The *linear extension diameter* of $\mathbf{P}$, $\mathrm{led}(\mathbf{P})$ is the maximum distance over all pairs of linear extensions. We introduce the *reversal ratio* of $\mathbf{P}$ as the ratio of $\mathrm{led}(\mathbf{P})$ to the total number of (unordered) incomparable pairs of $\mathbf{P}$. We provide a family of posets with reversal ratio tending to 0 with the number of points and investigate questions involving bounding the reversal ratio for posets of fixed width and posets of fixed dimension.

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MS1

Forbidden Structures for Efficient First-Fit Chain Partitioning

Using natural numbers for identifying chains, First-Fit algorithm processes elements of a poset P in some order and for each element it assigns the smallest natural number such that all elements with the same number form a chain. Let $\mathcal{P}$ be a class of posets with bounded-width, closed under taking induced subposets. We prove that there is a constant c such that all posets from P are partitioned by First-Fit into at most c chains if and only if there is a width 2 poset not in $\mathcal{P}$.

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MS1

Forbidden Induced Posets in the Boolean Lattice

The induced Turán number $\mathrm{La}^*(\mathrm{n}, \mathrm{P})$ is the maximum size of a family of elements in the n-dimensional Boolean lattice that does not contain P as *an induced* subposet. Not much is known about $\mathrm{La}^*(\mathrm{n}, \mathrm{P})$ when the Hasse diagram of P contains cycles. We present bounds on $\mathrm{La}^*(\mathrm{n}, \mathrm{P})$ for some such posets. This is joint work with Linyuan Lu.

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MS1

Title Not Available at Time of Publication

Abstract not available at time of publication

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MS2

Lie Theory for Hyperplane Arrangements

There is a well-known isomorphism of representations between the homology of the partition lattice and the multilinear part of the free Lie algebra. This is a result of Hanlon, Joyal, and Stanley. Rich combinatorics underlies this fact, as shown by subsequent work of several authors, including Barcelo, Bergeron, Bjorner, Garsia, Reutenauer and Wachs. In this talk we propose an extension of this and other classical results to real linear hyperplane arrangements. A central role is played by the notion of Hopf monoid. We develop a Lie theory for these objects which includes the Cartier-Milnor-Moore and Poincaré-Birkhoff-Witt theorems. The classical results are obtained by specializing to the case of braid arrangements. This is joint work in progress with Swapneel Mahajan.

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MS2

Tesler Matrices, Parking Functions, and Diagonal Harmonics

We show how the Hilbert series of the space of Diagonal Harmonics can be expressed in terms of combinatorial objects called Tesler matrices. This leads to some open positivity questions involving what we call "colored parking functions". This is joint work with D. Armstrong, A. Garsia, B. Rhoades, and B. Sagan.

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MS2

Combinatorial Ergodicity in Products of Chains

Many cyclic actions τ on a finite set S of combinatorial objects, along with many natural statistics ϕ on S, exhibit"combinatorial ergodicity': the average of ϕ over each τ-orbit in S is the same as the average of ϕ over the whole set S. This phenomenon was first noticed by Panyushev in 2007 in the context of antichains in root posets; Armstrong, Stump, and Thomas proved his conjecture in 2011. We describe a theoretical framework for results of this kind, and discuss old and new results for products of chains.

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MS2

Classical and Quasi Symmetric Hall-Littlewood Polynomials and Transition Matrices

An interesting property of Hall-Littlewood polynomials is that they interpolate between the Schur and monomial symmetric functions at $t = 0$ and 1, respectively. Hivert has constructed a family of quasisymmetric functions with a parameter t, which interpolate in a similar way between the fundamental and monomial quasisymmetric functions. In this talk we present a combinatorial interpretation for the expansion of Hall-Littlewood polynomials in terms of Hivert functions, as well as other transition matrices between the latter and other families of quasisymmetric functions.

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MS2

Demazure Crystals, Kirillov-Reshetikhin Crystals, and the Energy Function

I will discuss a paper with Anne Schilling which surveys and expands upon some relationships between Demazure crystals of non-exceptional affine Kac-Moody algebras and Kirillov-Reshetikhin (KR) crystals. In particular, certain Demazure crystals are isomorphic as classical crystals to tensor products of KR crystals, and we show that this isomorphism intertwines the natural affine grading on the Demazure crystals with a combinatorially defined energy function. This leads to a formula for the Demazure character in terms of the energy function, and has applications to symmetric function theory since certain specializations of Macdonald polynomials are equal to specializations of Demazure characters.

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MS3

Conjectures Equivalent to the Borodin-Kostochka Conjecture that a Priori Seem Weaker

Borodin and Kostochka conjectured that every graph G with maximum degree $\Delta \geq 9$ satisfies $\chi \leq \max\{\omega, \Delta - 1\}$. We carry out an in-depth study of minimum counterexamples to the Borodin-Kostochka conjecture. Our main tool is the classification of graph joins $A * B$ with $|A| \geq 2$, $|B| \geq 2$ that are f-choosable, where $f(v) := d(v) - 1$ for each vertex v. Since such a join cannot be an induced subgraph of a vertex critical graph with $\chi = \Delta$, we have a wealth of structural information about minimum counterexamples to the Borodin-Kostochka conjecture. Our main result is to prove that certain conjectures that a priori seem weaker than the Borodin-Kostochka Conjecture are in fact equivalent to it. One such equivalent conjecture is the following: Any graph with $\chi \geq \Delta = 9$ contains $K_3 * \overline{K_6}$ as a subgraph.

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MS3

List-coloring on Surfaces with Some Small Lists

C. Thomassen's celebrated 5-list-coloring theorem for planar graphs proves more. Among its consequences are the results that 1) a planar graph with one vertex with a 1-list and the rest with 5-lists and 2) a planar graph with 3-lists on the vertices of one face and 5-lists elsewhere can be list-colored. We study generalizations of these two variations for graphs on nonplanar surfaces. We obtain initial results for graphs on the projective plane and torus and begin a study for surfaces with larger Euler genus.

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MS3

Fractional Colorings of Cubic Graphs

Fractional coloring is a relaxation of classical graph coloring. Each independent set is assigned weight and each vertex is required to be in independent sets of weight at least one. The goal is to minimuze the total weight of independent sets. In the talk, we present two recent results: The fractional chromatic number of any triangle-free cubic graph is at most 32/11 and the fractional chromatic number of any cubic graph with sufficiently large girth is smaller than 23/10.

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MS3
4-critical Graphs on Surfaces without Contractible Cycles of Length at Most 4

We show that every 4-critical graph G embedded in a fixed surface Σ so that every contractible cycle has length at least 5 can be expressed as $G = G' \cup G_1 \cup G_2 \cup \ldots \cup G_k$, where $|V(G')|$ and k are bounded by a constant (depending linearly on the genus of Σ) and $G_1, \ldots, G_k$ are graphs (of unbounded size) whose structure we describe exactly. The proof is computer-assisted— we use computer to enumerate all plane 4-critical graphs of girth 5 with a precolored cycle of length at most 16, that are used in the basic case of the inductive proof of the statement.

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MS3
Extending Graph Choosability Results to Paintability

Introduced independently by Schauz and by Zhu, the *Marker/Remover game* is an on-line version of list coloring. The resulting graph parameter, *paintability*, is at least the list chromatic number (the *choosability*). We strengthen several choosability results to paintability. We study paintability of joins with complete graphs and determine bounds on the paintability of complete bipartite graphs. We characterize 3-paint-critical graphs and show that claw-free perfect graphs with $\omega(G) \leq 3$ have paintability equal to chromatic number. Finally, we introduce and study *sum-paintability*, the analogue of sum-choosability.

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MS4
Title Not Available at Time of Publication

Abstract not available at time of publication.

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MS4
On a Problem of Erdős and Rothschild on Edges in Triangles

Erdős and Rothschild asked to estimate the maximum number $h(n, c)$ such that every n-vertex graph with at least cn^2 edges, each of which is contained in at least one triangle, must contain an edge that is in at least $h(n, c)$ triangles. In 1987, Erdős asked whether for every $c > 0$, there is $\epsilon > 0$ such that $h(n, c) > n^{\epsilon}$. We prove $h(n, c) = n^{O(1/\log\log n)}$ for every fixed $c < 1/4$, the first improvement over an old construction of Alon and Trotter.

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MS4
Turan's Brickyard Problem and Flag Algebras

Recently, Razborov developed a "flag algebra" calculus which captures in pure form many of the techniques used in extremal combinatorics. This calculus has been successfully used in the last few years to improve the best known bounds on many of the long-standing open problems in extremal graph theory. In this talk we describe an application to the Turan's brickyard problem: the problem of determining the crossing number of the complete bipartite graph $K_{m,n}$. Beas on joint work with Yori Zwols.

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MS4
Turán Densities of Hypergraphs Related to K_{k+1}^k

Let $B_i^{(k)}$ be the k-uniform hypergraph on the vertex set $S \cup T$ with $|S| = i$ and $|T| = k - 1$ with the edges consisting of all k-sets containing S or T. We derive upper and lower bounds for the Turán density of $B_i^{(k)}$ that are close to each other as $k \to \infty$. We also obtain asymptotically tight bounds for the Turán density of several other infinity families of hypergraphs. The construction that supports the lower bounds is derived from elementary number theory by probabilistic arguments. The upper bounds are derived

from the results of de Caen, Sidorenko, and Keevash.

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MS4
Extremal results in sparse pseudorandom graphs

Szemerédi's regularity lemma is a fundamental tool in extremal combinatorics. However, the original version is only helpful in studying dense graphs. In the 1990s, Kohayakawa and Rödl proved an analogue of Szemerédi's regularity lemma for sparse graphs as part of a general program toward extending extremal results to sparse graphs. Many of the key applications of Szemerédi's regularity lemma use an associated counting lemma. In order to prove analogues of these results for sparse graphs, it remained a well-known open problem to prove a counting lemma in sparse graphs. The main advance of this paper lies in a new counting lemma, proved following the functional approach of Gowers, which complements the sparse regularity lemma of Kohayakawa and Rödl, allowing us to count small graphs in regular subgraphs of a sufficiently pseudorandom graph. We use this to prove analogues of several well-known combinatorial theorems, including the graph removal lemma, the Erdős-Stone-Simonovits theorem, and Ramsey's theorem, for subgraphs of sparse pseudorandom graphs. These results extend and improve upon a substantial body of previous work.

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MS5
On the Directed Oberwolfach Problem

The Oberwolfach problem asks whether the K_n (or $K_n - I$ if n is even) admits a 2-factorization in which each factor is isomorphic to a specified 2-factor F. We consider a directed variant of this problem, in which we are now required to factorize the complete symmetric digraph K_n^*. In particular, we consider the question of determining necessary and sufficient conditions for the existence of a resolvable decomposition of K_n^* into directed m-cycles, and present some results towards its solution.

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MS5
Defining Sets in Combinatorial Arrays

A defining set in a combinatorial array is a partially filled-in array with a unique completion. We compare what is known about the defining sets of $(0, 1)$-matrices and Latin squares. While these arrays on the surface seem quite different, for certain cases the minimum possible size for a defining set appears to be the same.

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MS5
Graph Decompositions and Convexity

One of the most interesting conjectures in the area of graph decompositions is due to Nash-Williams. It states that the edge set of any sufficiently large graph with all even degrees, $3m$ edges, v vertices and minimum degree of at least $3/4v$ can be partitioned into triangles. We discuss a new approach for exploring this problem using the inclusion matrix of the Johnson scheme and the facets of the convex cone it generates.

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MS5
Extending the Bruck-Ryser-Chowla Theorem to Coverings

The celebrated Bruck-Ryser-Chowla theorem rules out the existence of various balanced incomplete block designs, including projective planes of infinitely many orders. In this talk I will discuss how (parts of) the Bruck-Ryser-Chowla theorem can be extended to establish the nonexistence of various covering designs and, consequently, the nonexistence of certain decompositions of a complete graph into copies of a smaller complete graph minus an edge.

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MS5
Trinal Decompositions of Steiner Triple Systems

Let STS(n) be a Steiner triple system of order n. A *triangle* T is a set of three pairwise intersecting triples of an STS(n) whose intersection is empty. Z. Füredi posed a question whether the set of triples of any STS(n) can be decomposed into triangles. This question remains largely unanswered, although examples of such decomposition are known for every admissible order $n \equiv 1$ or 9 (mod 18). A triangle $T = \{\{a,b,c\},\{c,d,e\},\{e,f,a\}\}$ in an STS(n) is sometimes called a *hexagon triple* because the outer edges ab, bc, cd, de, ef, fa form a hexagon. Depending on a graph-theoretic or geometric representation, respectively, that triangle determines naturally two more triples: the *inner* triple $\{a,c,e\}$ and the *midpoint* triple $\{b,d,f\}$. In either case, the number of inner triples (called *type* 1) or that of midpoint triples (*type* 2) equals one third of the total number of triples in an STS(n). A problem which will be discussed concerns the existence of three distinct decompositions of an STS(n) into triangles such that the union of three collections of type 1 triples (type 2, respectively) from these three decompositions form a set of triples of a Steiner triple system of the same order n. Such decompositions are called *trinal* decompositions of type 1 and type 2, respectively. Solutions to the existence question for trinal decompositions of type 1 and type 2 will be presented.

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MS6
Structural Requirements for RNA Elements

RNA plays a major role in many regulatory circuits of cells, and new and often suprising function are discovered continously, The structure of RNA elements determines the associated function for many ncRNAs. Clustering by similarity on the level of sequence and structure is now an accepted approach for annotating ncRNAs and for determining new ncRNA classes. The problem, however, is the large number of RNAs to be clustered (e.g., up to 450.000 predicted ncRNAs in human), and the complexity of the similarity test. We have introduced a new alignment-free method for clustering that avoids the complex all-againts-all pairwise comparisons, and is still able to cluster according to sequential and structural properties. Furthermore, we will discuss application problems like the bacterial adaptive immunesystem called CRISPR that is based on RNA.

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MS6
Understanding SHAPE-directed RNA Secondary Structure Prediction

We investigate the interplay between experimental data and thermodynamic model via stochastic simulations. RNA prediction under the NNTM is a discrete optimization problem whose accuracy can be improved by the incorporation of auxiliary information. However, our results demonstrate that improvements in SHAPE-directed predictions are non-uniform and correlated with original MFE accuracies. This analysis suggests that further advances in computational molecular biology are needed to reliably predict RNA secondary structures.

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MS6
Detecting SNP-Induced Structural Changes in RNA: Application to Disease Studies

Single Nucleotide Polymorphisms (SNPs) are often linked to critical phenotypes such as diseases. However, the specific molecular mechanisms by which a causal SNP acts is usually not obvious. Changes in RNA secondary structure emerge as a possible explanation. We introduce *remuRNA*, an efficient method to compute the distance between the native and mutant RNA structure Boltzmann ensembles. We applied remuRNA to determine which of the disease-associated non-coding SNPs are potentially related to RNA structural changes.

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MS6
Efficient Algorithms to Explore the RNA Mutational Landscape

Understanding the relationship between RNA sequences and structures is essential to decipher evolutionary processes, predict deleterious mutations and design synthetic molecules. We introduce RNAmutants, the first algorithm for exploring complete RNA sequence-structures maps in polynomial time and space. Using statistical mechanics and importance sampling techniques, we estimate the thermodynamical pressure applied on sequences and explore regions of the mutational landscape preserving the nucleotide composition. We show that C+G-contents influence the evolutionary accessible structural ensembles.

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MS7
Path Graphs, PR-trees, and Split Decomposition

In this work we preset new characterizations of (directed) path graphs*. First, we describe a new data structure (*PR-trees*) which captures the set of path-tree models of a path graph (generalizing *PQ-trees*). This allows us to characterize and recognize (directed) path graphs via *split decomposition*. The recognition algorithm runs in $\mathcal{O}(|\mathcal{V}| * |\mathcal{E}|)$ for both directed path graphs and path graphs. * The intersection graphs of (directed) paths in (directed) trees.

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MS7
Algorithms for Unipolar and Generalized Split Graphs

G=$(V_1 \cup V_2, E)$ is *unipolar* when V_1 is a clique and V_2 induces the disjoint union of cliques. A *generalized split graph* is either unipolar or its complement is unipolar. We present an O(nm')-time recognition algorithm for unipolar graphs, where m' is the number of edges in a minimal triangulation of the given graph. We efficiently solve four classic optimization problems on unipolar and generalized split graphs and prove that perfect code is NP-complete for unipolar graphs.

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MS7
Recognizing Even-Cycle Matroids

A matroid M is an even-cycle matroid if the cycles of M correspond to the even cycles of a signed graph. The problem of recognizing whether a binary matroid (represented by a 0,1 matrix) is an even-cycle matroid is open. Progress on this problem has been hampered by the fact that even cycle matroids can have an arbitrary number of pairwise inequivalent representations (two signed graph are equivalent if they are related by a sequence of Whitney-flips and signature exchanges). We discuss how to proceed for the recognition problem for the case where we are given a fixed size minor that is not a projection of a graphic matroid.

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MS7
Fixed Weight De Bruijn Graphs

Let S be the set of all binary strings of length n with weight (number of 1s) w and w-1. The *de Bruijn graph* for S is a directed graph $G(S)$ whose nodes are the length $n-1$ prefixes and suffixes of the strings in S. There is an arc labeled $x \in \{0, 1\}$ from $\alpha = a_1 \cdots a_{n-1}$ to $\beta = a_2 \cdots a_{n-1}x$ if $\alpha x \in S$. In addition to considering constructions of fixed weight de Bruijn cycles, we consider the problem of determining the diameter of the de Bruijn graph $G(S)$.

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MS7
Induced and Distance-k Matchings and Some Related Min-Max Relations

A distance-k matching in a graph is a matching such that the distance between any two edges of the matching is at least k. Computing the size of a largest induced matching (distance-2 matching) in a graph is NP-hard. We consider finding a largest distance-k matching in certain classes of graphs. In some cases, along comes a relation between the size of a largest distance-k matching and the size of a smallest appropriate cover.

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MS8
Q_2-Free Families in the Boolean Lattice

For a family of subsets of $\{1, \ldots, n\}$, ordered by inclusion and a partially-ordered set P, we say that the family is P-free if it does not contain a subposet isomorphic to P. We are interested in finding ex(n, P), the largest size of a P-free family of subsets of $[n]$. It is conjectured that, for any fixed P, this quantity is $(k+o(1))\binom{n}{2}$ for some fixed integer

k, depending only on P. Recently, Boris Bukh has verified the conjecture for P which are in a “tree shape’. There are some other small posets P for which the conjecture has been verified. The smallest for which it is unknown is Q_2, the Boolean lattice on two elements. We will discuss improvements of the bounds of Griggs, Li, and Lu. This is joint work with Ryan Martin, Iowa State University and Michael Young, Iowa State University.

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MS8
First-Fit Coloring of Ladder-Free Posets

Bosek and Krawczyk provided a subexponential bound for the on-line chain partitioning of posets of width w and observed the problem could be reduced to First-Fit chain partitioning of $2w^2$-ladder-free posets of width w. We provide a subexponential upper bound (in terms of w with m fixed) for the performance of First-Fit chain partitioning on m-ladder-free posets. With the Bosek-Krawczyk observation, this yields an slightly improved upper bound for the general problem.

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MS8
Dimension and Height for Posets with Planar Cover Graphs

Planar posets can have arbitrarily large dimension. However, we show that the dimension of a planar poset is bounded as a function of its height. More precisely, we show that for each integer $h \geq 2$, there exists a least positive integer c_h so that if P is a poset with a planar cover graph and height h, then the dimension of P is at most c_h. Trivially, $c_1 = 2$. Felsner, Li and Trotter showed that $c_2 = 4$, but their proof techniques do not seem to apply when $h \geq 3$. In this paper, we establish the existence of c_h, although we suspect that the upper bound provided by our proof is far from best possible. From below, a construction of Kelly is modified to show that c_h is at least $h + 2$.

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MS8
The Width of the Family of Maximum Antichains

Felsner, Krawczyk and Micek conjectured in 2010 that the maximum possible width of the family of maximum antichains in a $(k + k)$-free poset of width w is $(k - 1)^{w-1}$. This is easily shown to be true for $w \leq 2$. We give the proof for $w = 3$ and present several different constructions attaining the conjectured extremal value for $w \geq 3$. Despite this support we still feel to be far away from the proof for all w.

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MS8
The Dimension of Posets with Planar Cover Graphs

We study the conditions that bound the dimension of posets with planar cover graphs. We show that if P is a poset with a planar comparability graph, then the dimension of P is at most four. We also show that if P has an outerplanar cover graph, then the dimension of P is at most four. Finally, if P has an outerplanar cover graph and the height of P is two, then the dimension of P is at most three. These three inequalities are all best possible.

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MS9
Tropisms, Surfaces and the Puiseux Series

We present a polyhedral method to develop Puiseux series expansions for surfaces, defined by a system of polynomials. Our starting point is the construction of cones of normal vectors to the Newton polytopes, associated with the system of polynomials. Generating vectors of the normal cone, which lead to an initial form system with regular, isolated solutions are considered pretropisms. When the generating vectors of the normal cone lead to an exact, finite representation of the surface or to its Puiseux series expansion, then they are referred to as tropisms.

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MS9
Divisors on Tropical Varieties

I will present notions of divisors, linear equivalence, and rank on tropical models. A tropical model is a simplicial complex together with some numerical data telling how the affine linear structures relate. Although the motivations come from algebraic varieties, I will discuss the combinatorial aspects.

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MS9
Orbits of Projective Point Configurations

Given an $r \times n$ matrix, thought of as representing n points in projective $(r-1)$-space, we consider the closure of the orbit of all projectively equivalent matrices. I will discuss the equations cutting out this variety, its finely graded Hilbert series, and their relation to the matroid of the point configuration.

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MS9
Log-concavity of Characteristic Polynomials and Tropical Intersection Theory

In a recent joint work with June Huh, we proved the log concavity of the characteristic polynomial of a realizable matroid by relating its coefficients to intersection numbers on an algebraic variety and applying an algebraic geometric inequality. In this talk, we outline that proof which involves algebraic geometric positivity.

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MS9
Tropical Torelli Space and Tropical Period Mapping

I will discuss the Teichmuller type approach to the moduli of tropical curves. We also define the tropical period mapping and investigate the injectivity of this map on the Torelli space (i.e. the generalized Torelli problem). We will describe the image of the period map (i.e. the Schottky locus). To better understand the Torelli problem and the Schottky locus, we consider the (marked) moduli of “metric” regular matroids. Various compactifications of the moduli of tropical curves will be obtained from this point of view.

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MS10
Globally Fair Stable Matchings

Stable marriage instances generally have many stable matchings. In spite of this, Gale and Shapley’s famous algorithm for computing stable matchings can only output two kinds: the man-optimal/woman-pessimal or the woman-optimal/man-pessimal stable matchings. This has motivated the study of fair stable matchings. This talk is about stable matchings whose fairness is derived from the fact that they are ”good” representatives of the distributive lattice of stable matchings of the instance.

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MS10
Stable Matching as a Heuristic for Cost-Based Matching Problems

Minimum-cost assignment problems arise in many situations in practice. The optimal solution of such problems usually requires network flow techniques, which can be computationally taxing for very large problem instances. Here, we discuss potential heuristics for minimum-cost assignment problems based on stable matchings, which can generally be computed much more efficiently. A number of approaches will be discussed, along with the results of empirical testing to assess their viability in practice.

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MS10
Some Open Problems in Matchings with Preferences

Matching problems involving preferences have been studied for many years, and have a range of real-world applications. The stable marriage problem is perhaps the most famous such problem, but many variants of it have been studied, involving extensions and variations of the basic model. Despite the extensive literature in this area, many challenging (and fascinating) open problems remain. I will survey some of these open problems that have connections with discrete mathematics, algorithms and complexity.

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MS10
A Unified Approach to Equivalence Results in Object Allocation

We consider probabilistic mechanisms that allocate indivisible objects to agents by hierarchical exchange using the top-trading cycles algorithm. The main result is a general technique for proving that seemingly different probabilistic mechanisms are in fact equivalent. This approach simplifies and unifies several equivalence results in the literature. The same technique is used to generalize these results to mechanisms in which the priority structure for each object is given by a tree (instead of a linear ordering of the agents).

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MS11
Homeomorphically Irreducible Spanning Trees

Let G be a graph. A spanning tree of G is called a *homeomorphically irreducible spanning tree* (HIST) if it does not contain vertices of degree 2. In 1979, Albertson, Berman, Hutchinson, and Thomassen asked the following two questions:

1. Does every triangulation of a surface contain a HIST except the triangle?
2. Does every graph with every edge on two triangles contain a HIST?

We have confirmed both questions positively. The outlines of the proofs will be given in this talk.

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MS11
Decompositions of (Hyper)Graphs into Cliques or Bicliques

This talk will be a brief survey of recent results regarding edge-decompositions of (hyper)graphs into cliques or bicliques. These include various extensions of De Bruijn-Erdos Theorem and Graham-Pollak Theorem. Despite recent progress, many problems remain open.

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MS11
Multipartite Version of the Alon-Yuster Theorem

In this talk, we prove the asymptotic multipartite version of the Alon-Yuster theorem. That is, if $k \geq 3$ is an integer, H is a k-colorable graph and $\gamma > 0$ is fixed, then for sufficiently large n and for every balanced k-partite graph G on kn vertices with each of its corresponding $\binom{k}{2}$ bipartite subgraphs having minimum degree at least $\frac{k-1}{k}n + \eta n$, the graph G has a subgraph consisting of $\lfloor n/|V(H)| \rfloor$ vertex-disjoint copies of H.

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MS11
An Erdos-Stone Theorem for Hypergraphs

This talk is about complete k-partite subgraphs in hypergraphs with sufficiently many k-cliques. These results generalize the Erdős-Stone theorem for 2-graphs.

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MS11
On Independent Sets in Steiner Systems

For a hypergraph H, let $\alpha(H)$ denote the largest set of vertices containing no edge of H. In this talk we give near-optimal bounds on the size of a largest independent set in Steiner systems on n points. We conjecture that the minimum value of $\alpha(H)$ over all Steiner systems H on n vertices is asymptotic to $\sqrt{3n \log n}$ as $n \to \infty$. The methods are a combination of spectral techniques and probabilistic combinatorics, which are useful for various other problems on independent sets in hypergraphs.

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MS12
Graph Homomorphisms: Mixing and Homotopies

Given a k-colouring of a graph, consider the process of recolouring a single vertex to obtain a new k-colouring. Provided k is sufficiently large, one can generate all k-colourings of the graph. We study circular colourings giving bounds on how large k/q must be to ensure all circular colourings can be generated by recolouing. We connect our work to discrete homotopies of graph homomorphisms and pre-colourings of graphs.

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MS12
Defective Colorings and Colorings that Avoid Large Monochromatic Components

We consider two types of colorings. Those that avoid monochromatic graphs with large degree and those that avoid monochromatic graphs with large components. We discuss relations between these two parameters and make several remarks on issues of computational complexity.

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MS12
Kempe-equivalence Classes for 3-edge-colored Cu-

bic Graphs

An edge-Kempe change switches the colors in a maximal two-colored chain in a proper edge coloring of a graph. Two proper edge colorings of a graph are called Kempe equivalent if you can get from one to the other by a sequence of edge-Kempe changes. This work examines Kempe equivalence in 3-edge colorable cubic graphs. Not all proper edge colorings of a 3-edge colorable cubic graph are Kempe equivalent. We give results about the number of non-equivalent proper edge colorings there can be for certain classes of cubic graphs.

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MS12
Distinguishing Edge Colourings of Graphs

An edge colouring of a graph G is *distinguishing* provided that the identity is the only automorphism of G that preserves the edge colours. The minimum number of colours required to produce such a colouring is the *edge distinguishing chromatic number* of G. In this talk I will describe results that we have obtained concerning the edge distinguishing chromatic number and the more general edge distinguishing number of a graph.

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MS12
Obstructions to Homomorphisms Involving the Graft Extension

Let H_1 be a digraph that has an $\underline{X}$-enumeration, say $\{h_1, h_2, \ldots, h_n\}$. Let H_2 be a digraph such that H_2-colouring is polynomial. Form a new digraph H by deleting the vertex h_n from H_1 and replacing it by the digraph H_2: every vertex $h_i \in V(H_1)$ that is adjacent to (from) h_n is now adjacent to (from) every vertex in H_2. The digraph H is denoted by graft(H_1,H_2). Given a digraph H, a dual (or obstruction) of H is a digraph F such that $G \not\to H$ if and only if $F \to G$. In this talk we aim to identify the obstructions of H in the case where $H = \text{graft}(H_1, H_2)$.

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MS13
TBD on Genome Assembly Algorithms

Abstract not available at time of publication.

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MS13
De Bruijn Graph Based Genome Assembly for Single Cells

Characterization of environmental bacteria, the vast majority of which elude cultivation, is necessary for many applications including discovery of rare novel species. The ability to generate high-quality draft genome assemblies that support annotation of the majority of genes will drive advances in characterizing such uncultured organisms. Recent advances in DNA amplification technology have enabled whole genome sequencing directly from individual cells without requiring growth in culture. These methods amplify femtograms of DNA extracted from a single bacterial cell into micrograms of DNA needed for current sequencing platforms. Based on these advances, we developed a specialized software tool for assembling sequencing reads from single cells and applied it to assembly of two known genomes, *E. coli* and *S. aureus*, and an unknown marine genome, SAR324 Deltaproteobacterium. These draft de novo single cell assemblies, with no efforts to close gaps and resolve repeats, identify more than 90% of genes. DNA amplification using Multiple Displacement Amplification (MDA), however, creates serious coverage bias and chimeric fragments. Our algorithm successfully deals with these errors. Our assembler is based on the celebrated de Bruijn graph in which nodes are $(k-1)$-mers and edges are k-mers. We present the general de Bruijn graph sequence assembly algorithm as well as our modifications to it.

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MS13
Quantifying Uniformity of Mapped Reads

We describe a tool for quantifying the uniformity of mapped reads in high-throughput sequencing experiments. Our statistic directly measures the uniformity of both read position and fragment length, and we explain how to compute a p-value that can be used to quantify biases arising from experimental protocols and mapping procedures. Our method is useful for comparing different protocols in experiments such as RNA-Seq.

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MS13

Combinatorial Designs for Sequencing Pooled Samples

Rare variants account for missing heritability that cannot be explained by common variants. DNA Pooling is a cost effective method to sequence a large number of samples and to discover rare variants. In this talk, I will present two new combinatorial designs for overlapped pooling strategies and show their effectiveness in discovering rare variants and in identifying variant carriers.

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MS13

Spaced Seeds and their Application in Next Generation Sequencing

We will briefly overview the spaced seeds technique for improving the speed and sensitivity of homology search. Then, a variation of spaced seeds is introduced to provide full sensitivity reads mapping for next generation sequencing analysis.

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MS14

The Pebbling Threshold of Graph Sequences

A pebbling threshold for a family of graphs is a function $g(n)$ such that any pebbling configuration of size much larger than $g(n)$ is almost surely solvable and of size much less than $g(n)$ is almost surely unsolvable. We will discuss pebbling threshold for an arbitrary graph family and present the results for particular families of graphs and discuss open problems. We will also introduce a probabilistic version of Graham's pebbling conjecture for the threshold.

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MS14

Complexity of Diameter Two Graph Pebbling

We present tight bounds on the number of vertices with two and three pebbles that can exist in an unsolvable configuration on a diameter two graph in terms of the size of the graph. We use the construction from this result to prove that determining reachability of a vertex is NP-complete, even in graphs of diameter two.

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MS14

Graph Pebbling: Past, Present, Future

In this talk we aim to give a gentle introduction to the subject of graph pebbling, including its history from combinatorial number theory, its growth as a purely graph theoretic topic, and its development into an area of combinatorial optimization. We shall describe some of its variations as well, such as optimal pebbling, cover pebbling, fractional pebbling, pebbling thresholds, and rubbling, along with its connections to computer science. Lastly, we will present a few of the major techniques in the field and offer some tantalizing open problems for further research.

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MS14

Graph Rubbling

Graph rubbling is a version of graph pebbling where an additional move is allowed. The new move adds one pebble at vertex u in exchange for removing one pebble each from two vertices that are neighbors of u. Rubbling numbers are defined analogously to pebbling numbers. The purpose of this talk is to give a summary of what is known about rubbling and optimal rubbling and to present a set of unanswered questions.

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MS14

Pebbling Graphs of Diameter Three and Four

Given a configuration of pebbles on the vertices of a connected graph G, a pebbling move is defined as the removal of two pebbles from some vertex and the placement of one of these on an adjacent vertex. The pebbling number of a graph G is the smallest integer k such that for each vertex v and each configuration of k pebbles on G there is a sequence of pebbling moves that places at least one pebble on v. We improve on a bound of Bukh by showing that the pebbling number of a graph of diameter three on n vertices is at most $\lfloor 3n/2+2 \rfloor$, and this bound is best possible. Further, we will describe an asymptotic bound for graphs of diameter four and an asymptotic bound for pebbling graphs of arbitrary diameter obtained via discharging.

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MS15
Phase Transition in Random Graph Processes through the Lens of PDE and Singularity Analysis

Erdős and Rényi show that in the standard random graph on n vertices, a phase transition takes place when the number of edges reaches $n/2$ and a giant component emerges. Since this seminal work, various random graph processes have been studied. In this talk we discuss new approaches to study the size and structure of components near the critical point of random graph processes: key techniques are a quasi-linear PDE and its singularity analysis.

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MS15
Self-similarity of Graphs

An old problem of Jacobson and Schönheim asks for the maximum s such that every m-edge graph contains a pair of edge-disjoint isomorphic subgraphs with s edges. We prove that every m-edge graph contains a pair of edge-disjoint isomorphic subgraphs with at least $c(m \log m)^{2/3}$ edges. We also construct graphs that show this estimate is correct up to a constant factor. Our results improve bounds of Erdős, Pach, and Pyber from 1987.

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MS15
Hunting the k-SAT Threshold

We prove that the threshold for the existence of solutions in random k-NAESAT is $2^{k-1}\ln 2 - (\frac{\ln 2}{2} + \frac{1}{4}) + \varepsilon_k$, where $|\varepsilon_k| \le 2^{-(1-o_k(1))k}$. According to deep but non-rigorous arguments from statistical mechanics, the insufficiency of current methods to prove such results is due to a change in the geometry of the set of solutions called *condensation* that occurs shortly before the actual threshold for the existence of solutions. In the talk I will describe a new method that is inspired by the sophisticated but non-rigorous formalism called Survey Propagation.

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MS15
The Fractal Nature of the Abelian Sandpile

The Abelian sandpile is a diffusion process for configurations of chips on the integer lattice; a vertex with at least 4 chips *topples*, distributing one chip to each of its neighbors. One of the most striking unexplained features of the sandpile is that it appears to produce terminal configurations converging to a peculiar fractal pattern when begun from increasingly large stacks of chips at the origin. We will present a mathematical explanation for this phenomenon.

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MS15
Achlioptas Processes: Recent Results and New Problems

Recent results have shown that the phase transition of a large class of Achlioptas processes looks qualitatively similar to that of the Erdos-Renyi random graph process. I will describe these results and pay particular attention to one technique involved in the proofs, combining the differential equation method with Flajolet-Sedgewick singularity analysis. I will then propose some open questions about Achlioptas processes related to both random graphs and random constraint satisfaction problems.

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MS16
Rational Noncrossing Partitions

For each positive rational number α/β in lowest terms we define a poset of noncrossing partitions $NC(\alpha/\beta)$ with the property that

$$|NC(\alpha/\beta)| = \frac{1}{2\alpha+\beta}\binom{2\alpha+\beta}{\alpha}.$$

For the rational number $\alpha/\beta = n/(kn-n+1)$ we obtain the poset of "k-divisible" noncrossing partitions of the cycle $(1, 2, \ldots, kn)$, in which the size of each block of a partition is divisible by k. For $k = 1$ we obtain the "good old' $NC(n) = NC(n/1)$.

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MS16

Separation Probabilities for Products of Permutations

We study the mixing properties of permutations obtained as product of two uniformly random permutations of fixed types. For instance, we give an exact formula for the probability that elements $1, 2, \ldots, k$ are in distinct cycles of the random permutation of $\{1, 2, \ldots, n\}$ obtained as product of two uniformly random n-cycles.

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MS16

Bijections for Lattice Paths Between Two Boundaries

We prove that on the set of lattice paths with north and east (unit) steps that lie between two boundaries B and T, the statistics 'number of east steps shared with B' and 'number of east steps shared with T' have a symmetric joint distribution. We give an involution that switches these statistics, and a generalization to paths that contain south steps. We show that a similar result relates to the Tutte polynomial of a matroid. Finally, we extend our main theorem to k-tuples of paths, and we provide connections to flagged semistandard Young tableaux and to k-triangulations.

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-
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MS16

Tableaux and Plane Partitions of Truncated Shapes

We consider a new kind of straight and shifted plane partitions/Young tableaux — ones whose diagrams are no longer of partition shape, but rather Young diagrams with boxes erased from their upper right ends. We find formulas for the number of standard tableaux in certain cases, namely a shifted staircase without the box in its upper right corner, i.e. truncated by a box, a rectangle truncated by a staircase and a rectangle truncated by a square minus a box. The proofs involve finding the generating function of the corresponding plane partitions using interpretations and formulas for sums of restricted Schur functions and their specializations. The number of standard tableaux is then found as a certain limit of this function.

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MS16

The Möbius Function of Generalized Subword Order

Let P be a poset and let P^* be the set of all finite length words over P. Generalized subword order is the partial order on P^* obtained by letting $u \leq w$ if and only if there is a subword u' of w having the same length as u such that each element of u is less than or equal to the corresponding element of u' in the partial order on P. Classical subword order arises when P is an antichain, while letting P be a chain gives an order on compositions. For any finite poset P, we give a simple formula for the Möbius function of P^* in terms of the Möbius function of P. This permits us to rederive in an easy and uniform manner previous results of Björner, Sagan and Vatter, and Tomie. We are also able to determine the homotopy type of all intervals in P^* for any finite P of rank at most 1. This is joint work with Peter McNamara

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MS17

Closed 2-cell Embeddings Under Partial Duality

In 2009 Chmutov introduced a partial duality operation, using only a subset of the edges, for graph embeddings. The topological consequences of this operation have not yet been intensively investigated. One important property of embeddings is being *closed 2-cell*, when the boundary of every face is a cycle in the graph. We present a necessary and sufficient condition for a closed 2-cell embedding to remain closed 2-cell after taking a partial dual.

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MS17

Biembedding Designs and Minimum Genus Embeddings

In this presentation I will discuss results establishing, for $n \equiv 3 \pmod{36}$, that K_n has a face 2-colourable, blue and green say, nonorientable embedding in which there are $(n-1)/2$ blue faces each of which have a Hamilton cycle as their facial walk and $n(n-1)/6$ green faces each of which have a triangle as their facial walk. By adapting the construction results on minimum genus embeddings of $K_n+\overline{K_m}$ are also obtained.

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MS17

Genus Distribution of Path-like Graphs: Transfer Matrix Method

The Transfer Matrix approach is taken for computing the genus distribution of graphs whose structure is repeated in a way of a long path or a cycle. As an example we provide explicit solutions for genus distributions of the Cartesian product of various small graphs with a long path or a cycle.

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MS17

Polychromatic Coloring of Graphs on Surfaces

Let G be a graph on a surface. A polychromatic k-coloring of G is a vertex-k-coloring of G such that each face of G receives all the k colors. Recently, Horev et al. proved that every cubic bipartite plane graph admits a polychromatic proper 4-coloring, where "4" is best possible, and the cubicity and bipartiteness cannot be omitted in the theorem. In my talk, we discuss a recent progress on polychromatic colorings of graphs on surfaces.

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MS17

Obstructions for Embeddings of Graphs in Surfaces

Only for two surfaces, the sphere and the projective plane, the complete list of obstructions (forbidden minors) for embedding graphs into the surface is known. We present our general results about the obstructions of connectivity 2. As a consequence, we obtain all obstructions for the torus of connectivity 2.

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MS18

The Δ^2 Conjecture for Graph Labellings with Separation Conditions

In 1988 Roberts described a problem posed to him by Lanfear concerning the efficient assignment of channels to a network of transmitters in the plane. To understand this problem, Griggs and Yeh introduced the theory of integer vertex λ-labellings of a graph G. To prevent interference, labels for nearby vertices must be separated by specified amounts k_i depending on the distance i, $1 \leq i \leq p$. One seeks the minimum span of such a labelling. The $p = 2$ case with $k_1 = 2$ and $k_2 = 1$ has attracted the most attention, particularly the tantalizing conjecture that for such "$L(2,1)$-labellings", if G has maximum degree $\Delta \geq 2$, then the minimum span is at most Δ^2. It has now been proven for all sufficiently large Δ, but remains open for small Δ, even for $\Delta = 3$.

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MS18

Backbone Coloring: Tree Backbone in Planar Graphs

Backbone coloring is a variation of channel assignment problem. For a graph G and a subgraph H (called *backbone*) of G, a *backbone k-coloring of G over H* is a proper vertex coloring of G using colors from $\{1, 2, \ldots, k\}$, such that the colors for any two adjacent vertices in H differ by at least two. The *backbone chromatic number of G over H*, $\mathrm{BBC}(G, H)$, is the smallest k of a backbone k-coloring admitted by G over H. Broesma et al. showed that $\mathrm{BBC}(G, H) \leq 2\chi(G) - 1$ holds for every G and H. This implies that if G is planar, then $\mathrm{BBC}(G, H) \leq 7$ for all H. They conjecture that if G is planar and T is a tree, then $\mathrm{BBC}(G, H) \leq 6$. We prove this conjecture when T is a tree of diameter at most 4.

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MS18

L(2,1,1)-Labeling Is NP-complete for Trees

An $L(p_1, p_2, p_3)$-labeling of a graph G with span λ is a mapping f that assigns each vertex u of G an integer label $0 \leq f(u) \leq \lambda$ such that $|f(u) - f(v)| \geq p_i$ whenever vertices u and v are of distance i for $i \in \{1, 2, 3\}$. We show that testing whether a given graph has an $L(2, 1, 1)$-labeling with some given span λ is even -complete for the class of trees.

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MS18

Backbone Colorings of Graphs with Large Girths

Backbone coloring is a variation of the channel assignment problem. For a graph G and a subgraph H (called *backbone*) of G, a *backbone k-coloring of G over H* is a proper vertex coloring of G using colors from $\{1, 2, \ldots, k\}$, such that the the colors of adjacent vertices in H differ by at least two. The *backbone chromatic number of G over H*, $\mathrm{BBC}(G, H)$, is the smallest k of a backbone k-coloring of G over H. Broersma, Fomin, Golovach, and Woeginger showed that $\mathrm{BBC}(G, H) \leq 2\chi(G) - 1$ holds in general. Mištkuf, Škrekovski, and Tancer proved that for any n there exists a triangle-free graph G with a spanning tree T such that $\chi(G) = n$ and $\mathrm{BBC}(G, T) = 2n - 1$. We generalize this result: For any n there exists a graph G with arbitrarily large girth and a tree $T \subseteq G$ with $\chi(G) = n$ and $\mathrm{BBC}(G, H) = 2n - 1$. Moreover, we prove that if T is a tree with degrees bounded by a given constant, and G is a subgraph of the square of T, then $\mathrm{BBC}(G, T)$ can be determined in polynomial time.

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MS18

Distance Three Labellings of Graphs

Let h be a positive integer. An $L(h, 1, 1)$-labelling of a (finite or infinite) graph is an assignment of nonnegative integers (labels) to its vertices such that adjacent vertices receive labels with difference at least h, and vertices distance two or three apart receive distinct labels. The span of such a labelling is the difference between the maximum and minimum labels used. Motivated by applications in frequency assignment, the $L(h, 1, 1)$-labelling problem seeks for the minimum span over all $L(h, 1, 1)$-labellings of a graph together with an optimal $L(h, 1, 1)$-labelling. In this talk I will review recent results on the $L(h, 1, 1)$-labelling problem.

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MS19

Cycle Extension Property in BIBD Block-Intersection Graphs

A cycle C in a graph G is said to be extendible if there exists a cycle C' such that $V(C) \subseteq V(C')$ and $|V(C')| = |V(C)| + 1$. A graph G is said to be cycle extendible if every non-Hamiltonian cycle of G is cycle extendible. A balanced incomplete block design $BIBD(v, k, \lambda)$ consists of a set of blocks, each of which is a k-subset of a point set V of cardinality v, such that each pair of points occurs in precisely λ of the blocks of the design. The block-intersection graph of a design D is the graph having the block set of D as its vertex set, and in which two vertices are adjacent if and only if their corresponding blocks have non-empty intersection. We show that for integers $k \geq 2$ and $\lambda \geq 1$, the block-intersection graph of a $BIBD(v, k, \lambda)$ is cycle extendable. This is joint work with David Pike.

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MS19

Schröder Quasigroups and Related Combinatorial Designs

Schröder quasigroups have been studied quite extensively over the years. Apart from corresponding to self-orthogonal Latin squares with the Weisner property, Schröder quasigroups are known to be associated with other combinatorial configurations such as orthogonal arrays with interesting conjugate invariant properties, a class of edge-colored designs with block size 4, and triple tournaments. The purpose of this talk is to survey known existence results for various aspects of these associations and to mention some open problems.

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MS19

Decompositions of Complete Graphs into Cycles and Related Problems

In 1981, Alspach posed the problem of proving that the obvious necessary conditions for a decomposition of a complete graph into cycles of specified lengths are also sufficient. In this talk I will briefly outline a solution to Alspach's problem and discuss other similar problems.

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MS19

Friendship 3-hypergraphs

Let $(X, \mathcal{B})$ be a set system in which $\mathcal{B}$ is a set of 3-subsets of X. Then $(X, \mathcal{B})$ is a *friendship 3-hypergraph* if it satisfies the following property: for distinct elements $u, v, w \in X$, there exists a unique fourth element $x \in X$ such that $\{u, v, x\}, \{u, w, x\}, \{v, w, x\} \in \mathcal{B}$. If a friendship 3-hypergraph contains a element $f \in X$ such that $\{f, u, v\} \in B$ for all $u, v \in X \setminus \{f\}$, then it is called a *universal friend 3-hypergraph* and the element f is called a *universal friend* of the hypergraph. In this presentation, we will show that if $(X, \mathcal{B})$ is a friendship 3-hypergraph with $|X| = n$, then $|\mathcal{B}| \geq \lceil \in(\setminus - \infty)(\setminus - \in)/\ni \rceil$. In addition, we will also show that if $n \equiv 2, 4 \pmod 6$, then this bound is met if and only if $(X, \mathcal{B})$ is a universal friend 3-hypergraph.

Ben Li
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MS19

Broadcast Systems

A broadcast system of order n is a decomposition of the complete directed graph D_n into n minimum broadcast trees, one rooted at each node. I will show that broadcast systems exist for all orders, and discuss some partial results on uniform broadcast systems where all of the broadcast trees are isomorphic.

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MS20

Graph Theoretical Design Strategies for DNA Self-assembly

Recent advances in DNA self-assembly have resulted in nanoscale graphs: cubes, octahedrons, truncated octahedra, and even buckyballs, as well as ultra-fine meshes, lidded boxes and 2D figures. These constructs serve emergent applications in biomolecular computing, nanoelectronics, biosensors, drug delivery systems, and organic synthesis. One construction method uses k-armed branched junction molecules, called tiles, whose arms are double strands of DNA with one strand extending beyond the other, forming a 'sticky end' at the end of the arm that can bond to any other sticky end with complementary Watson-Crick bases. A vertex of degree k in the target graph is formed from a k-armed tile, and joined sticky ends form the edges. Another construction method 'threads' a single strand of DNA through the graphical structure and then uses short 'staple' strands for an origami folding of the DNA into the desired geometric realization of the graph. A third method uses circular single strands of DNA to trace the faces of a topological embedding of the graph. We use graph theory to determine optimal design strategies for biologists producing these nanostructures, and conclude with a discussion of how the same mathematics, on the macroscale now, may be adapted to space applications. This is joint work with Greta Pangborn, with an undergraduate research component.

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MS20

Fluid Models for Self-organized Microtubule Arrays

In plant cells, microtubules self-organize into ordered arrays from an initially isotropic system as a result of their interactions. We develop a mean-field model which is used to derive sufficient conditions for self-organization by conducting a stability analysis. Considering parameter regions that satisfy conditions for organization, we develop predictive methodologies for expected number and average length of microtubules over time using fluid models for microtubule dynamics and approximations. Results are tested using computer simulations.

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MS20

Specification and Optimization of Synthetic Multicell Behaviors

The process by which a single cell develops into a multicelled organism is complicated. A combination of internal logic, control of growth and division, and cell-cell communication must coordinate the behaviors of the growing organism so that it differentiates correctly in time and space, in spite of environmental perturbations, and intrinsic or extrinsic noise. Although several formalisms have been defined to describe development to produce CGI plants using L-systems for example the relationship between high level programs and the possible biochemical implementation of those programs in micro-organisms is tenuous. Said differently, it is unknown whether the basic mechanisms available to the synthetic biologist are sufficient to implement the pattern formation algorithms defined at higher levels. Here, we introduce a formal specification and programming language, called gro, that allows the programmer to write distributed algorithms at a variety of different levels of abstraction. For example, the programmer may specify that a cell changes from one state to another, of that cell state is defined at the level of a multi-stable gene network with all of the low-copy number noise that would accompany it. The programs can be simulated in an environment that models the basic geometry of micro-colony growth and division, as one might see under a microscope, and also models the production, degradation, and diffusion of signaling molecules. In this talk, we illustrate gro with a variety of examples; focus on the example of symmetry-breaking in particular; and discuss a notion abstraction for gro programs using Wasserstein pseudometrics. The result is a tool that may someday allow the molecular programmer to specify a developmental process at a high level, and refine it, step-by-step, into a low level description of how an implementation would work, and finally to formally compare the specification to an actual experimental implementation.

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MS20

Inferring Physical Parameters and Assembly Pathways from Indirect Measures of Viral Self-assembly

Virus capsids have inspired many theoretical studies of assembly mechanisms and pathways accessible to a simple set of self-assembling components. It has generally proven impossible, though, to determine where any particular virus falls in this universe of possibilities. We have combined discrete assembly models with continuous optimization over rate parameters to infer assembly kinetics and pathways from bulk measures of assembly progress. Application to real viruses suggests a diversity of mechanisms in use in nature.

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MS20

Modelling the Co-operative Roles of Genomic RNA during Virus Assembly

We demonstrate that the genomes of ssRNA viruses impact on the assembly of the viral protein containers that package them. For a test virus, bacteriophage MS2, we show that its genomic sequence has evolved specific patterns that play important functional roles in the assembly process. We quantify these via kinetic modelling and a computation of the assembly pathways and, in combination with graph theory, predict unprecedented details concerning the organisation of the packaged genome.

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MS21

Egerváry LPs and Fractional Vertex Packing

We treat relations of Egerváry (i.e. Hungarian) type algorithms to various early results on fractional vertex packings and coverings by Nemhauser and Trotter, Picard and Queranne, Bourjolly and Pulleyblank, Lovász, Korach, Deming, Sterboul, and Kayll, including that, for any vertex weighted graph G, every maximal set of vertices with 0s and 1s, rather than halves, in an optimum weight fractional vertex packing is the same. It can be extended to an optimum integer vertex packing of G. It provides an easy way to test whether G is K-E since, with all weights one, some optimum fractional vertex packing has no fractions if and only if G is K-E.

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MS21

König-Egerváry Graphs: Introduction and a Warm-up Result

K-E graphs are those for which the maximum size of a matching coincides with the minimum size of a covering (bipartite graphs being a basic example). Edmonds (1965) characterized the perfect matching polytope PM(G) of a graph $G = (V, E)$ as the set of nonnegative $\mathbf{x} \in \Re^{\mathbf{E}}$ satisfying two families of constraints: 'vertex saturation' and 'blossom'. When the blossom constraints are redundant for determining PM(G), the graph is *non-Edmonds*. After discussing some early results on K-E graphs, we'll show that these graphs are non-Edmonds.

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MS21

Fractional Independence Number and König-Egerváry Graphs

The *fractional independence number* α_f of a graph is the maximum value of $\sum w(v_i)$, where $w(v_i) \in [0, 1]$, for each vertex v_i of the graph, and $w(v_i) + w(v_j) \le 1$ for each pair $\{v_i, v_j\}$ of adjacent vertices in the graph. This is the linear programming relaxation of the integer programming formulation for the independence number α of the graph. α_f is an upper bound for α and can be computed efficiently. We show that $\alpha = \alpha_f$ for a graph if, and only if, the graph is König-Egerváry, and discuss connections to the work of Nemhauser, Trotter, Bourjolly, Pulleyblank, and the theory of critical independent sets.

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MS21

Independent Sets in almost König-Egerváry Graphs

Let $\alpha(G)$ denote the cardinality of a maximum independent set and $\mu(G)$ the size of a maximum matching in $G = (V, E)$. If $\alpha(G) + \mu(G) = |V| - 1$, then G is an *almost König-Egerváry graph*. Let core(G) (corona(G)) be the intersection (union, respectively) of all maximum independent sets, and $\ker(G)$ be the intersection of all critical independent sets. In this talk we prove that if G is an almost König-Egerváry unicyclic graph, then: *(i)* $\ker(G) = \mathrm{core}(G)$ and *(ii)* $|\mathrm{corona(G)}| + |\mathrm{core(G)}| = 2\alpha(G) + 1$.

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MS22

Phase Transition in Random Integer Programs

We consider integer programs on random polytopes in R^n with m facets whose normal vectors are chosen independently from any spherically symmetric distribution. We show a phase transition phenomenon: a transition from integer infeasibility to integer feasibility happens within a constant factor increase in the radius of the largest inscribed ball. Our main tools are: a new connection between integer programming and matrix discrepancy, a bound on the discrepancy of random Gaussian matrices and Lovett-Meka's algorithm for finding low discrepancy solutions.

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MS22

The Game Chromatic Number of Sparse Random Graphs

Given a graph G and an integer k, two players properly color the vertices of G using k colors. The first player wins iff when the game ends all the vertices are colored. The game chromatic number $\chi_g(G)$ is the minimum k for which the first player has a winning strategy. We present results regarding the asymptotic behavior of this parameter for random graphs with constant average degree and for random regular graphs.

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MS22

Connectivity and Giant Components in Stochastic Kronecker Graphs

A stochastic Kronecker graph is a random graph model wherein each vertex is represented by a string in an alphabet Γ, and the probability that two vertices are adjacent is determined by comparing their corresponding strings. We use matrix concentration inequalities to develop conditions under which a stochastic Kronecker graph is asymptotically connected, and under which it has a giant component.

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MS22

The Power and Weakness of Two Choices: Unbalanced Allocations

The "power of two choices" (generating several random options and choosing among them) has been used successfully in load balancing algorithms, queuing theory, and Achlioptas processes. Here an allocation algorithm for generating an unbalanced distribution using this technique is presented and analyzed. This type of algorithm has connections to physics, biology, and economics, and arose originally from a real-world cost-minimization question. Its analysis uses ideas from differential equations, random walks, and some new concepts.

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MS23

Symmetric chain decomposition for necklace posets and relation to cyclic crystals

The quotient of a Boolean algebra by a cyclic group is proven to have a symmetric chain decomposition. This generalizes earlier work of Griggs, Killian and Savage on the case of prime order, giving an explicit construction for any order, prime or composite. The combinatorial map specifying how to proceed downward in a symmetric chain is shown to be a natural cyclic analogue of Kashiwara's sl_2 lowering operator in the theory of crystal bases. This is joint work with Anne Schilling.

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MS23

Volume Bounds for Shadow Covering

Suppose that K and L are compact convex subsets of Euclidean space such that, for every direction u, the orthogonal projection of L onto the subspace $u^\perp$ contains a translate of the corresponding projection of the body K. In spite of these covering conditions, it is possible for K to have *greater volume* than L. The question then turns to bounds: How large can the volume ratio $\frac{V(K)}{V(L)}$ be? And what other valid comparisons can be made? While these questions are posed in the setting of convex geometric analysis, a fundamental role in their resolution is played by Helly's Theorem.

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MS23

Perturbation of Transportation Polytopes

We introduce a perturbation method that can be used to reduce the problem of finding the multivariate generating function (MGF) of a non-simple cone to computing the MGF of simple cones. We then give a universal perturbation that works for any transportation polytope. We apply this perturbation to the family of central transportation polytopes of order $kn \times n$, and obtain formulas for the MGFs of the feasible cones of vertices of the polytope and the MGF of the polytope. The formulas we obtain are enumerated by combinatorial objects. A special case of the formulas recovers the results on Birkhoff polytopes given by the author and De Loera and Yoshida.

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MS23

Monotone Hurwitz Numbers: Polynomiality and Explicit Forms

Monotone Hurwitz numbers are a desymmetrized version of the classical Hurwitz numbers from enumerative algebraic geometry. They appeared recently in the context of random matrix theory. In this talk I will focus on the algebraic and combinatorial structure of monotone Hurwitz numbers, which is to a surprising extent similar to the classical case. In particular, I will discuss polynomiality and Toda equations for monotone Hurwitz numebers, as well as low-genus formulas. This is joint work with I. Goulden and M. Guay-Paquet (Waterloo).

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MS23

Orientations, Semiorders, Arrangements, and Parking Functions

It is known that the Pak-Stanley labeling of the Shi hyperplane arrangement provides a bijection between the regions of the arrangement and parking functions. For any graph G, we define the G-semiorder arrangement and show that the Pak-Stanley labeling of its regions produces all G-parking functions.

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MS24

Distances Between Evolutionary Trees

Phylogenetic (leaf-labelled) trees are used in computational biology to show the evolutionary relationships within a collection of species. A common way to measure the dissimilarity between phylogenetic trees with identical leaf sets is the minimum number of certain tree rearrangement operations that is necessary to transform one tree into the other. In other words, we use the graph distance of the graph where the vertices are all phylogenetic trees with given leaf set and two trees are adjacent if they are a single rearrangement operation apart. I will summarize recent results on the tree bisection and reconnection (tbr) and the subtree prune and regraft (spr) distances.

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MS24

On t-Path Closed Graphs

A t-path closed is a graph with girth $t+1$ such that for each pair of distinct vertices there is a path of length t connecting them. In this talk we will give several constructions of such graphs. Also we will give relations with cages and Moore graphs.

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MS24

Switchings, Extensions, and Reductions in Central Digraphs

A directed graph is called *central* if, for each ordered pair u, v of (not necessarily distinct) vertices, there is a unique vertex z such that the digraph contains the arcs uz, zv. Equivalently, the adjacency matrix A satisfies the matrix equation $A^2 = J$, where J is the matrix with a 1 in each entry. It has been conjectured that every central directed graph can be obtained from a standard example by a sequence of simple operations called switchings, and also that it can be obtained from a smaller one by an extension. We disprove these conjectures and present a general extension result which, in particular, shows that each counterexample extends to an infinite family of central digraphs.

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MS24

Greedy Trees and the Extremal Distances

We show a “universal property’ of the greedy tree with a given degree sequence, namely that the number of pairs of vertices whose distance is at most k is maximized by the greedy tree for all k. This rather strong assertion immediately implies, and is equivalent to, the minimality of the greedy trees with respect to graph invariants of the form $W_f(T) = \sum_{\{u,v\}\subseteq V(T)} f(d(u,v))$ for any nonnegative, nondecreasing function f. With different choices of f, one directly solves the minimization problems of distance-based graph invariants including the classical Wiener index, the Hyper-Wiener index and the generalized Wiener index.

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MS24

Walks and homomorphisms of digraphs

In this talk we try to discuss some connections between symbolic dynamics and digraph homomorphisms and then apply them to some problems on walks in digraphs posed by Delorme, Tvrdik, Harbane and Heydemann et al.

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MS25

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MS25

Convexity and Graph Classes

We survey graph classes that arise from convexity in graphs with emphasis on convex geometries.

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MS25

Atomic Structure, Hyperbolicity, and Recognition of AT-free Graphs with no Induced 4-cycles

An atom of a graph is a maximal induced subgraph with no clique cutset. We characterize atoms of C_4-free AT-free graphs. This class of graphs is of interest as it coincides with 1-hyperbolic AT-free graphs while all other AT-free graphs are 2-hyperbolic. Based on the structure of atoms, we describe an efficient algorithm for the recognition of the class.

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MS25

Polygon Numbers of Circle Graphs

Circle graphs and k-polygon graphs are intersection graphs of chords of a circle and chords of a convex k-sided polygon where each chord has its endpoints on distinct sides, respectively. Determining $\psi(G)$, the minimum number of sides in a polygon representation of a circle graph G, is NP-hard, whereas determining whether G is a k-polygon graph for fixed k can be done in polynomial time. We give bounds on $\psi(G)$ when G is an arbitrary circle graph and identify graph classes for which $\psi(G)$ can be computed in polynomial time.

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MS25

Unit Interval Graphs of Mixed Intervals

The class of unit interval graphs has a lovely characterization as those interval graphs with no induced claw $K_{1,3}$. The characterization remains the same whether the intervals used in the intersection representation are all open intervals or all closed intervals. In recent work, Rautenbach and Szwarcfiter characterize the broader class that arises when both open and closed intervals of unit length are permitted. In this talk we consider the same problem when unit length mixed intervals of the form $(x, x+1]$ and $[x, x+1)$ are also allowed. We give a structural characterization of this class of graphs.

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MS26

The Cost of 2-Distinguishing Cartesian Powers

A graph is said to be 2-*distinguishable* if there is a vertex labeling with two labels so that only the trivial automorphism preserves the labels. Define the *cost of 2-distinguishing* G, denoted $\rho(G)$, to be the minimum size of a label class in such a labeling. A *determining set* is a subset of vertices with trivial pointwise stabilizer; its minimum size is denoted $\mathrm{Det}(G)$. The main result of this talk is that under mild hypotheses, $\rho(G^k) \in \{\mathrm{Det}(G^k), \mathrm{Det}(G^k)+1\}$.

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MS26

Groups That Are Transitive on All Partitions of a Finite Set

We study the question of which subgroups of S_n are transitive on the set of all ordered partitions of the set $[n] = \{1, \ldots, n\}$ and all unordered partitions of $[n]$. This work can be considered a generalization of well known work in which subgroups of S_n that are transitive on the set of all subsets of $[n]$ of size k were determined. As an application of our results, we determine which Johnson graphs are Cayley graphs.

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MS26

Decomposing Hypergraphs on Finite Fields

We examine edge decompositions of complete uniform hypergraphs whose parts are permuted transitively by some permutation of the vertex set. We present an algebraic method for constructing such a hypergraph decomposition on a finite field which is related to the Paley graph construction and is derived from a partition of the cosets of the multiplicative group of units of the field. We discuss the symmetry and other properties of the hypergraphs we obtain.

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MS26

Infinite Motion and Distinguishing Number 2

Given a group A acting faithfully on a set X, define the *motion* (also known as minimal degree) of A, to be $m(A) = \min_{a\neq 1} |\{x : x^a \neq x\}|$. A general principle for finite A is that if $m(A) >> |A|$, then the action has distinguishing number 2, that is, there is a subset Y whose set-wise stabilizer is trivial. For infinite A and countable X, we make the *Infinite Motion Conjecture*: if $m(A)$ is infinite, then the action has distinguishing number 2. We consider various contexts for the conjecture in the case of locally finite graphs.

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MS26

Finite Subgraphs of d-Distinguishable, Locally Finite Graphs

It is known (M.E. Watkins and X. Zhou, 2007) that every infinite, locally finite tree T with finite distinguishing number $d(T) = d_0$ contains a finite subtree with distinguishing number d_0. It is not difficult to prove more generally that if every finite subgraph Φ of an infinite, locally finite graph Γ satisfies $d(\Phi) \leq d_0$, then $d(\Gamma) \leq d_0 + 1$. We investigate conditions subject to which this bound may be sharp.

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MS27

Fast Algorithms for Phylogenetic Reconstruction

We present two recent very fast algorithms to infer phylogenetic trees in $o(n^2)$ time when the input consists of data from n species. Our first algorithm uses a search tree much like a randomly balanced binary search tree to place each new species into its correct place. Our second algorithm uses nearest-neighbour search to speedily find roughly where each new taxon goes, and then uses more robust methods to exactly place the new species correctly.

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MS27

Gene Family Evolution by Duplication and Loss - Reconciliation and Species Tree Inference

Almost all genomes which have been studied contain genes that are present in two or more copies. They are usually identified through sequence similarity, and grouped into a single "Gene Family'. From a functional point of view, such grouping is not sufficient to infer a common function for genes. Indeed, it is important to distinguish between "orthologs' which are copies in different species related through speciation, and thus likely to have similar functions, and "paralogs', which are copies that have evolved by duplication, and more likely to have acquired new functions. Understanding the evolution of gene families through speciation, duplication, and loss is thus a fundamental question in functional genomics, and also in evolutionary biology and phylogenomics. Reconciliation is the commonly used method for inferring the evolutionary scenario for a gene family. It consists in "embedding' inferred gene trees into a a species tree. When a species tree is not known, a natural algorithmic problem is to infer a species tree from a set of gene trees, such that the corresponding reconciliation minimizes the number of duplications and/or losses. The main drawback of reconciliation is that the inferred evolutionary scenario is strongly dependent on the considered gene trees, as few misplaced leaves may lead to a completely different history. In this talk, we will clarify several theoretical questions and present various algorithmic issues related to reconciliation and species tree inference. In particular, we will present a strategy for "correcting' or preprocessing a gene tree prior to reconciliation or species tree inference, and give various complexity results and algorithmic solutions, in both cases of a known and an unknown species tree.

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MS27

Tree Compatibility, Character Compatibility, and Graph Triangulation

We consider two classic NP-complete problems in phylogenetic tree construction, tree compatibility and character compatibility. In each case, the "yes' instances are precisely those for which a specific kind of triangulation exists for a certain graph. The relationship between triangulations and character compatibility has been known for over three decades (Buneman, 1974); an analogous relationship with tree compatibility was identified more recently (Vakati and Fernández-Baca, 2011). We use these characterizations to gain insight into the fundamental differences in tractability between the two problems.

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MS27

Aspects of Fractionation; A Fundamental Evolutionary Process

In the evolutionary history of virtually all eukaryotic species is at least one whole genome duplication (WGD). Each WGD event is followed by a a period of fractionation whereby only one of the copies of almost all gene pairs is shed, sometimes on one of the two homeologous chromosomes, and sometimes on the other. This effectively scrambles the gene order on chromosomes and introduces an extreme level of noise into gene order comparisons between genomes descending from the WGD and those that diverged before this event, and also between genomes in sister lineages descending from the event radiating soon after the WGD. In these cases, fractionation is responsible for more gene order disruption than rearrangements such as inversion and translocation. We discuss three aspects of fractionation:

- the time course of fractionation on scales of tens to hundreds of millions of years,
- a recurrence for the run lengths of deleted and undeleted genes on a chromosome, and
- a model for gene family size, where a genome originates from more than one successive WGD or other polyploidization event.

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MS27

Reconstruction of Certain Phylogenetic Networks from the Tree-Additive Distances Between Their Leaves

Suppose N is a rooted directed graph and each leaf corresponds to an extant biological species. Suppose each arc of N has a nonnegative weight and inheritance of a character at a hybrid vertex occurs with a certain probability from each parent. The tree-additive distance between two leaves is the expected value of their distances in the displayed trees. Sufficient conditions are investigated so that, given the tree-additive distances between all leaves, it is possible to reconstruct the network.

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MS28

Quotients of the Boolean Lattice by Wreath Products

Rod Canfield has asked if all quotients of a Boolean lattice B_n induced by subgroups of its automorphism group, essentially S_n, are symmetric chain orders. K. Jordan verified this in the special case of a subgroup generated by an n-cycle, answering a question raised earlier by Griggs, Killian and Savage. In earlier work we found an especially straightforward proof of Jordan's result based on the Greene-Kleitman symmetric chain decomposition. Hersh and Schilling, and Dhand have presented other proofs of the same result, and the latter has the substantial generalization that P^n/Z_n is an SCO whenever P is an SCO. Here we continue in the same vein as our earlier work, describing circumstances under which subgroups G of the symmetric group which are wreath products are guaranteed to induce quotients that are symmetric chain orders. This is done by carefully winnowing Greene-Kleitman SCDs.

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MS28

Poset-free Families of Sets

Given a finite poset P, we consider the largest size $\mathrm{La}(n, P)$ of a family F of subsets of $[n] := \{1, \ldots, n\}$ that contains no (weak) subposet P. For fixed P it can be very difficult to determine $\mathrm{La}(n, P)$, even asymptotically. We continue to believe that $\pi(P) := \lim_{n\to\infty} \mathrm{La}(n, P)/\binom{n}{\lfloor n/2 \rfloor}$ exists for general posets P, and, moreover, it is an integer that we can predict. The existence of the limit remains open, for instance, for the four-element diamond poset and the six-element crown. However, we are developing methods that allow us to solve the asymptotic problem, and sometimes even the exact problem for all n, for increasingly many posets P. These methods involve studying the Lubell function of a family F, which is the average number of times a random full chain meets F.

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MS28

Chopping Celery and the Lattice of Integer Partitions

The *chop vector* of a set S of celery sticks of positive integer lengths is the infinite vector $\mathbf{v}_S = (v_1, v_2, v_3, \ldots)$, where each v_w is the minimum number of cuts needed to chop S

into unit pieces, using a knife that can cut up to w sticks at a time. In this talk we see a connection (found jointly with Thao Do) between the set of chop vectors and the lattice of integer partitions.

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MS28

Diamond-Free Collections of Subspaces

Let V be a finite-dimensional vector space over a finite field, and let A, B, C, and D be subspaces of V. We say that $\{A, B, C, D\}$ is a diamond if A is a subspace of both B and C which in turn are subspaces of D. Inspired by the recent work on the Boolean Lattices, we ask: What is the size of the largest collection of diamond-free subspaces of V? The corresponding question in the Boolean Lattices has not been completely settled and neither is the question in the Linear Lattices. We report on partial progress. Joint work with Ghassan Sarkis and the undergraduate math research circle at Pomona College.

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MS28

Linear Discrepancy of Partially Ordered Sets

The *linear discrepancy* of a P, denoted $\mathrm{ld}(P)$, is the minimum over all linear extensions of the maximum difference between the positions of two incomparable elements. Tanenbaum, Trenk, and Fishburn conjectured that always $\mathrm{ld}(P) \leq \lfloor (3r-1)/2 \rfloor$, where r is the maximum number of elements incomparable to any single element. We disprove this conjecture by showing that appropriately randomized bipartite posets have linear discrepancy asymptotic to the trivial upper bound, $2r-1$. On the other hand, we show that the conjecture does hold for posets having width 2.

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MS29

Roots of Combinatorial Polynomials

Polynomials arise in a variety of ways in combinatorics, from applications like graph colourings and network reliability, to theoretical investigations of sequences related to independent sets of graphs and open sets of finite topologies. We discuss some recent results about the roots of such polynomials, both in terms of location and nature, as well as some connections to fractals.

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MS29

Graph Colouring and the Topological Penrose Polynomial

The Penrose polynomial of a plane graph first appeared implicitly in Roger Penroses 1971 work on diagrammatic tensors, but was discovered to have a number of remarkable graph theoretical properties, particularly with respect to graph colouring. We now extend the Penrose polynomial, originally defined only for plane graphs, to graphs embedded in arbitrary surfaces. This leads to new identities and relations for the Penrose polynomial which cannot be realized within the class of plane graphs. In particular, by exploiting connections with the transition polynomial and the ribbon group action, we find a deletion-contraction-type relation for the Penrose polynomial and its relation to the ribbon graph polynomial of Bollobas and Riordan. We relate the Penrose polynomial of an orientable checkerboard colourable graph to the circuit partition polynomial of its medial graph and use this to find new combinatorial interpretations of the Penrose polynomial. We also show that the Penrose polynomial of a plane graph G can be expressed as a sum of chromatic polynomials of twisted duals of G. This allows us to obtain a new reformulation of the Four Colour Theorem.

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MS29

Matroids, Greedoids and the Tutte Polynomial

We present some conjectures and counterexamples related to the greedoid generalization of the Tutte polynomial of a matroid. In particular, we give simple examples to show the Tutte polynomial does not distinguish greedoids. We also study the affine relations satisfied by the coefficients of the Tutte polynomial in this more general setting.

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MS29

Some Recent Results on Chromatic and Tutte Polynomials for Families of Graphs

We discuss some recent results on chromatic and Tutte polynomials (equiv. to Potts model partition functions in statistical physics) and some generalizations for various families of graphs. These include weighted-set chromatic and Tutte polynomials, lower bounds on Potts ground-state entropy, and chromatic polynomials for one- and multi-parameter families of planar triangulation graphs. References include S.-C.Chang and R. Shrock, J. Phys. A (JPA) 42, 385004 (2009); J. Stat. Phys. (JSP) 138, 496 (2010); R. Shrock and Y. Xu, JSP 139, 27 (2010); JSP

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MS29

Peck orders and LYM orders

Abstract not available at time of publication.

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MS30

Edge-coloring 8-regular Planar Graphs

In 1974 Seymour made the following conjecture:

Let G be a k-regular planar graph, such that if X is an odd set of vertices of G, then at least k edges of G have one end in X and the other in $V(G) \setminus X$. Then G is k-edge colorable.

For $k = 3$ this is equivalent to the Four Color Theorem. The cases of $k = 4, 5$ were solved by Guenin, the case of $k = 6$ by Dvorak, Kawarabayashi and Kral, and the case of $k = 7$ by Edwards and Kawarabayashi. In joint work with Edwards and Seymour, we now seem to have a proof for the case $k = 8$, and that is the topic of this talk.

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MS30

Graph Stirling Numbers

For a graph G and an integer k, the graph Stirling number $S(G, k)$ is the number of partitions of $V(G)$ into k non-empty independent sets. Equivalently it is the number of proper colourings of G using exactly k colours, with two colourings identified if they differ only on the names of the colours. If G is the empty graph on n vertices then $S(G, k)$ is just $S(n, k)$, the familiar Stirling number of the second kind. In this talk, we look at the Stirling numbers of families and forests and cycles. Among other results, we generalize Harper's theorem on the asymptotic normality of the ordinary Stirling numbers.

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MS30

Recent Results on Grundy number

A k-coloring of a graph $G = (V, E)$ is a function $f : V \to \{1, \ldots, k\}$ such that $f(v) \neq f(w)$ for all $vw \in E$. The Grundy number of a graph is the largest integer k such that there is a k-coloring f of G such that if $1 \leq i < j \leq k$ and $f(v) = j$ then there exist $w \in N(v)$ such that $f(w) = i$. It is well known that the Grundy number of G is equal to the worst case performance of First-Fit on G. I will discuss many recent results concerning Grundy number.

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MS30

Bounding the Fractional Chromatic Number of K_Δ-free Graphs

In this talk I will discuss recent work in bounding the difference between the maximum degree and the fractional chromatic number in graphs for which the answer is not obvious, i.e. for graphs whose clique number is less than the maximum degree. This work has interesting ties to the Borodin-Kostochka conjecture and Reed's conjecture.

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MS30

Multicolor and Directed Edit Distance

For the edit distance problem, simple graphs on the same vertex set are elements in a metric space defined by the normalized edit distance. The primary question is the maximum distance of a graph from some fixed hereditary property.

In this talk, we generalize this concept to other kinds of graphs. We consider multicolorings of the edges of complete graphs as well as simple directed graphs. The same question – the maximum distance of an element from a hereditary property – is considered in these settings and we provide bounds for this quantity.

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MS31

Two Extensions of Ramsey's Theorem

Ramsey's theorem states that every 2-colouring of the edges of the complete graph on $\{1, 2, \ldots, n\}$ contains a monochromatic clique of order roughly $\log n$. We prove new bounds for two extensions of Ramsey's theorem, each demanding extra structure within the monochromatic clique. In so doing, we answer a question of Erdős and improve upon results of Rödl and Shelah.

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MS31
On Restricted Ramsey Numbers

A classical Ramsey theorem states that in any 2-coloring of the edges of a sufficiently large complete graph, one will always find a monochromatic complete subgraph. In 1970, Folkman extended this result showing that for any graph G there exists a graph H with the same clique number as G such that any 2-coloring of the edges of H yields a monochromatic copy of G. In this talk, we present some old and recent developments concerning Folkman-type results for vertex colorings.

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MS31
Ramsey Problems on Non-Complete Graphs

A typical question in Ramsey Theory is, for given graphs G and H, to determine the Ramsey number $R(G, H)$: the smallest integer N such that, in every colouring of the edges of the complete graph K_N on N vertices with red and blue, we either find a red copy of G or a blue copy of H. One naturally wonders whether the complete graph K_N in the above definition can be replaced by some other graph F on N vertices. It would be naive to think we can take *any* graph on N vertices, therefore, we put some restrictions on such a graph F. In this we shall discuss the following problem: For given graphs G and H, is there a constant $0 < c < 1$ such that if a graph F on $N = R(G, H)$ vertices has minimum degree at least $(1 - c)N$, then in every colouring of the edges of F with red and blue, we either find a red copy of G or a blue copy of H. It is not even clear why such c should even exist. We determine the maximum c when G and H are cycles or paths, and show that c exists for a rather large class of pairs (G, H).

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MS31
Title Not Available at Time of Publication

Abstract not available at time of publication.

TBA TBA
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MS31
Diagonal Forms for Incidence Matrices and Zero-Sum (mod 2) Ramsey Theory

Let H be a t-uniform hypergraph on k vertices, with $a_i \geq 0$ denotes the multiplicity of the i-th edge, $1 \leq i \leq \binom{k}{t}$. Let $\mathbf{h} = (a_1, \cdots, a_{\binom{k}{t}})^\top$, and $N_t(H)$ the matrix whose columns are the images of $\mathbf{h}$ under the symmetric group S_k. We determine a diagonal form (Smith normal form) of $N_t(H)$ for a very general class of H. Motivated by Y. Caro's results, we show that if H is simple, the zero-sum Ramsey number (mod 2) of H is almost surely k as $k \to \infty$.

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MS32
Non-extendible Latin Cuboids

There is a celebrated result due to Marshall Hall that every latin rectangle is completable to a latin square. However, the equivalent statement in higher dimensions is not true. A 3-dimensional array has lines of cells in three directions, called *rows*, *columns* and *stacks*. An $n \times n \times k$ *latin cuboid* is a 3-dimensional array containing n different symbols positioned so that every symbol occurs exactly once in each row and column and at most once in each stack. An $n \times n \times n$ latin cuboid is a *latin cube* of order n. An $n \times n \times k$ latin cuboid is *extendible* if it is contained in some $n \times n \times (k+1)$ latin cuboid and it is *completable* if it is contained in some latin cube of order n. In this talk I will present some results on non-extentible and non-completable $n \times n \times k$ latin cuboids where k is approximately half of n.

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MS32
Block Colourings of Designs Revisited

Block colourings of designs, both classical and its variants, and also the so-called specialized block colourings, offer an extensive variety of interesting problems. We will discuss some old and new concepts, results and open problems in colourings of block designs, mostly for Steiner triple systems and Steiner systems $S(2, 4, v)$.

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MS32

Skolem and Rosa Rectangles and Related Designs

A *Skolem sequence of order* n is a sequence $S = (s_1, s_2, \ldots, s_{2n})$ of $2n$ integers such that (1) for all $k = 1, \ldots, n$ there are exactly two terms s_i, s_j such that $s_i = s_j = k$, and (2) if $s_i = s_j = k$ and $i < j$, then $j - i = k$. Two Skolem sequences S, S' are disjoint if $s_i = s_j = k = s'_t = s'_u$ implies that $\{i, j\} \neq \{t, u\}$, for all $k = 1, 2, \ldots, n$. For example, the two Skolem sequences of order four $1, 1, 4, 2, 3, 2, 4, 3$ and $2, 3, 2, 4, 3, 1, 1, 4$ are disjoint. A set of m pairwise disjoint Skolem sequences forms a Skolem rectangle of strength m. The above sequences then form a Skolem rectangle of strength two: 1,1,4,2,3,2,4,3 2,3,2,4,3,1,1,4. We introduce several new and powerful constructions for Skolem and Rosa rectangles then we apply them to generate simple cyclic triple systems and cyclic disjoint triple systems.

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MS32

Cyclic Block Designs with Block Size 3 from Skolem-Type Sequences

A Skolem-type sequence is a sequence $(s_1, \ldots, s_t)$ of positive integers $i \in D$ such that for each $i \in D$ there is exactly one $j \in \{1, \ldots, t - i\}$ such that $s_j = s_{j+i} = i$. Positions in the sequence not occupied by integers $i \in D$ contain null elements. In 1939, Peltesohn solved the existence problem for cyclic Steiner triple systems for $v \equiv 1, 3 (mod\ 6), v \neq 9$. Using the same technique in 1981, Colbourn and Colbourn extended the solution to all admissible $\lambda > 1$. It is known that Skolem-type sequences may be used to construct cyclic Steiner triple systems as well as cyclic triple systems with $\lambda = 2$. The main result of this talk is an extension of former results onto cyclic triple systems with $\lambda > 2$. In addition we introduce a new kind of Skolem-type sequence. This is joint work with my supervisor, Dr. Nabil Shalaby.

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MS33

Combinatorics of Splice Graphcs

Splice graphs compactly represent the possible isoforms of a gene which undergoes multple splicing. I will talk about the combinatorics of splice graphs and how this relates to the problem of inferring them from RNA-Seq data.

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MS33

Bayesian Centroid Estimation for Genome-Wide Association Studies

Genome-Wide Association Studies (GWAS) attempt to identify a (possibly small) subset of single nucleotide polymorphisms (SNPs) from a large number of measured candidates that are associated with a specific observable trait. Identification of associated genetic variants is particularly hard due to very large genotype sizes in comparison to case-control group sizes. We formally frame this problem as Bayesian variable selection in a logistic regression model with spike-and-slab priors in the coefficients. To help overcome the curse of dimensionality, we set a hierarchical model that groups SNPs according to gene proximity and further explore a co-dependency structure between SNPs and genes by adopting an Ising hyper-prior on the space of possible SNP associations to trait. We introduce and derive centroid and graph centroid estimators and contrast them to the classical MAP estimators in this setup. We illustrate this approach with a toy example and a larger simulated dataset based on HapMap. Finally, we offer a few concluding remarks and directions for future work.

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MS33

Encoding Memories in Neuronal Networks

Various mechanisms for encoding memories in networks of neurons have been studied in the past few decades, most notably since Hopfield's famous papers in the early 1980s. Given a prescribed list of memory patterns, however, it is still an unsolved problem how to arrange connections between neurons in a recurrent network such that these - and only these - memories are encoded via stable fixed points of the dynamics. I will discuss some recent progress on this problem, which exploits connections to discrete geometry.

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MS33

Assembling Helices in RNA Junctions by Using 3D Graphs

The structure of RNA junctions is important to understand its function. A novel 3D tree graph approach is introduced to predict the geometrical helical arrangements of junctions in space. Tree graphs are implemented to represent junctions, and biological assumptions combined with graph combinatorics are used to study the geometrical/topological configurations of native-like junctions. For a given target junction, statistical analysis is then used to predict the tree graph that best resemble its RNA native structure.

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MS33

Asymptotic Distribution of Substructures in a Stochastic Context-free Grammar Model of RNA Folding

Some recent methods for predicting RNA secondary structures are based on stochastic context-free grammars

(SCFGs). We analyze one of the most notable SCFGs which is used in the prediction program Pfold. In particular, we show that the distribution of base pairs, helices and various types of loops in RNA secondary structures generated by this SCFG is asymptotically Gaussian, for a generic choice of the grammar probabilities. Our proofs are based on singularity analysis of probability generating functions.

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MS34

Improving Christofides' Algorithm for the Metric s-t Path Traveling Salesman Problem

The Metric s-t Path Traveling Salesman Problem (TSP) asks for a minimum-cost Hamiltonian path with specified start and end points in a finite metric space. Christofides' 3/2-approximation algorithm for the Metric TSP was shown by Hoogeveen in 1993 to be a 5/3-approximation for the Metric s-t Path TSP. We present a polynomial-time ϕ-approximation algorithm for the s-t Path TSP, where ϕ is the golden ratio, the first improvement upon Christofides' algorithm in general metrics.

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MS34

Electrical Flows, Laplacian Systems, and Faster Approximation of Maximum Flow in Undirected Graphs

In this talk, I'll describe a new technique for approximating the maximum flow in capacitated, undirected graphs. I'll then use this technique to develop the asymptotically fastest-known algorithm for solving this problem. Our approach is based on treating the graph as a network of resistors and solving a sequence of electrical flow problems with varying resistances on the edges. Each of these may be reduced to the solution of a system of linear equations in a Laplacian matrix, which can be solved in nearly-linear time.

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MS34

Title Not Available at Time of Publication

ABstract not available at time of publication.

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MS34

The Entropy Rounding Method in Approximation Algorithms

Let A be a matrix and x be a fractional vector, say an LP solution to some discrete optimization problem. We give a new randomized rounding procedure for obtaining an integral vector y such that $Ay \approx Ay$, provided that A has *bounded* Δ*-approximate entropy*. This property means that for uniformly chosen random signs $\chi(j) \in \{\pm 1\}$ on any subset of the columns, the outcome $A\chi$ can be approximately described using at most $\frac{m}{5}$ bits in expectation (with m being the number of selected columns). To achieve this result, we modify well-known techniques from the field of *discrepancy theory*, especially we rely on *Beck's entropy method*. We demonstrate our procedure by providing an $OPT + O(\log^2 OPT)$ approximation for Bin Packing With Rejection.

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MS34

Semidefinite Programming Hierarchies and the Unique Games Conjecture

We survey recent results about semidefinite programming (SDP) hierarchies in the context of the Unique Games Conjecture. This conjecture has emerged as a unifying approach towards settling many central open problems in the theory of approximation algorithms. It posits the hardness of a certain constraint satisfaction problem. We show both upper and lower bounds on the complexity of this problem within restricted computational models defined by SDP hierarchies.

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MS35

Some Problems and Results on the On-line Chain Partitioning of Posets

On-line chain partitioning of posets has been a widely researched topic since Kierstead's seminal paper on the subject in 1981. In this talk we describe a generalization of Kierstead's auxiliary order, and we prove many powerful properties, in hopes of providing a linear algorithm for the chain partitioning problem.

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MS35

News About Semiantichains and Unichain Coverings

Saks and West ask if for any product of posets the size of the minimum unichain covering equals of the size of a maximum semiantichain, which would be a nice generalization of Greene–Kleitman Theorem. We found several new classes of posets for which the conjecture is true. However, we found an example showing that in general this min-max relation is false. This finally disproofs 30 year old conjecture.

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MS35

An Improved Bound for First-Fit on Posets Without Two Long Incomparable Chains

It is known that the First-Fit algorithm for partitioning a poset P into chains uses relatively few chains when P does not have two incomparable chains each of size k. In particular, if P has width w then Bosek, Krawczyk, and Szczypka (*SIAM J. Discrete Math.*, 23(4):1992–1999, 2010) proved an upper bound of ckw^2 on the number of chains used by First-Fit for some constant c, while Joret and Milans (*Order*, 28(3):455–464, 2011) gave one of ck^2w. We prove an upper bound of the form ckw, which is best possible up to the value of c.

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MS35

First-Fit Coloring of Interval Graphs

Let $FF(k)$ be the maximum number of colors to be used when we adopt the First-Fit algorithm to color an interval graph with maximum clique size k. We will discuss the estimate of $FF(k)$ in this talk. Especially, we show that $4k - 5 \leq FF(k) \leq 8k - 11$ when $k > 1$, improving a little bit the current known best record. The upper bound is obtained basically by the column construction method invented by Pemmaraju, Raman, Varadarajan et al.

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MS35

Semiorders and Ascent Sequences

We analyze the recent bijection of Bousquet-Mélou, Claesson, Dukes and Kitaev between interval orders and ascent sequences restricted the the case of semiorders, resulting in a new structural result on the canonical representation of semiorders.

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MS36

Algorithms and Existential Polytime?

An EP theorem asserts the existence of something for which any instance is 'easy' to recognize. Often an EP theorem can be proved by a polytime algorithm for finding an instance of what is asserted to exist. We discuss favorite open problems about the following two EP theorems: (1) If there is a Hamiltonian cycle H containing edge e in graph G such that G minus the edges of H is connected, then there is another one H', different from H. (2) If a surface triangulation S contains a set T of triangles which partition the vertices of S, then S contains another such set T', different from T.

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MS36

Some Graph Theory Problems I Would Like to See Solved

I will describe a number of open graph theory problems which arise primarily out of questions in Ramsey theory.

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MS36

Euler's Rigidity Conjecture

In 1766, Euler conjectured that every polyhedron was rigid. Connelly finally disproved the conjecture in 1977. The investigations of the conjecture and rigidity in general included many other interesting conjectures; perhaps the most interesting has yet to be formulated.

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MS36
Ringel and Kotzig after Fifty Years

Next year will mark the 50th anniversary of the first truly large international graph theory conference which took place in Smolenice, Czechoslovakia. Many outstanding problems were posed there, including the celebrated Ringel's problem on decomposing the complete graph into isomorphic trees, and Kotzig's problem on perfect one-factorizations of the complete graph. We will discuss some developments related to these problems which remain still wide open today.

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MS37
Cops and Robbers on Geometric Graphs

In the game of cops and robbers, one robber is pursued by a set of cops on a graph G. In each round, these agents move between vertices along the edges of the graph. The cop number $c(G)$ denotes the minimum number of cops required to catch the robber in finite time. We study the cop number of geometric graphs. For points $x_1, x_2, \ldots, x_n \in R^2$, and $r \in R^+$, the geometric graphs $G(x_1, \ldots, x_n; r)$ is the graph on these n points, with x_i, x_j adjacent when $\|x_i - x_j\| \leq r$. We prove that $c(G) \leq 9$ for any connected geometric graph $G \in R^2$. We improve on this bound for random geometric graphs that are sufficiently dense. Let $G(n, r)$ denote the probability space of geometric graphs with n vertices chosen uniformly and independently from $[0, 1]^2$. For $G \in G(n, r)$, we show that with high probability (whp), if $nr^4 \gg \log n$ then $c(G) \leq 2$ and if $nr^4 \gg \log n$ then $c(G) = 1$. Finally, we provide a lower bound near the connectivity regime of $G(n, r)$: if $nr^2 \ll \log^2 n$ then $c(G) > 1$ whp.

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MS37
Seepage in Directed Acyclic Graphs

Seepage is a vertex-pursuit game played on directed acyclic graphs (or dags), introduced by Nowakowski et al. We consider applications of Seepage to the modelling of hierarchical social networks. A stochastic model is introduced which generates dags with a prescribed degree sequence. We play a variant of Seepage on the model, and contrast results on the green number in the case of a constant versus a power law degree sequence.

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MS37
Ambush Cops and Robbers

A variation of the game with two robbers is introduced. The cops win by moving onto the same vertex as *one* of the robbers after a finite number of moves. The robbers win by avoiding capture indefinitely or by both moving onto the same vertex as the cop. (Otherwise, the robbers are on distinct vertices.) We present a recognition theorem (and cop strategy) for graphs on which one cop can guarantee a win. (Joint work with M. Creighton)

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MS37
Cops and Scared Robber

In a traditional game of Cops and Robber, the cops and robber move alternately on a graph, where each player can elect to move to an adjacent vertex or remain at his current position. In this case, the Scared Robber has the restriction that he can not move closer to any cop. The motivation for adding this restriction is to gain insight into the robber's strategy in the traditional game, and determine when moving toward a cop would actually be to the robber's advantage.

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MS37
Chasing Cops on Random Graphs

In the game of cops and robber, the cops try to capture a robber moving on the vertices of the graph. The minimum number of cops required to win on a given graph G is called the cop number of G. The biggest open conjecture in this area is the one of Meyniel, which asserts that for some absolute constant C, the cop number of every connected graph G is at most $C\sqrt{|V(G)|}$. We show that Meyniel's conjecture holds asymptotically almost surely for a random d-regular graph, $d \geq 3$, as well as in the standard random graph model $G(n, p)$. (Joint work with Nick Wormald.) We also investigate the game played on a (percolated) random geometric graph. (Joint work with Noga Alon.)

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MS38

An Analogue of the Harer-Zagier Formula for General Surfaces

We consider the different ways of gluing the edges of a $2n$-gon in pairs so as to create a surface without boundary. Up to homeomorphism, the surface obtained is characterized by its genus and by its orientability. The Harer-Zagier formula characterizes the generating function of the genus of the orientable surfaces obtained from the gluings of the $2n$-gon. In this work we give an analogue of the Harer-Zagier for general (locally orientable) surfaces. The proof is bijective.

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MS38

Rooted $K_{2,4}$ Minors in Planar Graphs

Given 3 terminal vertices in a graph G, Robertson and Seymour characterized whether we could find a rooted $K_{2,3}$ minor in G using the terminals for the larger side of the bipartition. We provide a characterization for when G has 4 terminals and is planar.

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MS38

Coloring Graphs on Surfaces

We will review new progress on coloring and list-coloring embedded graphs. This talk is based on works with Kenichi Kawarabayashi, Bernard Lidicky, Bojan Mohar, Luke Postle and Robin Thomas.

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MS38

Clique Immersion in Digraphs

Immersion is a containment relation between graphs (or digraphs) which is defined similarly to the more familiar notion of minors, but is incomparable to it. This talk will begin with a gentle introduction, and eventually show that every Eulerian digraph with minimum degree at least $t(t-1)$ contains a bidirected clique of order t as an immersion. Joint work with Matt DeVos, Bojan Mohar and Diego Scheide.

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MS38

Hamiltonicity of Graphs on Surfaces

In 1956, Tutte proved that every 4-connected plane graph has a hamiltonian cycle. Beginning with the result by Tutte, many results on the hamiltonicity of graphs on surfaces were shown. However, the following conjecture by Grünbaum and Nash-Williams has been unsolved for more than 40 years; every 4-connected graph on the torus has a hamiltonian cycle. In this talk, we will mention recent results around the conjecture by Grünbaum and Nash-Williams.

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MS39

Distinguishing Numbers and Regular Orbits

For a group G acting on a set X, the *distinguishing number* is the least number of parts in a partition of X which is preserved only by the identity element of G. Various results about distinguishing numbers can be expressed in terms of orbits of G on the power set of X. We survey some known results from the group theory literature, and consider some problems of a combinatorial nature.

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MS39

On the Orders of Symmetric Graphs

In this talk I will describe some recent developments concerning finite symmetric (arc-transitive) graphs. The first is the computer-assisted determination of all cubic (3-valent) symmetric graphs on up to 10000 vertices, which produced some new large graphs with given degree and diameter. The second is a new approach for classifying all connected symmetric cubic graphs of given orders, showing for example that for any fixed k and any integer $s > 1$, there are only finitely many s-arc-transitive cubic graphs of order kp where p is prime. In turn, these results have led to some further new discoveries about the orders of symmetric graphs of higher valency (in some recent joint work with Caiheng Li and Primoz Potocnik).

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MS39

A Catalog of Self-Dual Plane Graphs with Max Degree 4

In this paper, we produce a catalog of self-dual plane graphs with maximum degree 4 (self-dual spherical grids). Based on their automorphism groups, self-dual spherical grids fall into a finite number of parameterized, infinite families. The individual self-dual spherical grids in a family have the same basic shape, differing only in size.

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MS39

Hamiltonian Cycles in Cayley Graphs

I will provide an overview of general results on hamiltonian cycles in Cayley graphs, focusing on some recent work that deals with graphs whose order has few prime factors. Some of this is based on work produced jointly in various combinations with Steve Curran, Klavdija Kutnar, Dragan Marušič, Dave Witte Morris, and Primoz Šparl.

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MS40

Title Not Available at Time of Publication

Abstract not avaialable at time of publication.

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MS40

Network Archaeology: Uncovering Ancient Networks from Present-Day Interactions

Abstract not available at time of publication.

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MS40

Understanding Phenome-genome Association by Co-clustering and Graph Matching

Graph algorithms are playing an increasingly important role in studying phenotype-gene relations in the context of systems biology and phenome (the whole collection of phenotypes) analysis. I will introduce two methods that utilize network information in phenome network and gene-relation network to study phenome-genome associations, a random-walk based graph-matching algorithm (Bi-RW) for unveiling associations between phenome and genes, and a regularized NMF algorithm (R-NMTF) to co-cluster phenotypes and genes, and detect associations between phenotype clusters and gene clusters.

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MS40

Sensitive Graph-theoretic Approaches for Extracting Function from Biological Networks

Sequence-based computational approaches have revolutionized our understanding of biology. Since proteins aggregate to perform function instead of acting in isolation, the connectivity of a protein interaction network (PIN) will deepen biological insights over and above sequences of individual proteins. The advancement relies on developing sensitive graph-theoretic methods for extracting biological knowledge from PINs. Analogous to sequence alignment, alignment of PINs will impact biological understanding. Network alignment maps nodes of different networks with the goal of "fitting" one network into the other well to identify topologically similar network regions and transfer function between them. Since network alignment is computationally infeasible, owing to the NP-completeness of the underlying subgraph isomorphism problem, heuristic algorithms are sought. We designed a sensitive measure of the topological position of a node in the network, graphlet degree vector (GDV), to measure the number of 2-5-node graphlets (induced subgraphs) that the node participates in. Hence, GDV of a node is a detailed topological descriptor of its extended network neighborhood. Our GDV-similarity measure compares GDVs of two nodes to quantify similarity of their extended networks neighborhoods. Using these measures, we developed two network alignment algorithms: a greedy "seed and extend" approach that quickly finds approximate alignments and an approach that finds optimal alignments by using the "expensive" Hungarian algorithm. Their alignments expose surprisingly large regions of network and functional similarity even in distant species, suggesting broad similarities in cellular wiring across all life on Earth. Also, we used these measures to show that aging, cancer, pathogen-interacting, drug-target and genes involved in signaling pathways are "central" in the network, occupying dense network regions and "dominating" other genes in the network.

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MS40

Biological Networks in Three Dimensions

Two studies are highlighted where three-dimensional modeling of protein networks provides insights into the biophysics and evolution of biological systems. First, a structural analysis of the yeast protein-protein interaction network reveals that protein evolution is constrained by the biophysics of protein folding, the mutational robustness of proteins, and the biophysics and function of protein-protein interactions. Second, a structural analysis of human-virus protein-protein interaction networks reveals distinct principles governing antagonism versus cooperation in host-pathogen interactions.

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MS41

Advances on Quantifier Elimination and Applications

In this talk, we present a new approach for computing cylindrical algebraic decomposition of real space via triangular decomposition of polynomial systems. Based on it, a general quantifier elimination method is proposed. The usage of our method is illustrated by several application examples.

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MS41

Automatic Quantifier Elimination Proves a Key Result in Submodular Function Minimization

We show how symbolic computation can automatically prove an important and well-known result in combinatorial optimization. Specifically, we address the question "Which objective functions can be minimized by reduction to *s-t min cut*?" This question has been answered by a number of highly-cited papers in discrete mathematics and computer vision. By posing this same question to a computer algebra system, we automatically identify *submodularity* as being the key condition for reduction to *s-t* min cut.

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MS41

On Newton Polytopes, Tropisms, and Puiseux Series to Solve Polynomial systems

Sparse polynomial systems in several variables are characterized by a set of exponents of monomials that appear with nonzero coefficient. The convex hull of this set of exponents is the Newton polytope. To a system of sparse polynomial equations corresponds a tuple of Newton polytopes. Vectors perpendicular to a tuple of edges of all polytopes are tropisms when they define the leading powers of a Puiseux series development for a solution of the polynomial system. In this talk we outline a polyhedral approach to solve polynomial systems by means of Puiseux series. On standard benchmark problems as the cyclic n-roots systems we obtained exact representations for surfaces of solutions.

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MS41

Algebraic Representations of Branches of Functions

Apparently-simple function definitions may hide subtleties from branch cuts in the complex plane. Hence formulae that initially seem correct may fail for various values. One remedy is to consider the complement of the branch cuts, decomposing this space by Cylindrical Algebraic Decomposition and checking validity on each connected component. This process will be discussed and how it is possible to improve this algorithm's efficiency with pre-conditioning and choice of variable order.

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MS41

A Solver for Linear Algebraic Systems Resulting from Selecting Discrete Structures

A computer algebra program LSSS (Linear Selective Systems Solver) has been developed to solve linear systems efficiently that are sparse, overdetermined and have many variables that take the value zero in the solution. Applications include the determination of first integrals and Lie-symmeties of systems of non-commutative ODEs requiring the solution of linear systems with over one billion equations, the computation of Poisson homologies and cohomologies of Poisson algebras and the study of compatible Poisson structures.

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MS42

A De Bruijn - Erdos Theorem in Connected Graphs?

De Bruijn and Erdős proved that every noncollinear set of n points in the plane determines at least n distinct lines. Chen and Chvátal suggested that this might generalize to all finite metric spaces with appropriately defined lines. As for metric spaces defined by connected graphs, the analogue of the De Bruijn - Erdős theorem is known to hold for all bipartite graphs, all chordal graphs, and all graphs of diameter two.

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MS42

Matthews Sumner Conjecture on Claw-Free Graphs

The Matthews Sumner Conjecture is that every 4-connected claw-free graph is Hamiltonian. There are a large number of conjectures, some seemingly weaker and some seemingly stronger, that are equivalent to this conjecture that will be discussed. For example, the Carsten Thomassen Conjecture that every 4-connected line graph is Hamiltonian is an equivalent conjecture.

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MS42

How to Recognize a Good Conjecture

The speaker will present some challenges in dealing with open problems and conjectures. He may discuss some specific graph theory conjectures and demonstrate some rationale behind the Open Problem Garden.

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MS42

Some of my favorite Conjectures

We will present and briefly discuss some open questions in two areas: (1) *Cyclic* Coloration of plane graphs and (2) Well-covered graphs.

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MS42

The Implicit Representation of Graphs Conjecture

A class of graphs $\mathcal{P}$ is called a *hereditary property* if it is closed under taking induced subgraphs and isomorphism. Common examples include being acyclic, being planar, and being bipartite. Given a hereditary property $\mathcal{P}$, we seek a method of labeling the vertices of graphs in $\mathcal{P}$ with short labels [that is, $O(\log n)$ bits for each vertex] such that we can determine adjacency of two vertices just by considering their labels. Formally, a property $\mathcal{P}$ admits an *implicit representation* provided there is a function $A : \mathbf{Z}^+ \times \mathbf{Z}^+ \to \{0, 1\}$ and a positive integer k such that for every $G \in \mathcal{P}$ with there is a mapping $\ell : V(G) \to [n^k]$ (where $n = |V(G)|$) such that $u \sim v$ if and only if $A(\ell(u), \ell(v)) = 1$. It is easy to create such a labeling for acyclic graphs: Pick a root vertex in each component, number the vertices from 1 to n, and label vertex v as (v, w) where w is the unique neighbor of v on a path from v to the root (or use the label (v, v) if v is the root). However, bipartite graphs admit no such representation simply because there are too many. That is, for a property $\mathcal{P}$, the *speed* of $\mathcal{P}$ is a function that gives for each n the number of labeled graphs in $\mathcal{P}$ with $V = [n]$. If a property has an implicit representation, then necessarily its speed is bounded by an expression of the form n^{cn} for a positive constant c. The *Implicit Representation Conjecture* of Kannan, Naor, and Rudich posits that this necessary condition is also sufficient.

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MS43

Ramsey Classes Defined by Forbidden Homomorphisms

I will talk about Ramsey properties of classes of digraphs (or more generally, relational structures) defined by forbidding homomorphisms from a fixed set of digraphs. Cases with infinitely many forbidden structures are of particular interest. These classes have several interesting applications.

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MS43

A Randomized Version of Ramsey's Theorem

For every integer $r \geq 2$ we call a k-uniform hypergraph H on n vertices r-Ramsey-forcing if every r-edge-coloring of K_n contains a monochromatic copy of K_k whose vertices form a hyperedge in H. We determine the threshold for a random k-uniform hypergraph on n vertices and edge probability q to be r-Ramsey-forcing. Further we discuss common features of the above problem with the more classical Ramsey's theorem for random (hyper-)graph $G(n, p)$.

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MS43

General Deletion Lemmas via the Harris Inequality

For a given graph H let X_H denote the random variable that counts the number of copies of H in a random graph $G_{n,p}$. In order to control the upper tail of X_H, Rödl and Ruciński showed that with 'Janson-like' probability, deleting a small fraction of all edges suffices to reduce the number of copies of H to at most $(1+\varepsilon)E[X_H]$. This approach is known as the 'deletion method' and appears in many proofs of Ramsey properties of random structures. In this talk I will present a variant of the deletion method that is based on the Harris inequality and extends to more general graph properties.

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MS43

On Ramsey Multiplicities of Graphs Containing Triangles

A graph G is k-common ($k > 1$) if the minimum number of monochromatic copies of G over all k edge colorings of K_n is asymptopic to the expected number of monochromatic copies of G in a random k edge coloring. Jagger, Šťovíček and Thomason defined the class of k-common graphs, and showed among other results that every graph containing K_4 as a subgraph is not 2-common. We prove that every graph containing K_3 as a subgraph is not 3-common.

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MS44

Multidimensional Algorithmic Mechanism Design

In his seminal paper, Myerson [1981] provides a revenue-optimal auction for a seller who is looking to sell a single item to multiple bidders. Extending this auction to simultaneously selling multiple heterogeneous items has been one of the central problems in Mathematical Economics. We provide such an extension that is also computationally efficient.

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MS44

Combinatorial Walrasian Equilibria

One way to resolve a combinatorial auction is via Walrasian equilibrium: setting a price for each item so that, when bidders take their most demanded sets, each object is chosen by exactly one bidder. Such equilibria have desirable properties, but they exist only in special cases. In this work we introduce the alternative notion of combinatorial Walrasian equilibrium, in which one first partitions the objects into indivisible bundles and then sets a price for each bundle. We design mechanisms that generate combinatorial Walrasian equilibria for various classes of bidder valuations, with the goal of maximizing social welfare. Our study also touches upon revenue and truthfulness in such mechanisms.

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MS44

Knightian Auctions

In an auction, a player may not exactly know his own valuation, or its distribution. We thus study single-good auctions whose players know their own valuations only within a multiplicative factor (e.g., 10%). The notions of implementation in dominant and undominated strategies are naturally extended to this setting, but their power is vastly different. Namely, (1) We prove that no dominant-strategy mechanism can guarantee more social welfare than by assigning the good at random; but (2) We prove a much better performance can be obtained via undominated-strategy mechanisms, and actually provide tight upper and lower bounds for the fraction of the maximum social welfare guaranteeable by such mechanisms, whether deterministic or probabilistic.

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MS44

Online Procurement

We present results for online procurement markets. We introduce mechanisms with desirable approximation guarantees in various models of online procurement. We also present new models of strategic bidding in such markets, and discuss new mechanism design frameworks for these bidding models.

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MS44

Bayesian Multi-Parameter Scheduling

We study the makespan minimization problem with unrelated selfish machines. Specifically, our goal is to schedule a given set of jobs on m machines; the machines are strategic agents who hold the private information of the run-time of each job on them. The goal is to design a mechanism that minimizes makespan — the time taken for the last job to complete. In the strategic setting, strong impossibility results are known that show that no truthful (anonymous) mechanism can achieve better than a factor m approximation. We show that under mild Bayesian assumptions it is possible to circumvent such negative results and obtain a constant approximation.

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MS45
Graph Homomorphism Counts Mod M

I will talk about the numbers hom(F, G) mod m as the graphs F and G vary.

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MS45
Frozen Vertices in Colourings of a Random Graph

Over the past decade, much of the work on random k-SAT, random graph colouring, and other random constraint satisfaction problems has focussed on some foundational unproven hypotheses that have arisen from statistical physics. Some of the most important such hypotheses concern the "clustering' of the solutions. It is believed that if the problem density is sufficiently high then the solutions can be partitioned into clusters that are, in some sense, both well-connected and well-separated. Furthermore, the clusters contain a linear number of "frozen variables", whose values are fixed within a cluster. The density where such clusters arise corresponds to an algorithmic barrier, above which no algorithms have been proven to solve these problems. In this talk, we prove that frozen vertices do indeed arise for k-colourings of a random graph, when k is a sufficiently large constant, and we determine the exact density threshold at which they appear.

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MS45
Colorings and Homomorphisms of Sparse Graphs

chromatic number and low tree-width / low tree-depth colorings. Dichotomy of sparsity by means of chromatic numbers. Applications to distance coloring, circular chromatic number of large girth graphs with sub-exponential expansion, etc.

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MS45
Fast Algorithms for Sparse Graphs

Algorithms for sparse graphs: subgraph isomorphism problem, connection with bounded local tree-width. Low Tree Depth Decomposition and first-order properties. Application to graph invariants.

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MS45
Semilattice and NU Polymorphisms on Reflexive Graphs

The structures H for which arc-consistency solves H-COL are exactly those that admit TSI polymorphisms. The two main sources of TSI polymorphisms are *near unanimity* (NU) and *semilattice* (SL) polymorphisms. Much has been done to understand the nature of NU polymorphisms, but SL polymorphisms are not so well understood. In this talk we describe the structure of symmetric reflexive graphs admitting various types of SL polymorphisms. Further we relate the existence of SL polymorphisms on these graphs to the existence of NU polymorphisms of various types, and to related classes of graphs. This is preliminary work in in understanding SL polymorphisms, and includes joint work with Pavol Hell.

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MS46
Near Factorisations of the Complete Graph

A w-near k-factor of a graph G on n vertices is a spanning subgraph of G with w vertices of degree 0 and $n - w$ vertices of degree k. In this talk, we introduce the concept of a w-near k-factorization of a graph G, which is a decomposition of G into w-near k-factors. Thus, for example, a k-factorization is equivalent to a 0-near k-factorization, and a near 1-factorization is equivalent to a 1-near 1-factorization. We focus on w-near 2-factorizations of the complete graph K_n and $K_n - I$; in the case that the partial 2-factors are required to be pairwise isomorphic, this may be viewed as a generalization of the Oberwolfach problem. We discuss some constructions of w-near 2-factorizations in which all cycles in the near-factors have the same length.

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MS46
Bounds for Covering Arrays with Row Limit

Covering arrays with row limit ($CARL$s) are a generalization of covering arrays. They have a new parameter **row weight**, w, representing the number of non-empty cells in a row. Considering w as a function of the number of columns, k, there are two extremal cases: when w is a constant, $CARL$s are equivalent to group divisible covering designs and we know their optimal size; when $w = k$, $CARL$s are covering arrays, and their optimal size is still unknown in most cases. We present two probabilistic models to determine the upper bounds on the size of a $CARL$ when $w = f(k)$ and we look into critical points where the change in the behaviour occurs.

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MS46

A new construction of strength-3 covering arrays using primitive polynomials over finite fields

In this talk, we present a new construction of covering arrays based on Linear Feedback Shift Register (LFSR) sequences constructed using primitive polynomials over finite fields. For any prime power q, this construction gives a covering array of strength 3 with $q^2 + q + 1$ factors/columns over q levels/symbols that has size $2q^3 - 1$ (number of rows). The construction can be extended to non-prime powers v by dropping levels from a larger prime power. This results in significant reductions on known upper bounds for covering array sizes in most cases covered by this construction. In particular, for the values of $v \leq 25$ kept in Colbourn's covering array tables, this construction improves upper bounds for all $v \neq 2, 3, 6$.

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MS46

New Areas in Covering Arrays

In recent years, with Gary Bazdell, I have had increased communication and collaboration with industrial users of combinatorial designs, predominantly covering arrays. Coming out of their needs and interests, Gary and I have been motivated to think about new generalisations of covering arrays, specifically ones that introduce order to the rows and columns. I will discuss these definitions, the mathematics and their connections to applications.

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MS46

Nonincident Points and Blocks in Designs

We study the problem of finding the largest possible set of s points and s blocks in a balanced incomplete block design, such that that none of the s points lie on any of the s blocks. We investigate this problem for two types of BIBDs: projective planes and Steiner triple systems. For a projective plane of order q, we prove that $s \leq 1 + (q+1)(\sqrt{q} - 1)$ and we also show that equality can be attained in this bound whenever q is an even power of two. For a Steiner triple system on v points, we prove that $s \leq (2v + 5 - \sqrt{24v + 25})/2$ and we determine necessary and sufficient conditions for equality to be attained in this bound.

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MS47

Optimality of the Neighbor Joining Algorithm and Faces of the Balanced Minimum Evolution Polytope

Balanced minimum evolution (BME) is a statistically consistent distance-based method to reconstruct a phylogenetic tree from an alignment of molecular data. In 2000, Pauplin showed that the BME method is equivalent to optimizing a linear functional over the BME polytope, the convex hull of the BME vectors obtained from Pauplins formula applied to all binary trees. The BME method is related to the popular Neighbor Joining (NJ) algorithm, now known to be a greedy optimization of the BME principle. In this talk I will elucidate some of the structure of the BME polytope and strengthen the connection between the BME method and NJ Algorithm. I will show that any subtree-prune-regraft move from a binary tree to another binary tree corresponds to an edge of the BME polytope. Moreover, I will describe an entire family of faces parametrized by disjoint clades. Finally, given a phylogenetic tree T, I will show that the BME cone and every NJ cone of T have intersection of positive measure.

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MS47

Finding the Max Cut of the Genetic Interactions Graph in Yeast Finds Compensatory Pathways.

By using a randomized local search method to find the max cut in the graph of genetic interactions in yeast we generate potential compensatory networks. Unlike other methods, this method works solely on genetic interaction data from epistatic miniarray profiles (E-MAP) and synthetic genetic array analysis (SGA), this enables us to use physical interactions as an additional validation source. We finish with some open questions regarding the behavior of our technique on different graphs and weights.

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MS47
Statistics and Applications of Tree Space

The space of metric n-trees is a polyhedral complex, in which each polyhedron corresponds to a different tree topology. Under the construction of Billera, Holmes, and Vogtmann, this space is non-positively curved, so there is a unique geodesic (shortest path) between any two trees. We will look at what it means to do statistics on this space, as well as some biological applications.

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MS47
Comparing Biological and Mathematical Approaches to Modeling Tissue Development in *C. elegans*

Gene networks are often inferred from experimental data using single-method approaches; however, an individual method may not sufficiently recover the network. We developed a modeling pipeline that combines statistical and algebraic methods. We built a mathematical model of tissue development from wildtype *C. elegans* data. We compared it to an existing biological model on a gold-standard network. While both models identified many interactions, the mathematical model was enriched for positive predictions compared to biological model.

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MS47
Profiling RNA Secondary Structures

Efficient methods for sampling from the Boltzmann distribution have led to an emergence of ensemble-based approaches to RNA secondary structure prediction. We present a novel combinatorial method, RNA structure profiling, for identifying patterns in structural elements across a Boltzmann sample. Our approach is based on classifying structures according to features chosen from well-defined structural units called helix classes. We show that combinatorial profiling is straightforward, stable and surprisingly comprehensive.

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MS48
New Results on D-Optimal Matrices

D-optimal matrices are 2v 2v (-1,+1)-matrices that have maximal determinant among all 2v 2v (-1,+1)-matrices, where v is an odd positive integer. The value of the maximal determinant is given by Ehlich's bound. We present new theoretical and computational results on D-optimal matrices of circulant type. Such D-optimal matrices are constructed via two circulant submatrices of orders v each. In particular, we construct new D-optimal matrices of orders 206, 242, 262, 482. Joint work with D. Z. Djokovic.

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MS48
Matroid Base Polytope Decomposition and Applications

Let $P(M)$ be the matroid base polytope of a matroid M. A matroid base polytope *decomposition* of $P(M)$ is a decomposition of the form $P(M) = \bigcup_{i=1}^{t} P(M_i)$ where each $P(M_i)$ is also a matroid base polytope for some matroid M_i, and for each $1 \leq i \neq j \leq t$, the intersection $P(M_i) \cap P(M_j)$ is a face of both $P(M_i)$ and $P(M_j)$. In this talk, we shall present some new results on the above decomposition. We give sufficient conditions on M in order that $P(M)$ has a *hyperplane split* (that is, a decomposition with $t = 2$) and show that $P(M)$ has not a hyperplane split if M is binary. We finally discuss an application in relation with Tutte and Ehrhart polynomials.

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MS48
Generating Program Invariants via Interpolation

This talk focuses on automatically generating polynomial equations that are inductive loop invariants of computer programs. A new method which is based on polynomial interpolation is proposed. Though the proposed method is not complete, it is efficient and can be applied to a broader range of problems compared to existing methods targeting similar problems. The efficiency of our approach is testified by experiments on a large collection of programs.

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MS48
Parallel Computation of the Minimal Elements of a Poset and Applications

Computing the minimal elements of a partially ordered finite set (poset) is a fundamental problem in combinatorics with numerous applications. In a previous work, we have developed for this task a divide-and-conquer algorithm which is also cache-efficient and which can be efficiently parallelized free of determinacy races. We adapted this technique to questions arising in computer algebra (polynomial expression optimization) and combinatorics (transversal hypergraph generation). In this talk, we present new applications in both computer algebra (coprime factorization) and combinatorics (orthogonal hypergraph generation). We have implemented the corresponding algorithms in Cilk++ targeting multi-cores. For our test problems of sufficiently large input size our code demonstrates a linear speedup on 32 cores.

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MS49

Conjectures on Thickness, Connectivity, and Other Things

Various conjectures that I've found intriguing will be discussed. These will include a conjecture on thickness and chromatic number, a mixed-connectivity conjecture, and the total graph conjecture.

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MS49

Snarks and Their Relation to Conjectures about Graphs

In this talk I will shortly discuss the role of snarks in proving or refuting conjectures and sketch an algorithm that was used to generate large lists of snarks. The results of these computations and some of the published conjectures that could be refuted by the snarks generated will be presented. This research is joint work with Jan Goedgebeur, Jonas Hägglund and Klas Markström

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MS49

On Conjectures of Grafitti.pc

This talk will begin with a brief description of how the conjecture-making computer program, Graffiti.pc, generates graph theoretical conjectures. Then, I will talk about some of my favorite Graffiti.pc conjectures.

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MS49

Title Not Available at Time of Publication

Abstract not available at time of publication.

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MS51

On Metric Dimension of Functigraphs

A set S of vertices in a graph G is called a *resolving set* for G if for every pair of vertices $x, y \in V(G)$, there is a vertex $s \in S$ such that $d(x, s) \neq d(y, s)$. The minimum number of vertices in a resolving set for G is the *metric dimension* $dim(G)$ of G. Given two copies G_1 and G_2 of a graph G and a function $f : V(G_1) \to V(G_2)$, the *functigraph* $C(G, f)$ is the graph with vertices $V(G_1) \cup V(G_2)$ and edges $E(G_1) \cup E(G_2) \cup \{xy|y = f(x)\}$. In this talk, we give bounds on the metric dimension of functigraphs, particularly in the cases when G is a cycle or path and when the function f is a constant function or permutation.

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MS51

Closed K-Stop Distance in Graphs.

The Traveling Salesman Problem (TSP) is still one of the most researched topics in computational mathematics, and we introduce a variant of it, namely the study of the closed k-walks in graphs. We search for a shortest closed route visiting k cities in a non complete graph without weights. This motivates the following definition. Given a set of k distinct vertices $\mathcal{S} = \{v_1, v_2, \ldots, v_k\}$ in a simple graph G, the k-circuit-distance of set $\mathcal{S}$ is defined to be

$$d_k(\mathcal{S}) = \min_{\theta \in \mathcal{P}(\mathcal{S})} \Big(d(\theta(x_1), \theta(x_2)) + d(\theta(x_2), \theta(x_3)) + \ldots + d(\theta(x_k), \theta(x_1)) \Big),$$

where $\mathcal{P}(\mathcal{S})$ is the set of all permutations from $\mathcal{S}$ onto $\mathcal{S}$. That is the same as saying that $d_k(\mathcal{S})$ is the length of the shortest circuit through the vertices $\{x_1, \ldots, x_k\}$. Recall that the Steiner distance $sd(\mathcal{S})$ is the number of edges in a minimum connected subgraph containing all of the vertices of $\mathcal{S}$. We note some relationships between Steiner distance and circuit distance. The 2-circuit distance is twice the ordinary distance between two vertices. We conjecture that $rad_k(G) \leq diam_k(G) \leq \frac{k}{k-1} rad_k(G)$ for any connected graph G for $k \geq 2$. For $k = 2$, this formula reduces to the well-known classical result $rad(G) \leq diam(G) \leq 2rad(G)$. We prove the conjecture in the cases when $k = 3$ and $k = 4$ for any graph G and for $k \geq 3$ when G is a tree.

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MS51
Distance in Rainbow Connected Graphs

A path (not necessarily a shortest one) between two vertices in a connected graph is rainbow-colored if each edge of the path is labeled with a distinct color. A connected graph is rainbow-connected if the edges of the graph are assigned colors so that a rainbow-colored path exists between every pair of vertices. In this paper, I discuss the recent work on methods for determining rainbow-colored paths in a given rainbow-connected graph.

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MS51
Using Graphs for Facility Location Problems

The eccentricity of a vertex v in a connected graph G is the distance from v to a vertex farthest from v in G. The distance of a vertex v in a connected graph G is the sum of the distances from v to the vertices of G. In this talk, we will consider subgraphs induced by these concepts for facility location problems.

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MS52
Near-Unanimity Graphs and Absolute Retracts

We describe a generating set for the variety of reflexive graphs that admit a k-ary near-unanimity operation; we further delineate a very simple subset that generates the variety of *absolute retracts* with respect to j-holes; in particular we show that every reflexive graph with a 4-NU operation is an absolute retract for 3-holes. Our results generalise and encompass several results on NU-graphs and absolute retracts from the past 30 years.

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MS52
Graph Partitions

We consider partitions of the vertices of a graph into a fixed number of labelled cells such that (i) the subgraph induced by each cell belongs to a family that depends on the cell, and (ii) edges joining vertices in different cells are allowed only if the cells correspond to adjacent vertices in a given pattern graph H. Both polynomiality and NP-completeness results are presented.

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MS52
Graph Partitions With Emphasis on $2K_2$-Partition

Pavol Hell will present some recent progress and some open questions on the problem of partitioning a graph, or digraph, according to a prescribed pattern of adjacencies. Both classifications by complexity and characterizations by forbidden induced subgraphs will be discussed. Then Daniel Paulusma will describe a recent solution (joint with Barnaby Martin) of the problem of complexity of the disconnected cut, or equivalently the problem of $2K_2$-partition. Specifically, for a connected graph $G = (V, E)$, a subset U of V is called a disconnected cut if both U and V disconnect G. The problem to decide whether a graph has a disconnected cut is shown to be NP-complete. This problem is polynomially equivalent to the following problems: testing if a graph has a $2K_2$-partition, testing if a graph allows a vertex-surjective homomorphism to the reflexive 4-cycle and testing if a graph has a spanning subgraph that consists of at most two bicliques. Hence, as an immediate consequence, these three decision problems are NP-complete as well.

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MS52
Bipartite Graphs and Approximation of Minimum Cost Homomorphisms

For a fixed target graph H, the minimum cost homomorphism problem, MinHOM(H), asks, for a given graph G with integer costs $c_i(u)$, $u \in V(G)$, $i \in V(H)$, and an integer k, whether or not there exists a homomorphism of G to H of cost not exceeding k. When the target graph H is a bipartite graph, a dichotomy classification is known: MinHOM(H) is solvable in polynomial time if and only if H is a proper interval bigraph (i.e., a bipartite permutation graph). We suggest an integer linear program (ILP) formulation for MinHOM(H), and by rounding the ILP solution, we obtain a 2-approximation algorithm for MinHOM(H), when H is a doubly convex bipartite graph. If time permits, we explain how to modify the rounding procedure to obtain a $|V(H)|$ - approximation algorithm for MinHOM(H) when the complement of the bipartite graph H is a circular arc graph.

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MS52
Adjoint Functors in Graph Theory

Functors in graph theory are essentially constructions that make new graphs out of input graphs. Two functors L, R are respectively right and left adjoint to the other if there is a correspondence between the homomorphisms of $L(G)$ to H and the homomorphisms of G to $R(H)$. There are various places where adjoint functors arise naturally without necessarily being noticed: - Viewing lexicographic products by complete graphs as right adjoints naturally defines Kneser graphs as (cores of) left adjoints of complete graphs. - Reformulating the question of Harvey and Murty on the existence of k-chromatic graphs with strongly independent colour classes in terms of adjoint functors naturally leads to the approach taken by Gyárfás, Jensen and Stiebitz to answer it affirmatively. In the case of directed graphs and constraint satisfaction problems, the adjoint functors arise in the arc graph construction, and they preserve tree duality and many Maltsev-type operations related to complexity classifications. All of this suggests that the power and limitations of adjoint functors in graph theory should be better understood.

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MS53
New Results and Open Problems on Random Geometric Graphs

Abstract not available at time of publication.

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MS53
Modelling Interference in Wireless Networks using Geometric Graphs

Given a set of positions for wireless nodes, the interference minimization problem is to assign a transmission radius (equivalently, a power level) to each node such that the resulting communication graph is connected, while minimizing the maximum interference. In this talk I will discuss recent geometric graph models for representing interference in ad hoc and sensor wireless networks, along with corresponding algorithmic and complexity results for the interference minimization problem.

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MS53
On the Treewidth of Random Geometric Graphs

We give asymptotically exact values for the treewidth $tw(G)$ of a random geometric graph in $[0, \sqrt{n}]^2$. More precisely, we show that there exists some $c_1 > 0$, such that for any constant $0 < r < c_1$, $tw(G) = \Theta(\frac{\log n}{\log \log n})$, and also, there exists some $c_2 > c_1$, such that for any $r = r(n) \geq c_2$, $tw(G) = \Theta(r\sqrt{n})$. Our proofs show that for the corresponding values of r the same asymptotic bounds also hold for the pathwidth and treedepth of a random geometric graph.

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MS53
On the 2-Edge Connectivity of Geometric Planar Graphs With Bounded Edge Length

Abstract not available at time of publication.

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MS53
Some Results about Disk Graphs and Pseudocircle Arrangements

Abstract not available at time of publication.

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MS54
Generating Trees for Partitions and Permutations with No k-nestings

We describe a generating tree approach to the enumeration and exhaustive generation of set partitions and permutations with no k-nestings. Unlike previous work in the literature using connections of these objects with Young tableaux and restricted lattice walks, our approach deals directly with partition and permutation diagrams. We detail a generation algorithm that uses only labels to describe these set partitions and permutations with no k-nestings, and provide explicit functional equations for the generating functions, with k as a parameter, getting valuable series results.

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Lily Yen
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MS54

Bijections Between Truncated Affine Arrangements and Valued Graphs

We present some contructions on the set of nbcs (No Broken Circuit sets) of some deformations of the braid arrangement. This leads us to some new bijective proofs for Shi, Linial and similar hyperplane arrangements.

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MS54

What Computer Algebra Systems Can Offer to Tackle Realizability Problems of Matroids

In his PhD dissertation, Hiroki Nakayama establishes a connection between oriented matroids and mathematical programming, by applying polynomial optimization techniques to the realizability problem of oriented matroids. In this talk, I will discuss what are the tools that computer algebra systems offer today to implement realizability algorithms, such as the one of Nakayama.

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MS54

Stochastic Ptri Nets and Symbolic Calculus

Abstract not available at time of publication.

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MS54

The Interplay Between Finite Fields and Computer Algebra

Finite fields display erratic behavior when the field size is small and for large finite fields memory usage and processor power become bottlenecks. I will outline the computer algebra packages containing finite fields implementations and will list drawbacks and advantages to each. I will illustrate this with examples from my research including an exhaustive search algorithm for normal bases as well as data sets obtained for a section of the forthcoming "Handbook of Finite Fields".

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MS55

A Theoretical Foundation for Neural Sensor Networks

Multiple recent multi-neuron recordings have uncovered structure in the statistics of mammalian retinal output that is well-captured by a probabilistic model from statistical physics called the Ising model. Guided by these findings and motivated by classical ideas in theoretical neuroscience, we have developed a model of neural sensor networks. Our approach incorporates a recently developed Ising model parameter fitting technique called Minimum Probability Flow (MPF). Although a theoretical explanation for network processing of sensory stimuli, our model can also be used to uncover structure in many highly noisy datasets. We discuss several such applications to neuroscience, behavioral genetics, and machine learning. In addition, we discuss how our network can learn an exponential number of combinatorial structures (cliques in graphs) from only a small number of training samples.

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MS55

Neural Code Topology Imposes Constraints on the Network Architecture

There are two complementary perspectives on what controls neural activity in sensory systems: receptive fields, and neural network dynamics. Receptive fields largely determine the representational function of a neuronal network, while network dynamics stem from the network structure. We propose a mathematical framework where the structure of neuronal networks can be related to combinatorial properties of receptive fields, and demonstrate how this can be used to relate network structure to homotopy invariants of represented stimuli.

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MS55

Stable Exponential Storage in Hopfield Networks

A Hopfield auto-associative neural network on n nodes can store a random collection of at most 2n binary patterns as memories. However, it has been observed experimentally that random networks are typically capable of exponential storage in the form of *spurious memories*, which emerge mysteriously from the random network coupling. We give for the first time a parameterized family of Hopfield networks that stably store exponential numbers of binary patterns. Moreover, we give experimental evidence suggesting that these memories are attractors for the clean-up dynamics of the Hopfield network with large basins of attraction. We also present some applications.

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MS55

Noise-Induced Dynamics in Electricaly Coupled Neuronal Networks

Electrically coupled networks of excitable neurons forced by small noise are analyzed in this work, using techniques from dynamical systems and algebraic graph theories. The results are presented from two complementary perspectives of variational analysis of spontaneous network dynamics and the slow-fast analysis of synchronization. The former yields geometric interpretation of various dynamical regimes, while the latter highlights the contribution of the network architecture to the stability of the synchronous state.

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MS55

Simplex Packings of Marginal Polytopes and Mixtures of Exponential Families

A combinatorial approach to the representational power of mixtures of discrete exponential families is presented based on combinatorics of convex polytopes and coding theory. The number of mixtures of a hierarchical model which contain another hierarchical model can be bounded by the cardinality of simplex face packings of their marginal polytope lattices. A bound for such packings is presented for the k-way interaction exponential families.

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Notes

DM12 Speaker and Organizer Index

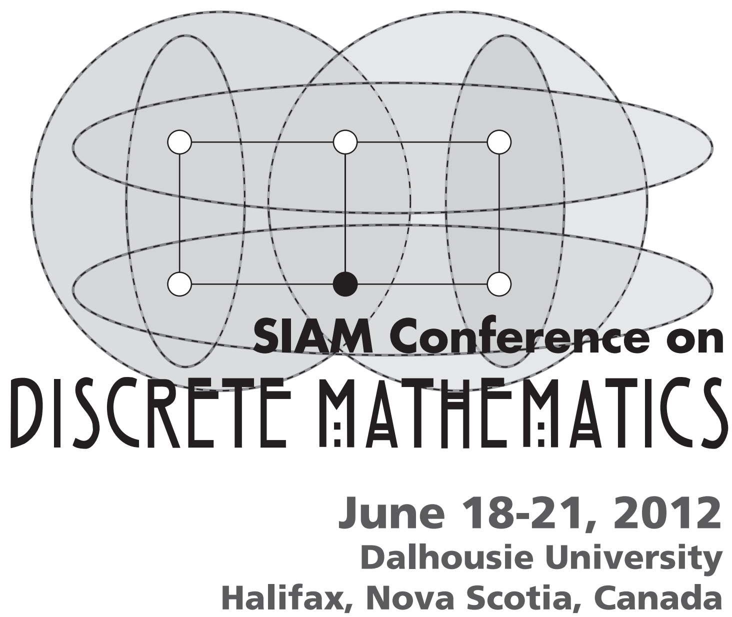

Figure courtesy Victor Chepoi, Hans-Juergen Bandelt, David Eppstein from SIDMA 24-4

Italicized names indicate session organizers.

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B

C

D

E

F

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Notes

DM12 Budget

June 18-21, 2012
Halifax, Nova Scotia, Canada

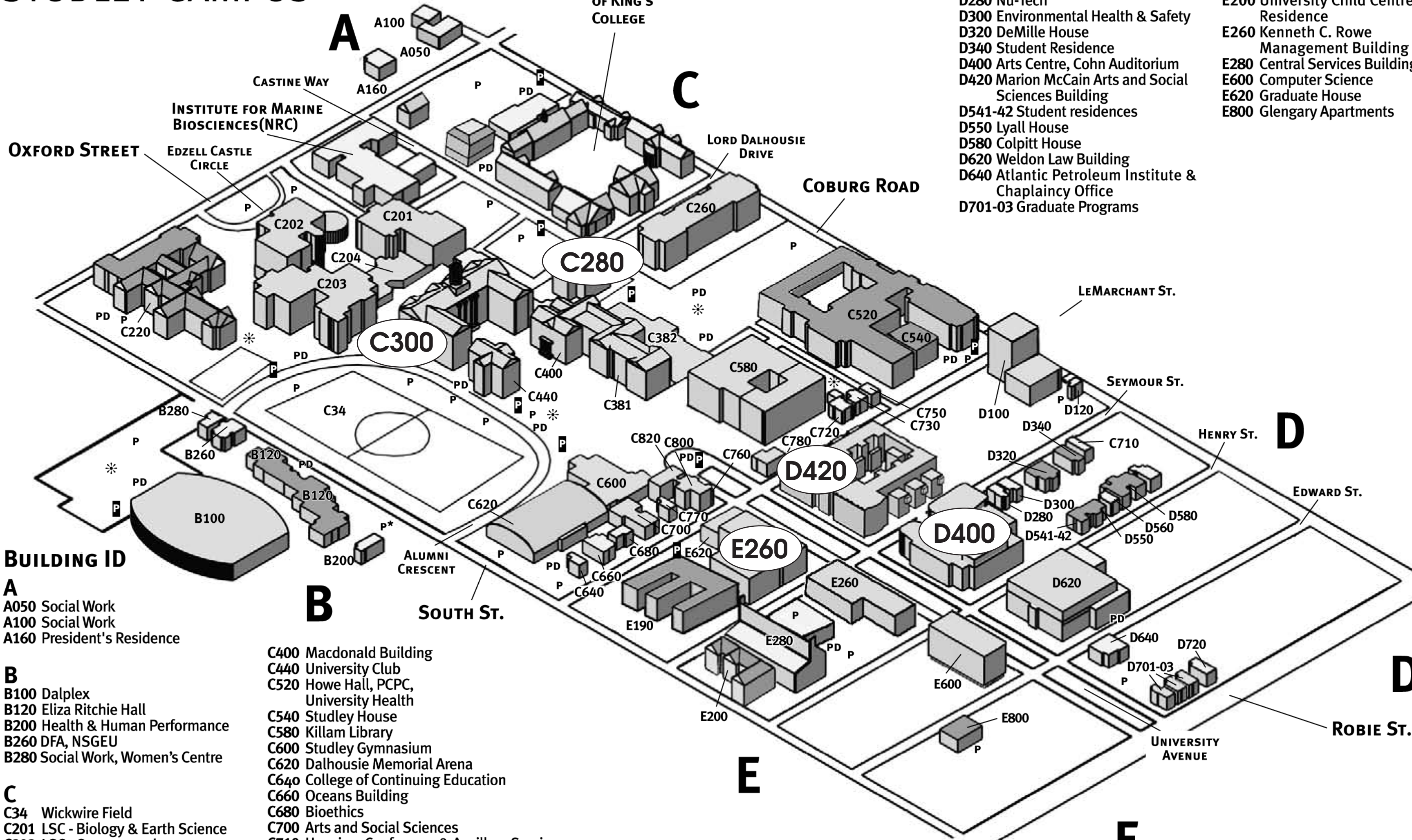
Expected Paid Attendance 330

Revenue	
Registration	$89,735
Total	$89,735
Direct Expenses	
Printing	$2,200
Organizing Committee	$2,600
Invited Speaker	$9,800
Food and Beverage	$24,500
Telecomm	$0
AV and Equipment (rental)	$0
Room (rental)	$6,700
Advertising	$4,400
Conference Staff Labor	$17,000
Other (supplies, staff travel, freight, exhibits, misc.)	$9,000
Total Direct Expenses:	$76,200
Support Services: *	
Services covered by Revenue	$13,535
Services covered by SIAM	$31,522
Total Support Services:	$45,057
Total Expenses:	$121,257

* Support services includes customer service (who handle registration), accounting, computer support, shipping, marketing and other SIAM support staff. It also includes a share of the computer systems and general items (building expenses in the SIAM HQ).

DALHOUSIE UNIVERSITY CAMPUS

Studley Campus



D
D100 6152 Coburg Road
D120 Banner Project Office, IRM
D280 Nu-Tech
D300 Environmental Health & Safety
D320 DeMille House
D340 Student Residence
D400 Arts Centre, Cohn Auditorium
D420 Marion McCain Arts and Social Sciences Building
D541-42 Student residences
D550 Lyall House
D580 Colpitt House
D620 Weldon Law Building
D640 Atlantic Petroleum Institute & Chaplaincy Office
D701-03 Graduate Programs

E
E100 Student Union Building (SUB)
E190 Risley Hall
E200 University Child Centre & Residence
E260 Kenneth C. Rowe Management Building
E280 Central Services Building
E600 Computer Science
E620 Graduate House
E800 Glengary Apartments

Building ID

A
A050 Social Work
A100 Social Work
A160 President's Residence

B
B100 Dalplex
B120 Eliza Ritchie Hall
B200 Health & Human Performance
B260 DFA, NSGEU
B280 Social Work, Women's Centre

C
C34 Wickwire Field
C201 LSC - Biology & Earth Science
C202 LSC - Oceanography
C203 LSC - Psychology
C204 Life Sciences Centre (LSC)
C220 Shirreff Hall
C260 Sir James Dunn Building
C280 Chase Building
C300 Henry Hicks Building
C381, C382 Chemistry
C400 Macdonald Building
C440 University Club
C520 Howe Hall, PCPC, University Health
C540 Studley House
C580 Killam Library
C600 Studley Gymnasium
C620 Dalhousie Memorial Arena
C640 College of Continuing Education
C660 Oceans Building
C680 Bioethics
C700 Arts and Social Sciences
C710 Housing, Conference & Ancillary Services, DalCard Office
C720 European Studies
C730 APICS, Science Co-op
C750 Transition Year Program
C760, C800, C820 Economics
C770 1252 LeMarchant
C780 Arts and Social Sciences

Key to symbols
P —— Permit Parking
P —— Metered Parking
PD —— Parking for people with disabilities
✳ —— Emergency "Code Blue" Phone

01/07

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