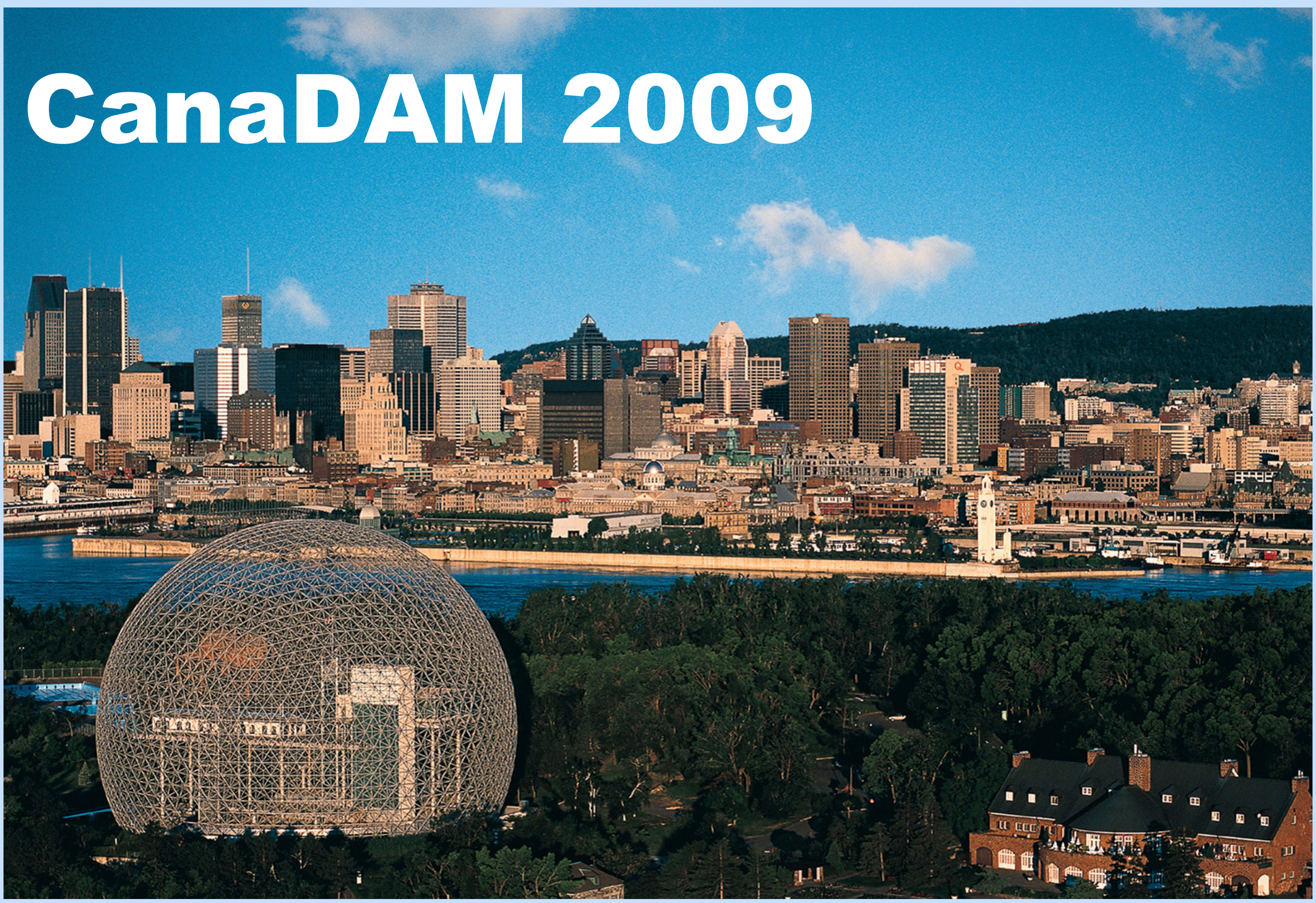
2e Congrès canadien de mathématiques discrètes et algorithmiques

2nd Canadian Discrete and Algorithmic Mathematics Conference

25 au 28 mai 2009

MONTRÉAL, QUÉBEC, CANADA

May 25-28, 2009



CRM

FIELDS

CanaDAM 2009

PIMS

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CanaDAM 2009
2nd Canadian Discrete and Algorithmic Mathematics Conference
Montréal, Québec, Canada
May 25 – 28, 2009

The 2nd Canadian Discrete and Algorithmic Mathematics Conference will be held on May 25 – 28, 2009, at the Centre de recherches mathématiques in Montréal (Canada). This will be the second conference in a new series on discrete mathematics that is held every two years (in the odd years) and has the same format as the "SIAM Conference on Discrete Mathematics." The first conference in this new series was held in Banff (see `www.cs.ualberta.ca/~mreza/CANADAM`).

The general topic of the conference is the theory and application of discrete structures and its goal is to highlight the most salient trends in the field, which has close links to such diverse areas as cryptography, computer science, large-scale networks and biology. The conference will bring together researchers from the various disciplines with which discrete and algorithmic mathematics interact.

Particular areas of interest are the following: graphs and digraphs, hypergraphs, matroids, ordered sets, designs, coding theory, enumeration, combinatorics of words, discrete optimization, discrete and computational geometry, lattice point enumeration, combinatorial algorithms, computational complexity, and applications of discrete and algorithmic mathematics, including (but not limited to) web graphs, computational biology, telecommunication networks, and information processing.

CanaDAM 2009
2^e^ *Congrès canadien de mathématiques discrètes et algorithmiques*
Montréal, Québec, Canada
25 *au* 28 *mai* 2009

Le 2^e^ *Congrès canadien de mathématiques discrètes et algorithmiques se tiendra au Centre de recherches mathématiques* (*Montréal*) *du* 25 *au* 28 *mai* 2009*. Ce congrès est le deuxième d'une nouvelle série, de format semblable à celui de la* SIAM Conference on Discrete Mathematics*. Les congrès canadiens de mathématiques discrètes et algorithmiques auront lieu tous les deux ans* (*les années impaires*)*. Le premier congrès s'est tenu à Banff* (*voir le site* `www.cs.ualberta.ca/~mreza/CANADAM`).

Les sujets abordés pendant le congrès proviendront de tous les domaines des mathématiques discrètes et le but du congrès est de diffuser les avancées les plus importantes de cette branche des mathématiques, qui a des liens étroits avec des domaines tels que la cryptographie, l'informatique, les réseaux de grande taille et la biologie.

Parmi les sujets couverts par le congrès, mentionnons en particulier les suivants : graphes et digraphes, hypergraphes, matroïdes, ensembles ordonnés, combinatoire des plans d'expérience, théorie des codes, combinatoire énumérative, combinatoire des mots, optimisation discrète, géométrie discrète et algorithmique, dénombrement des points d'un réseau, algorithmes combinatoires, complexité des calculs, applications des mathématiques discrètes et algorithmiques à divers domaines, incluant (*entre autres*) *les graphes du web, la bioinformatique, les réseaux de télécommunication et le traitement de l'information.*

Organizing Team ◇ *Équipe organisatrice*

Programme Committee ◇ *Comité de programme*

Jean-Paul Allouche (Université Paris-Sud 11)
David Avis (McGill University)
François Bergeron (Université du Québec à Montréal)
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Carla D. Savage (North Carolina State University; chair ◇ *présidente*)
Jozsef Solymosi (University of British Columbia)
John Watrous (University of Waterloo)

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Pavol Hell (Simon Fraser University)
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Benoit Larose (Champlain College Saint-Lambert & Concordia University)
Odile Marcotte (Université du Québec à Montréal & Centre de recherches mathématiques)
Adrian Vetta (McGill University)

The committee members are very grateful to the CRM administrative and support staff for helping to organize this conference. In particular, they wish to thank Louis Pelletier, Coordinator of Scientific Activities, Louise Letendre, Administrative Assistant, Suzette Paradis, Webmaster, Daniel Ouimet, System Administrator, and André Montpetit, Publications Expert.

Les membres des comités désirent exprimer leur plus vive reconnaissance au personnel du CRM, dont la collaboration fut essentielle pour l'organisation de ce congrès. En particulier, ils remercient Louis Pelletier, coordonnateur des activités scientifiques, Louise Letendre, technicienne en administration, Suzette Paradis, webmestre, Daniel Ouimet, administrateur de systèmes, et André Montpetit, spécialiste en publications.

Plenary Talks ◇ *Conférences plénières*

PT-01 Monday A.M. ◇ *Lundi matin*
Sylvie Corteel (Université Paris-Sud 11)
Enumeration of Fillings of Young Diagrams

PT-02 Monday P.M. ◇ *Lundi après-midi*
Dannie Durand (Carnegie Mellon University)
Genes as LEGO: What Trees and Graphs Can Tell Us About the Evolution of Modular Proteins

PT-03 Tuesday A.M. ◇ *Mardi matin*
Joel Spencer (Courant Institute)
78 Years of Ramsey $R(3,k)$ (and Counting!)

PT-04 Tuesday P.M. ◇ *Mardi après-midi*
Carsten Thomassen (Danmarks Tekniske Universitet)
Graph Decomposition

PT-05 Wednesday A.M. ◇ *Mercredi matin*
Jesús A. De Loera (University of California, Davis)
Two Geometric Algorithms and Their Many Applications in Discrete Optimization

PT-06 Wednesday P.M. ◇ *Mercredi après-midi*
Valérie Berthé (Université Montpellier 2)
Discrete Geometry and Word Combinatorics

PT-07 Thursday A.M. ◇ *Jeudi matin*
Qing Xiang (University of Delaware)
Modular Ranks and Smith Normal Forms of some Incidence Matrices

PT-08 Thursday P.M. ◇ *Jeudi après-midi*
Shafi Goldwasser (Massachusetts Institute of Technology & Weizmann Institute of Science)
Program Obfuscation and One-Time Programs

Invited Minisymposia ◇ *Minisymposiums invités*

IM-01
Enumerative Combinatorics ◇ *Combinatoire énumérative*

Organizer ◇ ***Organisateur*:**
Andrew Rechnitzer (University of British Columbia)
Talks ◇ ***Exposés*:**
- Ira Gessel (Brandeis University)
  Schröder Numbers, Large and Small
- Juan Alvarez (University of Toronto; York University)
  Force, Density, and Extension Relations in Adsorbing Polymers Subject to a Force
- Éric Fusy (École Polytechnique)
  Asymptotic Enumeration of Subfamilies of Unlabelled Planar Graph
- John Irving (Saint Mary's University)
  Another Look at Factorizations of a Full Cycle
- Doron Zeilberger (Rutgers University)
  Probability Theory Done Right! (with a computer of course!)

IM-02

Bioinformatics ◇ *Bioinformatique*

Organizers ◇ *Organisateurs*:
Nadia El-Mabrouk (Université de Montréal)
Cédric Chauve (Simon Fraser University)
Talks ◇ *Exposés*:

- Anne Bergeron (Université du Québec à Montréal)
  Parking Functions, Labeled Trees and DCJ Sorting Scenarios
- David Sankoff (University of Ottawa)
  A Connection between Gene Clusters and Record Times for Random Variables
- Mathieu Blanchette (McGill University)
  Maximum Likelihood Indel Reconstruction
- Mathieu Lajoie (Université de Montréal)
  A Heuristic Algorithm to Infer the Evolutionary History of Tandemly Arrayed Gene Clusters
- Nadia El Mabrouk (Université de Montréal)
  New Perspectives on Gene Family Evolution
- Aida Ouangraoua (Simon Fraser University; Université du Québec à Montréal)
  Ancestral Genome Architecture Reconstruction

IM-03

Graph Theory I ◇ *Théorie des graphes* I

Organizer ◇ *Organisateur*:
Bojan Mohar (Simon Fraser University)
Talks ◇ *Exposés*:

- Bojan Mohar (Simon Fraser University)
  Is There a Structural Graph Theory Based on the Spectral Radius?
- Xingxing Yu (Georgia Institute of Technology)
  K_5-Subdivisions in 5-Connected Nonplanar Graphs
- Alexandr Kostochka (University of Illinois at Urbana-Champaign; Sobolev Institute of Mathematics)
  Unbalanced Minors in $(s+t)$-Chromatic Graphs
- Sergey Norine (Princeton University)
  K_t Minors in Large t-Connected Graphs
- Daniel Král' (Charles University in Prague)
  Perfect Matchings in Cubic Graphs
- Linda Lesniak (Drew University)
  Conditional Matching Preclusion Sets

IM-04

Random Graphs and the Probabilistic Method
Les graphes aléatoires et la méthode probabiliste

Organizers ◇ *Organisateurs*:
Bruce Reed (McGill University)
Michael Molloy (University of Toronto)
Talks ◇ *Exposés*:

- Robin Moser (ETH Zürich)
  A Constructive Proof of the Lovász Local Lemma
- Alan Frieze (Carnegie Mellon University)
  Coloring Simple Hypergraphs
- Tom Bohman (Carnegie Mellon University)
  The Early Evolution of the H-Free Process
- Nikolaos Fountoulakis (Max-Planck-Institut für Informatik)
  A Generalized Critical Condition for the Emergence of the Giant Component in Random Graphs with Given Degrees
- Colin McDiarmid (Oxford University)
  Random Graphs with Few Disjoint Cycles

IM-05

Graph Theory II ◇ *Théorie des graphes* II

Organizer ◇ *Organisateur*:
Bojan Mohar (Simon Fraser University)
Talks ◇ *Exposés*:

- Penny Haxell (University of Waterloo)
  Packing and Covering in Hypergraphs
- Pavol Hell (Simon Fraser University)
  Adjusted Interval and Proper Interval Digraphs
- Ken-ichi Kawarabayashi (National Institute of Informatics)
  On Hadwiger's Conjecture and Hajos' Conjecture — Structure and Algorithms
- Luis Goddyn (Simon Fraser University)
  Excluded Minors for Bicircular Matroids

- Robert Samal (Charles University in Prague)
  An Eberhard-Like Theorem for Pentagons and Heptagons
- Joan P. Hutchinson (Macalester College)
  A Tribute to the Memory of Michael O. Albertson (1946 – 2009)

IM-06

Combinatorial Design Theory I ⋄ *Combinatoire des plans d'expérience* I

Organizers ⋄ *Organisateurs*:
Clement Lam (Concordia University)
John van Rees (University of Manitoba)
Talks ⋄ *Exposés*:

- Clement Lam (Concordia University)
  Strongly Regular Graphs with Nontrivial Automorphisms
- Ralph Stanton (University of Manitoba)
  Butterfly Factorizations of K_n
- Patric R.J. Östergård (Helsinki University of Technology)
  Properties of the Steiner Triple Systems of Order 19
- F.E. Bennett (Mount Saint Vincent University)
  Existence of Directed BIBDs with Block Size 7 *and Related Codes*
- David A. Pike (Memorial University of Newfoundland)
  Embedding and Colouring Odd Cycle Systems

IM-07

Discrete and Computational Geometry ⋄ *Géométrie discrète et algorithmique*

Organizer ⋄ *Organisateur*:
Antoine Deza (McMaster University)
Talks ⋄ *Exposés*:

- David Bremner (University of New Brunswick)
  A Computational Approach to Bounding Polytope Diameters
- Karoly Bezdek (University of Calgary)
  On the Maximum Number of Touching Pairs in Packings of Given Number of Congruent Balls
- Tamon Stephen (Simon Fraser University)
  Computing Knock out Strategies in Metabolic Networks
- Antoine Deza (McMaster University)
  Hyperplane Arrangements with Large Average Diameter
- Yuriy Zinchenko (University of Calgary) *A Continuous d-Step Conjecture for Polytopes*

IM-08

Combinatorics of Words ⋄ *Combinatoire des mots*

Organizers ⋄ *Organisateurs*:
James Currie (The University of Winnipeg)
Amy Glen (Reykjavik University)
Narad Rampersad (The University of Winnipeg)
Talks ⋄ *Exposés*:

- Jason Bell (Simon Fraser University)
  Logarithmic Frequency in Morphic Sequences
- Julien Cassaigne (Institut de mathématiques de Luminy)
  On the Number of α-Power-Free Words for $2 < \alpha \leq \frac{7}{3}$
- Frantisek Franek (McMaster University)
  Suffix-Based Text Indices, Construction Algorithms, and Applications
- Jeffrey Shallit (University of Waterloo)
  Periodicity and Repetitions in Automatic Sequences
- Luca Q. Zamboni (Université Lyon 1; Reykjavik University)
  Finite Colorings of Factors of Words

IM-09

Combinatorial Design Theory II ◇ *Combinatoire des plans d'expérience* II

Organizers ◇ *Organisateurs*:
Clement Lam (Concordia University)
John van Rees (University of Manitoba)
Talks ◇ *Exposés*:

- G.H.J. van Rees (University of Manitoba)
  Constructions and Bounds on $(m, 3)$-Splitting Systems
- Ben Li (University of Manitoba)
  Searching for Steiner Triple System with no Parallel Classes
- Douglas R. Stinson (University of Waterloo)
  Combinatorial Batch Codes
- Catharine Baker (Mount Allison University)
  Skolem Sequences: From Coloured Blocks to Communication Networks
- R. Wei (Lakehead University)
  Decomposing Triples into Cyclic Designs

Contributed Minisymposia ◇ *Minisymposiums libres*

CM-01

Algebraic Graph Theory ◇ *Théorie algébrique des graphes*

Organizers ◇ *Organisateurs*:
Sebastian Cioaba (University of Delaware)
Mike Newman (University of Ottawa)
Talks ◇ *Exposés*:

- Sebastian Cioaba (University of Delaware)
  The Spectral Radius and the Diameter of a Graph
- Randy Elzinga (Queen's University)
  Weighted Adjacency Matrices, Eigenvalues and the Independence Number
- Jason Williford (University of Colorado Denver)
  Q-Polynomial Schemes
- Karen Meagher (University of Regina)
  The Erdős – Ko – Rado Theorem for Permutations
- Mike Newman (University of Ottawa)
  Partition Graphs

CM-02

Complex Real-World Networks
Réseaux sociaux et informatiques de grande taille

Organizers ◇ *Organisateurs*:
Anthony Bonato (Ryerson University)
Jeannette Janssen (Dalhousie University)
Talks ◇ *Exposés*:

- Jeannette Janssen (Dalhousie University)
  Challenges and Achievements in Modelling Complex Networks
- Jure Leskovec (Cornell University)
  Large Social and Information Networks, Clusters and Kronecker Products
- Allon Percus (Claremont Graduate University)
  The Structure of Geographical Threshold Graphs
- Nataša Pržulj (University of California, Irvine)
  From Network Topology to Biological Function and Disease
- Raissa D'Souza (University of California, Davis)
  Networks: Growing, Jamming and Changing Phase

CM-03

Asymptotic Enumeration I ◇ *Énumération asymptotique* I

Organizer ◇ *Organisateur*:
Daniel Panario (Carleton University)
Talks ◇ *Exposés*:

- Edward A. Bender (University of California, San Diego)
  Locally Restricted Compositions, Infinite Matrices, and Normality
- Rod Canfield (University of Georgia)
  Problems and Results in Asymptotic Combinatorics

- Conrado Martínez (Universitat Politècnica de Catalunya)
  Asymptotic Analysis and Optimal Selection
- Alfredo Viola (Universidad de la República)
  Some Asyptotic Issues Related with the Exact Distribution of Individual Displacements in Linear Probing Hashing
- Daniel Panario (Carleton University)
  Asymptotics of Smallest Components Sizes in Decomposable Combinatorial Structures of Alg-Log Type

CM-04

Graph Pebbling ◇ *Jeux de galets sur les graphes*

Organizers ◇ *Organisateurs*:
Glenn Hurlbert & Andrzej Czy (Arizona State University)
Talks ◇ *Exposés*:

- Glenn Hurlbert (Arizona State University)
  An Application of Graph Pebbling to Zero-Sum Sequences in Abelian Groups
- David Herscovici (Quinnipiac University)
  Graham's Conjecture in some Pebbling Variants
- Kevin Milans (University of Illinois at Urbana-Champaign)
  Computational Complexity Aspects of Graph Pebbling
- Airat Bekmetjev (Hope College)
  The Pebbling Threshold of Graph Sequences
- Anant Godbole (East Tennessee State)
  Pebbling Probabilities at the Threshold

CM-05

Linear Algebra in Combinatorics ◇ *Algèbre linéaire en combinatoire*

Organizer ◇ *Organisateur*:
Mahdad Khatirinejad (Helsinki University of Technology)
Talks ◇ *Exposés*:

- Joel Friedman (University of British Columbia)
  Girth and Lifts
- Mahdad Khatirinejad (Helsinki University of Technology)
  Optimal Configuration of Points in Quaternionic Projective Spaces
- Robert Craigen (University of Manitoba)
  Partial Circulant Hadamard Matrices
- Kseniya Garaschuk (University of Victoria)
  Rational Decomposition of Graphs
- Peter Dukes (University of Victoria)
  Rational Decomposition of Almost Complete Graphs

CM-06

Graph Theory with Applications I ◇ *Théorie des graphes et applications* I

Organizer ◇ *Organisatrice*:
Wendy Myrvold (University of Victoria)
Talks ◇ *Exposés*:

- Ermelinda DeLaVina (University of Houston)
  Graph Theoretical Conjectures of Graffiti.pc
- Gunnar Brinkmann (Universiteit Gent)
  Classification and Generation of Nanocones
- Jack Graver (Syracuse University)
  A Catalog of Self-Dual Plane Graphs with Maximum Degree 4
- William Kocay (University of Manitoba)
  Drawing Graphs on the Plane, Torus, Projective Plane and Sphere
- Jennifer Woodcock (University of Victoria)
  Continuing the Search for Torus Obstructions

CM-07

Graph Classes and their Structures ◇ *Familles de graphes et leurs structures*

Organizers ◇ *Organisateurs*:
Andreas Brandstädt (Universität Rostock)
Ortrud Oellermann (The University of Winnipeg)
Talks ◇ *Exposés*:

- Chính Hoàng (Wilfrid Laurier University)
  The Problem of Deciding Whether a Graph Contains a Sun Is NP Complete

- Feodor Dragan (Kent State University)
  Navigating in a Graph by Aid of its Spanning Tree
- Terry McKee (Wright State University)
  Pentangulated Graphs
- Andreas Brandstädt (Universität Rostock)
  Leaf Powers: Recent Results and Open Problems
- Ortrud Oellermann (The University of Winnipeg)
  Induced Trees and Monophonic Convexity

CM-08

Asymptotic Enumeration II ◇ *Énumération asymptotique* II

Organizer ◇ *Organisateur*:
Daniel Panario (Carleton University)
Talks ◇ *Exposés*:

- Boris Pittel (The Ohio State University)
  On a Random Graph Evolving by Degrees
- Peter Cameron (Queen Mary, University of London)
  TBA
- Bruce Richmond (University of Waterloo)
  Maximum Stirling Numbers of the Second Kind
- Alex Iosevich (University of Missouri)
  Geometric Configurations in Vector Spaces over Finite Fields
- Jason (Zhicheng) Gao (Carleton University)
  Asymptotics of Some Convolutional Recurrences

CM-09

Graph Theory with Applications II ◇ *Théorie des graphes et applications* II

Organizer ◇ *Organisateur*:
Patrick W. Fowler (University of Sheffield)
Talks ◇ *Exposés*:

- Sean Daugherty (University of Victoria)
  A Linear-Time Algorithm for Finding a Maximum Independent Set on a Fullerene
- Tomislav Došlić (University of Zagreb)
  Graph-Theoretic Indicators of Fullerene Stability
- Gilles Caporossi (HEC Montréal)
  Features of the System ChemoGraphiX
- Patrick W. Fowler (University of Sheffield)
  Characteristic Polynomials and Electron Conduction
- Douglas Klein (Texas A&M University at Galveston)
  Substitution-Reaction Posets in Chemistry

CM-10

Degree Sequences in Graphs and Digraphs
Suites de degrés dans les graphes et les digraphes

Organizer ◇ *Organisateur*:
Michael Ferrara (The University of Akron)
Talks ◇ *Exposés*:

- Stephen Hartke (University of Nebraska – Lincoln)
  Forbidden-Graph Classes Characterized by Their Degree Sequences: The Nonminimal Triple Case
- Arthur Busch (University of Dayton)
  Tournament Score Sequences with k-Partition Transitive Realizations
- Michael Ferrara (The University of Akron)
  Packings of Degree Sequences
- David Kirkpatrick (University of British Columbia)
  Realizations of Near-Graphical Sequences with Maximum Saturation and Minimum Deficiency
- Nathan Kahl (Seton Hall University)
  Strongest Monotone Degree Conditions and Bounds
- John Schmitt (Middlebury College)
  A Lower Bound for Potentially H-Graphic Sequences

CM-11

Graph Protection ◇ *Protection dans les graphes*

Organizer ◇ ***Organisatrice*:**
Kieka Mynhardt (University of Victoria)
Talks ◇ ***Exposés*:**
- Bert Hartnell (Saint Mary's University)
  Red, White and Blue Protection
- Drago Bokal (University of Maribor)
  Guarding a Subgraph as a Tool in Pursuit-Evasion Games
- Stephen Benecke (University of Victoria)
  Domination of Generalized Cartesian Products
- Sarada Herke (University of Victoria)
  A Characterization of Radial Trees
- Ernie Cockayne (University of Victoria)
  Trees with Equal Broadcast and Domination Numbers
- Stephen Finbow (St. Francis Xavier University)
  On the Surviving Rates of a Graph

CM-12

Constraint Satisfaction Problems ◇ *Satisfaction de contraintes*

Organizers ◇ ***Organisateurs*:**
Andrei Krokhin (University of Durham)
Benoit Larose (Champlain College Saint-Lambert; Concordia University)
Claude Tardif (Royal Military College of Canada)
Talks ◇ ***Exposés*:**
- Libor Barto (Charles University in Prague)
  Marcin Kozik (Jagellonian University)
  Constraint Satisfaction Problems of Bounded Width I & II
- Andrei Bulatov (Simon Fraser University)
  The Complexity of Global Cardinality Constraints
- Hubie Chen (Universitat Pompeu Fabra)
  Arc Consistency and Friends
- Laszlo Egri (McGill University)
  The Complexity of the List Homomorphism Problem for Graphs

CM-13

Broadcasting and Gossiping in Graphs
Diffusion et échange total dans les graphes

Organizer ◇ ***Organisateur*:**
Hovhannes Harutyunyan (Concordia University)
Talks ◇ ***Exposés*:**
- Stephen Hedetniemi (Clemson University)
  Topics Involving Broadcasts in Graphs
- Dana Richards (George Mason University)
  Broadcasting from Multiple Originators: *A Census*
- Joseph Peters (Simon Fraser University)
  Epidemics in Communication Networks
- Ke Qiu (Brock University)
  On Broadcasting, Neighbourhood Broadcasting, and Whitney Numbers of the Second Kind
- Hovhannes Harutyunyan (Concordia University)
  Construction of Broadcast Graphs

CM-14

Colourings, Homomorphisms, and Beyond
Colorations et homomorphismes

Organizers ◇ ***Organisateurs*:**
Richard Brewster (Thomson Rivers University)
Jing Huang (University Of Victoria)
Gary MacGillivray (University of Victoria)
Talks ◇ ***Exposés*:**
- Richard Brewster (Thompson Rivers University)
  Colourings, Homomorphisms, and Constraint Satisfaction Problems Overview
- Ross Kang (McGill University)
  On Distance-t Edge Colourings and Induced Matchings
- Ruth Haas (Smith College)
  The Canonical Coloring Graph
- Nancy Clarke (Acadia University)
  Injective Colourings and Homomorphisms of Oriented Graphs
- Jacobus Swarts (University of Victoria)
  Weak Near-Unanimity Functions and NP-Completeness

CM-15

On Graphs with Crossings ◇ *Sur les croisements dans les graphes*

Organizer ⋄ *Organisateur*:
Michael O. Albertson (Smith College)
Chair ⋄ *Présidente*:
Joan Hutchinson (Macalester College)
Talks ⋄ *Exposés*:

- Dan Cranston (Rutgers University)
  Crossings, Colorings, and Cliques
- Sally Cockburn (Hamilton College)
  Geometric Homomorphisms, Part I
- Debra Boutin (Hamilton College)
  Geometric Homomorphisms, Part II
- Daniel Král' (Charles University in Prague)
  Coloring Plane Graphs with Independent Crossings

Abstracts ◇ *Résumés*

Monday May 25 ◇ *lundi* 25 *mai*
9:15 – 10:05 S1-151

PT-01
Plenary Talk ◇ *Conférence plénière*

Enumeration of Fillings of Young Diagrams
Sylvie Corteel
Université Paris-Sud 11
corteel@lri.fr

In this talk I will present different pattern avoiding fillings of Young diagrams and show how they are interesting combinatorial objects and also how they can be used to solve problems coming from other fields. For example, the permutation tableaux come from the study of the positive part of the Grassmannian and can be used to understand a statistical physics model called the partially asymmetric self exclusion process. But they are also related to patterns in permutations, acyclic orientations of graphs, orthogonal polynomials and Hall – Littlewood functions.

This talk will be targeted for a general audience and will be dedicated to the memory of Pierre Leroux.

Monday May 25 ◇ *lundi* 25 *mai*
10:25 – 12:30 Z-315

IM-01
Enumerative Combinatorics
Combinatoire énumérative

Schröder Numbers, Large and Small
Ira Gessel
Brandeis University
gessel@brandeis.edu

A Schröder path is a path in the plane starting and ending on the x-axis, with up steps $(1,1)$, down steps $(1,-1)$, and flat steps $(2,0)$. The large Schröder number r_n counts Schröder paths from $(0,0)$ to $(2n,0)$ and the small Schröder number s_n counts Schröder paths from $(0,0)$ to $(2n,0)$ with no flat steps on the x axis. It is known that for $n>0$, $r_n = 2s_n$. I will discuss several proofs of this result and its connection with Motzkin, Riordan, and Narayana numbers.

Force, Density, and Extension Relations in Adsorbing Polymers Subject to a Force
Juan Alvarez
University of Toronto; *York University*
jalvarez@chem.utoronto.ca
jalvarez@mathstat.yorku.ca

We consider directed walk models of a polymer that is adsorbing at a surface due to polymer-surface interactions, and is also pulled away from the surface by an elongational force. We obtain force-temperature, force-extension, and density-extension curves for Dyck path and partially directed walk models in the situation when the polymer is pulled from one end, and for Dyck paths when the polymer is pulled from a central location in the polymer. We obtain force-extension curves for these models, and their dependence on the length of the polymer.

Asymptotic Enumeration of Subfamilies of Unlabelled Planar Graph
Éric Fusy
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Recently Gimenez and Noy have found a complete analytic solution to the problem of counting labeled planar graphs, which yields precise asymptotic enumeration estimates, as well as limit laws for many parameters. In the unlabeled case the problem is still open, due to the difficulty of dealing with the symmetries. As a first step we focus here on subfamilies of unlabeled planar graphs, such as outerplanar graphs (exclude the minors $K_{2,3}$ and K_4) and series-parallel graphs (exclude the minor K_4). Using cycle index sums (as a refinement of ordinary generating functions) and singularity analysis, we show that the counting coefficients (which can be according to the number of vertices or edges) satisfy $c_n \sim c g^n n^{-5/2}$ when n goes to infinity, as in the labeled case, but with different constants that are more difficult to compute.

Another Look at Factorizations of a Full Cycle
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We will look at an interesting symmetric function identity that serves as an implicit formula for certain top connection coefficients of the symmetric group. This will lead to an alternative proof of a result of Goulden and Jackson concerning factorizations of a full cycle into an ordered product of permutations of known cycle types.

Probability Theory Done Right! (with a computer of course!)

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Probability theory started out on the right foot, as a branch of enumerative combinatorics, with finite (but arbitrary) "sample space," but later it got completely ruined by analysis and "continuous" distributions, "culminating" with Kolmogorov's "rigorous" foundation using "measure theory" (on "infinite" sigma algebras and all that nonsense).

But, it is hard to blame them, since they didn't have computers. With computers (used correctly!), one can redo Probability theory, and stay in the discrete realm, and now everything is truly rigorous. Perhaps sticking to the discrete and the finite would save us from future abuses of mathematics caused by continuous probability theory recently witnessed in Wall Street.

Monday May 25 ⋄ *lundi* 25 *mai*
10:25 – 12:30 Z-317

CM-01

Algebraic Graph Theory
Théorie algébrique des graphes

The Spectral Radius and the Diameter of a Graph

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Joint work with Edwin van Dam, Jack Koolen, and Jae-Ho Lee

Recently, van Dam and Kooij have raised the problem of determining the minimum spectral radius among the graphs of fixed order and diameter. In this talk, I will study the cases when the diameter is fixed, when the diameter is about half the number of vertices, and when the diameter is near the number of vertices. I will show how these problems are related to the degree/diameter problem and to the classification of graphs of small spectral radius.

Weighted Adjacency Matrices, Eigenvalues and the Independence Number

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Let G be a graph with adjacency matrix A and independence number $\alpha(G)$. There are two well-known bounds on $\alpha(G)$ in terms of the eigenvalues of A, one due to Cvetković and another due to Hoffman. Cvetković's *inertia bound* asserts that

$$\alpha(G) \leq n_0(A) + \min\{n_+(A), n_-(A)\}$$

where $n_0(A), n_+(A)$, and $n_-(A)$ are the numbers of zero, positive, and negative eigenvalues of A. If G is r-regular, then Hoffman's *ratio bound* states that

$$\alpha(G) \leq \frac{|\lambda_n(A)|}{r + |\lambda_n(A)|} n$$

where $\lambda_n(A)$ is the least eigenvalue of A.

A matrix $\hat{A}$ is called a *weighted adjacency matrix* for G if $\hat{A}_{ij}$ is in $\mathbb{R}$ when ij is an edge of G and $\hat{A}_{ij} = 0$ when ij is not an edge. Both the inertia bound and the ratio bound can be adapted to include weighted adjacency matrices. Then, given one of these bounds, we may ask whether or not for each graph G there is some weighted adjacency matrix $\hat{A}$ of G such that equality is attained in the bound. In this talk, the weighted adjacency matrix versions of each bound will be presented, conditions for equality in the weighted versions will be discussed, and a comparison of the two bounds will be given.

***Q*-Polynomial Schemes**

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The theory of association schemes has proven useful in several areas of discrete mathematics such as coding theory, finite geometry, and design theory, to name a few. Much attention has been paid to association schemes which are generated by distance-regular graphs; however, the formal dual to this type of scheme, known as a "Q-polynomial" scheme, remains less understood.

In this talk we will give a description of recent progress toward understanding the structure of Q-polynomial schemes.

The Erdős – Ko – Rado Theorem for Permutations

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The Erdős – Ko – Rado Theorem is a major result in extremal set theory. It gives the exact size of the largest system of sets that has property that any two sets in the system have nontrivial intersection. There have been many extensions of this theorem to combinatorial objects other than set systems. For example, in 1977 Deza and Frankl proved a restricted version of this result for permutations and conjectured that the natural extension of the Erdős – Ko – Rado theorem holds for permutations. In recent years there has been major progress on this problem. I will give an overview of these results and describe what open problems remain.

Partition Graphs

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Partition graphs are graphs whose vertices are partitions of an n-set, and where adjacency means that each class of one partition intersects each class of the other. The idea goes back to Rényi's *Qualitative Independence* and has since found applications in covering arrays.

Still, surprisingly few exact results have been established on these graphs. We will describe some of the important results, as well as recent work and indicate some strategies for better understanding these graphs.

Monday May 25 ◇ *lundi* 25 *mai*
10:25 – 12:30 Z-337

CM-02

Complex Real-World Networks
Réseaux sociaux et informatiques de grande taille

Challenges and Achievements in Modelling Complex Networks

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An important step towards understanding the link structure of complex networks is to develop an appropriate model. Interest in graph models started about a decade ago, with the introduction of the preferential attachment model. Since then, several different models have been proposed and analyzed, based on a variety of paradigms. I will present some of the highlights of this decade in graph modelling, and discuss the challenges that lay ahead.

Large Social and Information Networks, Clusters and Kronecker Products

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The emergence of the web gave us access to rich data on human social activity that can be represented as an interaction graph. One of the principal challenges is to build models of the structure of such large networks. In this talk I will present work on the cluster or community structure in large networks, where clusters are thought of as sets of nodes that are better connected internally than to the rest of the network. We find that large networks have fundamentally different clustering than well-studied small social networks and graphs that are well ,embeddable in a low-dimensional structure. Surprisingly in networks of millions of nodes, tight clusters exist only at very small size scales up to around 100 nodes, while at large size scales networks becomes expander-like. This behaviour is unexplained, even at a qualitative level, by any of the commonly-used network generation models. I present a network model based on the Kronecker product of a graph adjacency matrix that is analytically tractable and is able to produce graphs exhibiting a network structure similar to our observations.

The Structure of Geographical Threshold Graphs

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Joint work with Milan Bradonjic and Aric Hagberg (*Los Alamos*)

The geographical threshold graph (GTG) model is a static network model that combines aspects of the random geometric graph (RGG) model with threshold graphs, where edges are placed according to a function of node weights. In a GTG, nodes are placed in a Euclidean space, and are assigned weights (w_i) that are i.i.d. random variables. Two nodes i and j separated by distance r_{ij} are connected by an edge if $(w_i + w_j)/r_{ij}^2 \geq \theta$ is satisfied, for some fixed parameter θ that controls the graph density.

The GTG model is rich enough to capture specific desired properties of real networks, while simple enough that it yields to combinatorial analysis. Moreover, many of the intuitions and techniques for studying RGGs extend to this ensemble. Although a few high-weighted nodes may result in long-range links that are not present in RGGs, these links do not change qualitatively some of the basic network properties such as percolation threshold, connectivity and diameter. We give bounds on the threshold value guaranteeing the existence and absence of a giant component, connectivity and disconnectivity of the graph, and small diameter, showing how these relate to the weight distribution. Finally, we consider the clustering coefficient for nodes with degree l, finding that its scaling is very close to $1/l$ when node weights are exponentially distributed.

From Network Topology to Biological Function and Disease

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We discuss our new tools that are advancing network analysis towards a theoretical understanding of the structure of biological networks. Analogous to tools for analyzing and comparing genetic sequences, we are developing new tools that decipher large network data sets, with the goal of improving biological understanding and contributing to development of new therapeutics. We demonstrate that local node similarity corresponds to similarity in biological function and involvement in disease. We introduce a systematic highly constraining measure of a network's local structure and demonstrate that protein-protein interaction (PPI) networks are better modeled by geometric graphs than by any previous model. The geometric model is further corroborated by demonstrating that PPI networks can explicitly be embedded into a low-dimensional geometric space. We also present a new network alignment algorithm.

Networks: Growing, Jamming and Changing Phase

Raissa D'Souza
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Key notions from statistical physics, such as "phase transitions" are providing important insights in fields ranging from computer science to probability theory to epidemiology. Underlying many of the advances is the study of phase transitions on models of networks. Starting from the classic ideas of Erdős and Rényi, recent attempts to control and manipulate the nature of the phase transition in network connectivity will be discussed. Then, turning to network growth, I will show that local optimization can play a fundamental role leading to the mechanism of Preferential Attachment, which previously had been assumed as a basic axiom.

Monday May 25 ⋄ *lundi* 25 *mai*
10:25 – 12:30 Z-345

CTS-01

Algorithms and Complexity
Algorithmes et complexité

Computing Fault Tolerance of Cayley Graphs

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Joint work with Shuhong Gao

Cayley graphs from finite groups are excellent candidates for interconnection networks. We are interested in efficient algorithms for computing fault tolerance of Cayley graphs. It is a difficult problem to decide whether a given Cayley graph is connected. Testing primitivity of an element in a finite field is a notoriously hard special case. We present a polynomial time algorithm for computing the fault tolerance of connected Cayley graphs.

Dichotomy for Tree-Structured Trigraph List Homomorphism Problems

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Joint work with T. Feder, P. Hell, and D.G. Schell

Trigraph list homomorphism problems (also known as list matrix partition problems) have generated recent interest, partly because there are concrete problems that are not known to be polynomial time solvable or NP-complete; this is known as dichotomy.

In this talk, we show a large class of tree-like trigraphs for which list homomorphism problems do exhibit a dichotomy. In particular, they include all trigraphs whose underlying graphs are trees.

Homomorphisms to Local Tournaments

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Joint work with Jacobus Swarts

A dichotomy theorem for the complexity of homomorphisms to fixed local tournaments is described. The local tournaments for which the problem is polynomial are those which have the X-underbar property or are instances of the graft extension. The problem is NP-complete for all other fixed local tournaments.

Cycle Transversals in Bounded Degree Graphs

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Joint work with M. Groshaus, P. Hell, L.T. Nogueira, and F. Protti

In this talk we consider the problem of finding a maximum C_k-transversal (a subset of vertices hitting all the induced chordless cycles with k vertices) in a graph with bounded maximum degree Δ. In particular, we seek for dichotomy results as follows: for a fixed value of Δ, finding a maximum C_k-transversal is polynomial-time solvable if $k \leq p$, and NP-hard otherwise.

Monday May 25 ◇ *lundi* 25 *mai*
10:25 – 12:30 Z-350

CTS-02

Words I ◇ *Mots* I

Pancake Sorting

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We are given a stack of n pancakes of different sizes and the only allowed operation is to take several pancakes from top and flip them. The aim is to sort the pancakes by their sizes and in the burnt version they additionally need to be oriented burnt-side down.

In both versions, we study the average number of flips needed. We also present the maximum numbers of flips needed to sort a stack of n burnt pancakes up to $n = 17$, that disprove a conjecture of Cohen and Blum.

Construction of Markoff Triples Using Christoffel Words

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An explicit bijection is given between Christoffel words and Markoff triples, that is, natural integers a, b, c such that $a^2 + b^2 + c^2 = 3abc$. This result is an appplication of Combinatorics on Words to the theory of Markoff of "badly approximable" numbers. Markoff's theory uses many tools of Combinatorics on Words (long before this field exists, in 1879) and is closely related to the theory of Sturmian sequences, which appeared much later. I will give some hints to this connection. The above result is also closely related to the famous "Markoff numbers injectivity conjecture," which appears however to be much more difficult. I will explain also this connection.

On Fixed Points of the Iterated Pseudopalindromic Closure

Geneviève Paquin
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First introduced in the study of the Sturmian sequences, the iterated palindromic closure was recently generalized to pseudopalindromes. This operator allows one to construct words with an infinity of pseudopalindromic prefixes, called pseudostandard words. With Jamet, Richomme, and Vuillon, we have studied the words that are fixed point under the iterated pseudopalindromic closure. I will present the different combinatorial properties exhibited by this family of words.

The Sage-Words Library

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Le 18 décembre 2008, plus de 10000 lignes de code sur la combinatoire des mots ont été fusionnées à Sage, un logiciel de mathématiques libre et gratuit. C'est le fruit du travail de plusieurs étudiants qui, sous la direction de Srecko Brlek, ont implémenté de nombreux algorithmes.

Nous présenterons

- un historique de la librairie ;
- des démonstrations des nombreuses fonctionnalités existantes ;
- un aperçu des fonctionnalités à venir ;
- comment vous la procurer.

Références : www.sagemath.org

Propriétés combinatoires des f-palindromes

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La conjecture de Hof, Knill et Simon, énoncée pour la première fois en 1995, donne une caractérisation des points fixes de morphismes dont la complexité palindromique (le nombre de facteurs palindromes) est infinie. Récemment, elle a été résolue pour les points fixes sur un alphabet binaire (Tan, 2007). Nous démontrons un résultat similaire pour les points fixes de morphismes uniformes contenant une infinité de f-pseudo-palindromes.

Références : S. Labbé, *Propriétés combinatoires des f-palindromes*, Mémoire de maîtrise en mathématiques, UQÀM, Montréal, 2008.

Monday May 25 ◇ *lundi* 25 *mai*
10:25 – 12:30 S1-131

CTS-03

Hypergraphs ◇ *Hypergraphes*

Forbidden Configurations: Indicator Polynomials

Richard Anstee
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Joint work with Balin Fleming

We discuss the extremal set theory problem of forbidden configurations and an application of indicator polynomials and linear algebra to obtain a difficult bound.

On Higher-Level Erdős – Ko – Rado Theorems and Conjectures

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The celebrated Erdős – Ko – Rado theorem (1961) determines the maximum size and structure of a maximal family of k-subsets of an n-set such that any two k-subsets intersect, when n is large enough. There has been a number of generalizations of this theorem, and we will look at “higher-level” generalizations. In these cases, the basic objects considered (in place of k-subsets) are themselves set systems, usually very structured ones, such as set-partitions of an n-set or permutations of an n-set. The notion of “intersecting” needs to be generalized and in many cases we end up with some Erdős – Ko – Rado type of theorem. We will discuss some of these theorems, conjectures and open problems.

Generating Self-Complementary Uniform Hypergraphs

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In 2007, Szymanski and Wojda proved that for positive integers n and k, $n < k$, a self-complementary k-uniform hypergraph of order n exists if and only if $C(n,k)$ is even. In this talk, we characterize the cycle types of the k-complementing permutations in $\mathrm{Sym}(n)$ which have order equal to a power of 2. This yields an algorithm for generating all self-complementary k-uniform hypergraphs of order n, up to isomorphism, for feasible n.

Ghost Symmetries of Planar Configurations

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Let C be a finite subset of $\mathbb{R}^2$ and let S be the symmetry group of C. A projection p of C onto a linear subspace of $\mathbb{R}^2$ is called isonumerous if the cardinality of $p(C)$ is the same as that of C. Under certain isonumerous projections, the image of C may have symmetries not found in S. Such symmetries are called Ghost Symmetries. In this talk we shall provide a brief introduction and some preliminary results on Ghost symmetries of finite subsets of $\mathbb{R}^2$, as well as the groups which these symmetries generate.

Splittability of Integer Coverings

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Joint work with Joshua Cooper

The goal of the present work is to study the splittability of coverings of the integers with translates of a given set, a natural one-dimensional analogue of a question from discrete geometry. We say that a k-fold covering is “splittable” whenever it can be decomposed into two 1-fold coverings. For a given base set S of integers, define the “splitting number” to be the least k so that every k-fold covering with translates of S is splittable. We consider the splitting number of sets of small cardinality and other sets of various types. Methods from hypergraph theory, number theory, and design theory are employed.

Monday May 25 ◇ *lundi* 25 *mai*
14:00 – 14:50 S1-151

PT-02

Plenary Talk ◇ *Conférence plénière*

Genes as LEGO: What Trees and Graphs Can Tell Us About the Evolution of Modular Proteins

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Protein evolution through duplication and rearrangement of functional subunits, called domains, is Nature's equivalent of LEGO. The combinatorial possibilities of domain arrangements enables rapid evolution of new gene functions. For example, rapid proliferation of modular, multidomain proteins played a key role in the emergence of multicellular animals and the vertebrate immune system. I will discuss the use of tree and graph algorithms for investigating the evolutionary history of modular proteins.

Monday May 25 ⋄ *lundi* 25 *mai*
15:20 – 17:50 Z-315

IM-02

Bioinformatics ⋄ *Bioinformatique*

Parking Functions, Labeled Trees and DCJ Sorting Scenarios

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In genome rearrangement theory, one of the elusive questions raised in recent years is the enumeration of rearrangement scenarios between two genomes. This problem is related to the uniform generation of rearrangement scenarios, and the derivation of tests of statistical significance of the properties of these scenarios. We will give an exact formula for the number of double-cut-and-join (DCJ) rearrangement scenarios of co-tailed genomes. We will also construct effective bijections between the set of scenarios that sort a cycle and well studied combinatorial objects such as parking functions and labeled trees.

A Connection between Gene Clusters and Record Times for Random Variables

David Sankoff
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Definitions of conserved clusters in two genomes differ in how much emphasis they place on common gene content versus unrelated gene and how similar are the orders of the common genes. Operationalizing these desiderata requires imposing values on some threshhold parameters. We investigate the notion of generalized gene adjacency, a clustering criterion that adjusts the trade-off between content and order. We suggest a way of determining "natural" values for the clustering parameter in terms of maximizing sensitivity of a weighting scheme on pairs of genes at different distances in two random genomes. This leads surprisingly to questions in the theory of record times of random variables.

Maximum Likelihood Indel Reconstruction

Mathieu Blanchette
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The problem of ancestral genome reconstruction can be formulated as follows: Given a set of orthologous DNA sequences labeling the leaves of a phylogenetic tree, infer the most likely ancestral sequence at each internal node of the tree. Following multiple sequence alignment, a critical step is the inference of the most likely scenario of insertions and deletions that may have led to the observed alignment. We first show that the parsimony version of this problem is NP-hard, but present a practical solution based on integer linear programming. We then propose a tree-HMM based approach for the inference of the maximum likelihood indel scenario. The approach is exact and very fast even on large alignments. In addition, it provides confidence estimates for each aspect of the reconstructed ancestral sequences.

A Heuristic Algorithm to Infer the Evolutionary History of Tandemly Arrayed Gene Clusters

Mathieu Lajoie
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Tandemly arrayed genes (TAG) represent an important fraction of most genomes and are involved in various biological processes such as signal transduction (e.g., olfactory receptors), regulation of gene expression (e.g., zinc finger genes) and molecular transport (e.g., goblins). A fundamental mechanism in the evolution of TAG clusters is unequal crossing-over during meiosis, which can duplicate (or delete) one or more adjacent genes simultaneously. Such duplications are called tandem duplications. Different algorithms have been proposed to infer the tandem duplication history of a TAG cluster. However, their applicability is limited in practice since they do not take into account other evolutionary events such as inversions (whose existence is reflected by the presence of genes in both transcriptional orientations within a TAG cluster) and deletions. In this talk, I will present a heuristic algorithm to infer the evolutionary history of TAG clusters, which takes into account tandem and inverted duplications, inversions and deletions.

New Perspectives on Gene Family Evolution

Nadia El-Mabrouk
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We explore the problem of inferring a parsimonious evolutionary scenario for gene families involving speciations, duplications and/or losses. We propose a new simple algorithm for reconciling a gene tree and a species tree, and we describe the problem of inferring a species tree that minimizes the number of duplications and a supertree problem.

Ancestral Genome Architecture Reconstruction

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We describe a general methodological framework for the reconstruction of ancestral genome architectures based on the detection of conserved groups of genomic markers and a classical graph-theoretical problem, the Consecutive Ones Problem and the associated PQ-tree.

Monday May 25 ⋄ *lundi* 25 *mai*
15:20 – 17:25 Z-317

IM-03

Graph Theory I
Théorie des graphes I

Is There a Structural Graph Theory Based on the Spectral Radius?

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Every tree of maximum degree D is a subgraph of the infinite D-regular tree. This observation immediately implies that the spectral radius of every such tree is at most $2\sqrt{D-1}$. One can also show (T. Hayes, V. Nikiforov, Z. Dvořak and the speaker) that planar graphs and graphs of bounded genus also satisfy a similar relation: the spectral radius is $O(\Delta(G)^{1/2})$. Whenever a result can be proved for tree-like graphs and for graphs of bounded genus, it is natural to ask if it can be extended to a more general setting of minor-closed families (or beyond) and what new tools does it bring. In the talk we will try to answer this question.

K_5-Subdivisions in 5-Connected Nonplanar Graphs

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A well-known theorem of Kuratowski states that a graph is planar iff it contains no subdivision of K_5 or $K_{3,3}$. It is also known that any 3-connected nonplanar graph other than K_5 contains a subdivision of $K_{3,3}$. Seymour and Kelmans independently conjectured that every 5-connected nonplanar graph contains a subdivision of K_5. We establish this conjecture for graphs containing K_4^-.

Unbalanced Minors in $(s+t)$-Chromatic Graphs

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In search of approaches to Hadwiger's conjecture, Woodall and independently Seymour suggested to attack the weaker conjecture that for all positive integers s and t, every $(s+t)$-chromatic graph has a $K_{s,t}$ minor. Woodall proved that for $s = 2$ and each t, the conjecture holds in slightly stronger form: with $K^*_{2,t}$ in place of $K_{2,t}$, where $K^*_{s,t}$ denotes the graph obtained from $K_{s,t}$ by adding all edges connecting the vertices in the partite set of size s. The main result of this talk is that for every s, the Woodall – Seymour conjecture holds for sufficiently large t with $K^*_{s,t}$ in place of $K_{s,t}$. The result is sharp in the sense that for every $s, t \geq 3$, there are infinitely many $(s+t)$-critical graphs that do not have $K_{s,t+1}$-minors.

K_t Minors in Large t-Connected Graphs

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A graph G has a K_t minor if a graph isomorphic to K_t, the complete graph on t vertices, can be obtained from a subgraph of G by contracting edges. In recent joined work with Robin Thomas we have proved a conjecture of his showing that for every integer t there exists an integer $N = N(t)$ such that every t-connected graph on at least N vertices with no K_t minor has a set of at most $t-5$ vertices whose deletion makes the graph planar. In this talk, I will describe the motivation behind this result and mention potential applications of our methods to other problems.

Perfect Matchings in Cubic Graphs

Daniel Kráľ
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Joint work with Louis Esperet (Charles University in Prague) and František Kardoš (University of Pavol Jozef Šafárik in Košice)

By a classical theorem of Petersen, every cubic bridgeless graph has a perfect matching. In fact, every edge of a cubic bridgeless graph is contained in a perfect matching, and thus every n-vertex cubic bridgeless graph has at least three perfect matchings. Lovász and Plummer conjectured that the number of perfect matchings in cubic bridgeless graphs should grow exponentially with n. The conjecture has been verified for several special classes of graphs, most importantly bipartite and planar graphs. Though, until a year ago, the only known lower bound on the number of perfect matchings of a general cubic bridgeless graph was an estimate of $n/4 + 2$ given by the dimension of the perfect matching polytope. In this talk, we will present the first superlinear bound for the problem.

Conditional Matching Preclusion Sets

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The matching preclusion of a graph is the minimum number of edges whose deletion results in a graph that has neither a perfect matching nor an almost-perfect matching. For many interconnected networks, the optimal sets are precisely those induced by a single vertex. In this paper, we look for obstruction sets beyond these sets. We introduce the condition matching preclusion number of a graph. It is the minimum number of edges whose deletion results in a graph with no isolated vertices that has neither perfect matchings nor almost perfect matchings. We find this number and classify all optimal sets for several classes of graphs.

Monday May 25 ◇ *lundi* 25 *mai*
15:20 – 17:25 Z-337

CM-03

Asymptotic Enumeration I
Énumération asymptotique I

Locally Restricted Compositions, Infinite Matrices, and Normality

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Joint work with Rod Canfield

In locally restricted compositions, some condition must be satisfied in a bounded-width sliding window. Carlitz compositions, for which adjacent parts must differ, have a 2-wide window. While some locally restricted compostions, are easily studied, we need infinite matrices (and hence some functional analysis) for the general case. We show that the generating function by sum of parts has a simple pole and that a wide variety of counts have an asymptotic normal distribution with means vector and covariance matrix asymptotically proportional to the sum of parts. Our results are existential and our method does not lead to a reasonable estimation method.

Problems and Results in Asymptotic Combinatorics

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We report recent work on three problems, all involving integer partitions. The q-multinomial is the generating function for inversions of a multiset; with S. Janson and D. Zeilberger we have looked at central/local limit theorems and log-concavity for the coefficients. The generating function for partitions according to Durfee square size has been somewhat overlooked in the combinatorial literature; with S. Corteel and C. Savage we have discovered some interesting properties of these polynomials. The third problem is ongoing work with H. Wilf: we ask for a class of partitions defined by restricting part sizes and multiplicities whose associated counting function $p(n)$ has prescribed properties.

Asymptotic Analysis and Optimal Selection

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Based in our previous works with Daniel Panario and Alfredo Viola, with Jean Daligault, and more recently with Rosa Jimenez

The problem of selection is to find the kth smallest element out of n, given the *rank* k and the n elements. One of first efficient solutions to this problem is the quickselect algorithm by Hoare, whose expected cost is $\Theta(n)$, for any rank k. However, its worst-case can be as bad as $\Theta(n^2)$ and the average number of comparisons that it makes is far from optimal. More specifically, the average number of comparisons made by quickselect is $E[C_{n,k}] =$

$\big(2 - 2\alpha\log(\alpha) - 2(1-\alpha)\log(1-\alpha)\big)n + o(n)$, where $\alpha = k/n$, whereas the average optimal number of comparisons is $E[C^*_{n,k}] = n + \min(k, n-k) + \text{l.o.t.}$. Here I describe a variant of quickselect where we sample pivots at each recursive stage in such a way that the average number of comparisons is theoretically optimal. In fact, if we consider the limit of $C_{n,k}/n$ when $n \to \infty$ and $k/n \to \alpha$, the process tends to $C(\alpha) = 1 + \min(\alpha, 1-\alpha)$. To prove this result we use a delicate asymptotic analysis of the solution to the integral equations that characterize the moments of $C(\alpha)$.

Some Asyptotic Issues Related with the Exact Distribution of Individual Displacements in Linear Probing Hashing

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In this talk we present the study of the distribution of individual displacements for the the Robin Hood linear probing hashing algorithms with buckets of size b. This work generalizes previous results for the case $b = 1$, that includes the first analysis done by Donald E. Knuth in 1962. One of the main tools in this analys is the introduction of a new family of sequences called Tuba Numbers. One sequence of this family is sequence A124453 in the *Sloane Encyclopedy of Integer Sequences*. Some problems related with the asymptotic behaviour of these numbers will be presented.

Asymptotics of Smallest Components Sizes in Decomposable Combinatorial Structures of Alg-Log Type

Daniel Panario
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Joint work with Li Dong, Zhicheng (Jason) Gao, and Bruce Richmond

We review the relation between objects and components in *decomposable combinatorial structures*. These structures consist of simpler entities called *components* which by themselves can not be further decomposed.

The *restricted pattern* of an object of size n is a mapping $S\colon J \mapsto \mathbb{N}$, where J is a set of components' sizes, $\mathbb{N}$ is the set of nonnegative integers, and $S(j)$ is the number of components of size j. We want to count objects such that the components with sizes excluded from J may appear any number of times but there are exactly $S(j)$ components of size j, $j \in J$.

In this talk we survey several properties of smallest components, with and without restricted patterns, for these type of combinatorial objects. We assume that the component generating function $C(z)$ is of *alg-log type*, that is, $C(z)$ behaves like

$$(1 - z/\rho)^{-\alpha} \ln\left(\frac{1}{1 - z/\rho}\right)^{-\beta}$$

near its dominant singularity ρ. These concepts will be defined and examples will be given.

Monday May 25 ⋄ *lundi* 25 *mai*
15:20 – 17:25 **Z-345**

CTS-04

Applications

A Discrete Optimization Formulation and Analysis for the General Minimum Cost Vaccine Formulary Selection Problem

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Joint work with Shane N. Hall (Air Force Institute of Technology) and Edward C. Sewell (Southern Illinois University – Edwardsville)

As the complexity of the US Recommended Childhood Immunization Schedule increases, a combinatorial explosion of choices is being presented to public-health policymakers. This problem is modeled as a discrete optimization problem, termed the General Minimum Cost Vaccine Formulary Selection Problem. An efficient exact algorithm based on dynamic programming, which exploits a shortest path network flow problem structure, is presented. Computational results are reported. The results reported provide fundamental insights into the structure of the problem.

The Peirce – Smith Converter Problem

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Peirce – Smith Conversion (PSC) is used in over 80% of global copper production, and over 60% of nickel. It is continuously fed by smelting furnaces, leading a sequence of batch operations. PSC limits the rhythm of the subsequent batch operations, and is hence a major bottleneck. Its operation is modeled as finite sequences over a discrete set, or as traversals of a directed graph. The optimization of a PSC vessel is equivalent to a Shortest-path problem.

Computing Geodesic Distances in Tree Space

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The geodesic distance between two phylogenetic (evolutionary) trees is the length of the shortest path between them in tree space, as introduced by Billera, Holmes, and Vogtmann (2001). We present an algorithm for computing this distance, based on a combinatorial framework in which the candidate shortest paths between trees are represented by a partially ordered set. We also give a linear algorithm for a higher dimension, special case of the Euclidean shortest path problem with obstacles.

Scheduling with Identical Parallel Machines and Servers

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Joint work with Wafaa Labbi

In this talk, we address the problem of minimizing the makespan of n independent jobs on m parallel machines, no preemption is allowed in presence of k specialized servers. In this context, the presence of specialized servers is necessary to prepare the machines and jobs, so, each job J_i ($i = 1, \ldots, n$) require a processing time p_i and a preparation time S_i. We present an approximation algorithm based on linear programming formulations and we prove the NP-hardness of the general problem. Polynomial subproblem, also, heuristic algorithms are presented with numerical experimentations.

Multipopulation Genetic Algorithm

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Evolutionary computation based on ideas of spatial-temporal resource allocation is developed under the framework of a multi-agent system consisting of sub-populations of agents. Each subpopulation contains a set of agents undergoing evolution with mutation and crossover using the recently developed mutation matrix formalism. A migration operator is used to control the exchange of chromosomes between different sub-populations. We illustrate these general ideas using the example of finding the local optima of a complex function.

Monday May 25 ⋄ *lundi* 25 *mai*
15:20 – 17:25 Z-350

CTS-05

Combinatorial Algorithms and Words
Algorithmes combinatoires et mots

Solution of Peter Winkler's Pizza Problem

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Joint work with Josef Cibulka, Jan Kyncl, Rudolf Stolar, and Pavel Valtr

Bob cuts a pizza into slices of not necessarily equal size and shares it with Alice by alternately taking turns. One slice is taken in each turn. The first turn is Alice's. She may choose any of the slices. In all other turns only those slices can be chosen that have a neighbor slice already eaten. We prove a conjecture of Peter Winkler by showing that Alice has a strategy for obtaining $\frac{4}{9}$ of the pizza. This is best possible, that is, there is a cutting and a strategy for Bob to get $\frac{5}{9}$ of the pizza. We also give a characterization of Alice's best possible gain depending on the number of slices. For a given cutting of the pizza, we describe a linear time algorithm that computes Alice's strategy gaining at least $\frac{4}{9}$ of the pizza and another algorithm that computes the optimal strategy for both players in any possible position of the game in quadratic time. We distinguish two types of turns, shifts and jumps. We prove that Alice can gain $\frac{4}{9}$, $7/16$ and $\frac{1}{3}$ of the pizza if she is allowed to make at most two jumps, at most one jump and no jump, respectively, and the three constants are the best possible.

Necklace Gray Codes in Cool-lex

Joe Sawada
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Joint work with Aaron Williams

Currently there exist two Gray code algorithms for listing binary necklaces with fixed density (Wang/Savage, Ueda). However the algorithms (1) are rather complex, (2) do not use the lexicographically smallest representative and (3) do not lead to a Gray code for binary necklaces. We will present a new simple "cool-lex" algorithm to generate binary necklaces (or Lyndon words) with fixed density that can be extended into a Gray code for all binary necklaces (Lyndon words).

De Bruijn Cycles for Fixed-Density Binary Strings

Aaron Williams
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De Bruijn cycles are circular binary strings of length 2^n that contain every binary string of length n exactly once as a substring. This talk describes the first construction for fixed-density de Bruijn cycles, which are circular strings of length $\binom{n}{k}$ where each binary string of length n containing k ones is contained exactly once as a shorthand substring.

[This talk may be of interest to the Combinatorics on Words mini-symposium]

Intermediate Trees

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Joint work with Joanna Fawcett

The intermediate spanning tree problem is: Given two distinct spanning trees, T and T', of a graph G, is there another spanning tree, T'' of G such that the degree of each vertex of T'' is between its degree in T and its degree in T'. A theorem of Ken Berman implies that if T and T' are edge-disjoint and do not have the same degree at each vertex, then an intermediate tree exists. Cameron and Edmonds gave an algorithm to find an intermediate tree in this case although the complexity of their algorithm is not known. We have characterized the graphs in which no pair of spanning trees have an intermediate tree. We have found some classes of graphs in which every pair of spanning trees has an intermediate tree. We can show that in most cases, an intermediate tree can be found by adding at most one edge to G.

Transitive Closure of Fuzzy Cognitive Maps

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Fuzzy cognitive maps (FCMs) are “graphical” ways to represent a body of knowledge surrounding a particular issue. A (sensibly defined) transitive closure of an FCM contains new information that can be used to inform management and intervention planning. Mathematically speaking, an FCM is a directed graph together with sign and weight functions on the arcs such that no two parallel arcs have the same sign. In this talk we present recent results on how to meaningfully define and efficiently compute the transitive closure of a fuzzy cognitive map.

Tuesday May 26 ⋄ *mardi* 26 *mai*
9:00 – 9:50 S1-151

PT-03

Plenary Talk ⋄ *Conférence plénière*

78 Years of Ramsey $R(3,k)$ (and Counting!)

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The Ramsey Number $R(3,k)$ is that least number n (dependent on k) so that *any* triangle-free graph on n vertices *must* contain an independent set of k vertices. An examination of (appropriately defined) random graphs and random processes plays a key role in finding the asymptotics of $R(3,k)$. Our story takes us from three youngsters, George Szekeres, Esther Klein and Paul Erdős, in the winter of 1931/2 through Greenwood, Gleason, Graver, Yackel, Ajtai, Komlós, Szemerédi, Kim, Lovász, Wormald, Winkler, Suen (to name a few!) to very recent work of Bohman.

Tuesday May 26 ⋄ *mardi* 26 *mai*
10:20 – 12:25 S1-151

IM-04

Random Graphs and the Probabilistic Method
Les graphes aléatoires et la méthode probabiliste

A constructive proof of the Lovász Local Lemma

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The Lovász Local Lemma [Erdős, Lovász, 1975] is a powerful tool to nonconstructively prove the existence of combinatorial objects meeting a prescribed collection of criteria. In his breakthrough paper [Beck, 1991], Beck demonstrated that a constructive variant can be given under certain more restrictive conditions. Simplifications of his procedure and relaxations of its restrictions were subsequently exhibited in several publications [Alon; Molloy and Reed; Czumaj, Scheideler; Srinivasan; M]. In this talk, a new algorithm is presented that can find the object guaranteed to exist by the Local Lemma in polynomial time. In contrast to all previous approaches, the new algorithm applies to almost all known applications of the lemma and since the original nonconstructive proofs are not invoked anymore, it can be regarded as a constructive proof variant.

Coloring Simple Hypergraphs

Alan Frieze
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Joint work with Dhruv Mubayi

Fix an integer $k > 2$. A k-uniform hypergraph is simple if every two edges share at most one vertex. We prove that there is a constant c depending only on k such that every simple k-uniform hypergraph H with maximum degree D has chromatic number satisfying $\chi(H) < c(D/\log D)^{1/(k-1)}$. This implies a classical result of Ajtai – Komlós – Pintz – Spencer – Szemerédi and its strengthening due to Duke – Lefmann – Rodl. The result is sharp apart from the constant c.

The Early Evolution of the H-Free Process

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Joint work with Peter Keevash

The H-free process, for some fixed graph H, is the random graph process defined by starting with an empty graph on n vertices and then adding edges one at a time, chosen uniformly at random subject to the constraint that no H subgraph is formed. For H strictly 2-balanced, we apply the differential equations method for random graph processes to analyze the early evolution of this process (in the limit as n tends to infinity). When H is the complete graph K_s the graph produced gives a new lower bounds on the Ramsey number $R(s,t)$ for t large.

A Generalized Critical Condition for the Emergence of the Giant Component in Random Graphs with Given Degrees

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Joint work with Bruce Reed

Random graphs undergo a sudden transition in their structure, when their density crosses a critical point. In this talk, we revisit the classical result by Molloy and Reed regarding the critical condition for the emergence of a giant component in random graphs with given degrees. We obtain a generalization of the above condition for degree sequences with heavy tails.

Random Graphs with Few Disjoint Cycles

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Joint work with Valentas Kurauskas

Fix a positive integer k, and consider the collection of graphs with no $k+1$ vertex-disjoint cycles (or equivalently, with no minor consisting of $k+1$ disjoint triangles). We introduce an extension of a classical result of Erdős and Pósa, and deduce that almost all such labelled graphs on vertex set $1,\ldots,n$ have a set of k nodes the deletion of which leaves a forest. This yields an asymptotic counting formula for such graphs; and allows us to deduce further properties of a graph R_n taken uniformly at random from the class: we see for example that the probability that R_n is connected tends to a specified limit as $n \to \infty$.

We consider also variants of the problem involving different excluded minors, for example where there are no $k+1$ vertex disjoint minors C_4.

Tuesday May 26 ⋄ *mardi 26 mai*
10:20 – 12:25 Z-220

CM-04

Graph Pebbling
Jeux de galets sur les graphes

An Application of Graph Pebbling to Zero–Sum Sequences in Abelian Groups

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Joint work with Shawn Elledge

A sequence of elements of a finite group G is called a zero-sum sequence if it sums to the identity of G. The study of zero-sum sequences has a long history with many important applications in number theory and group theory. In 1989 Kleitman and Lemke, and independently Chung, proved a strengthening of a number theoretic conjecture of Erdős and Lemke. Kleitman and Lemke then made more general conjectures for finite groups, strengthening the requirements of zero-sum sequences. In this paper we prove their conjecture (first obtained by Geroldinger) in the case of abelian groups. Namely, we use graph pebbling to prove that for every sequence $(g_k)_{k=1}^{|G|}$ of $|G|$ elements of a finite abelian group G there is a nonempty subsequence $(g_k)_{k\in K}$ such that $\sum_{k\in K} g_k = 0_G$ and $\sum_{k\in K} 1/|g_k| \leq 1$, where $|g|$ is the order of the element $g \in G$.

Graham's Conjecture in some Pebbling Variants

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We consider a number of variations of pebbling and investigate Graham's conjecture in all of them. We examine relationships between various forms of Graham's conjecture, and we give a variation in which Graham's conjecture does not hold.

Computational Complexity Aspects of Graph Pebbling

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Joint work with Bryan Clark

Given a distribution of pebbles to the vertices of a graph G, a *pebbling move* removes two pebbles from a vertex and adds one pebble to a neighbor, and a vertex r is *reachable* if it is possible to place a pebble on r via a sequence of zero or more pebbling moves. The *pebbling number* of a graph is the minimum k such that each vertex is reachable under every distribution of k pebbles.

Several variants of the pebbling number have been studied. The *optimal pebbling number* of a graph is the minimum k such that each vertex is reachable under some distribution of k pebbles. The *cover pebbling number* of a graph is the minimum k such that for every distribution of k pebbles, some sequence of pebbling moves results in a pebble on each vertex.

Problems in graph pebbling exhibit a wide range of computational difficulty. For example, the Cover Pebbling Theorem of Sjostrand, and independently, Vuong and Wyckoff, implies that the cover pebbling number is computable in polynomial time. By contrast, computing the optimal pebbling number is NP-hard. Consequently, unless P=NP, computing the optimal pebbling number in polynomial time is impossible. Even worse, computing the pebbling number is Π_2-hard. As a result, unless the polynomial hierarchy collapses (a possibility regarded by complexity theorists as highly unlikely), computing the pebbling number is impossible in polynomial time, even when granted the ability to solve NP-hard problems quickly.

The talk is accessible to those without a background in computational complexity.

The Pebbling Threshold of Graph Sequences

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Pebbling is a process defined on a connected graph G. Pebbles are configured on vertices of G and are moved along the edges. A pebbling move consists of taking two pebbles from a vertex, placing one on an adjacent vertex, and discarding the other. The objective of pebbling is to put at least one pebble on a designated vertex, called the root. A configuration of pebbles is called solvable if it is possible to place a pebble on any vertex through a sequence of pebbling moves. A pebbling threshold for a family of graphs is any function $g(n)$ (where n is the order of graph G) 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 not solvable. In this talk we will discuss general questions related to pebbling threshold for an arbitrary graph family and present the results for particular families of graphs. We will also introduce a probabilistic version of Graham's pebbling conjecture for the threshold of the Cartesian product of graphs and establish it for the product of complete graphs.

Pebbling Probabilities at the Threshold

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In most cases, it is difficult if not impossible to write down a single analytic condition under which a configuration of t pebbles on the n vertices of a graph G is solvable or cover solvable. This talk will focus on the simplest possible case, namely when $G = K_n$ and when conditions for both solvability and cover solvability are easy to state. We know that the threshold function in this case is either $\sqrt{n}$ (pebbling) or $An + \sqrt{n}$ (cover pebbling, where A depends on whether the pebbles are distinct or not). We use techniques such as the Stein Chen method of Poisson approximation and the theory of analytic dePoissonization to establish what happens when the number of pebbles is *at* the threshold value, e.g. $t = \gamma \cdot n + B\sqrt{n}$ in the case of cover pebbling of K_n with identical pebbles (γ is the golden ratio).

Tuesday May 26 ⋄ *mardi 26 mai*
10:20 – 12:25 Z-310

CM-05

Linear Algebra in Combinatorics
Algèbre linéaire en combinatoire

Girth and Lifts

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Joint work with Nati Linial

The so-called "Moore Bound" is one of the great puzzles of graph theory. It is an upper bound on the girth of a d-regular graph on n vertices; it is almost immediate, and appeared in publication roughly 50 years ago. However, this bound has only been improved by an additive factor of -1 or -2 for any $d > 2$ and n.

We focus on the problem of fixing d and letting n tend to infinity. The Moore Bound gives an upper bound of roughly $2\log(n)/\log(d-1)$, whereas the highest girth known is roughly $\frac{4}{3}\log(n)/\log(d-1)$ (for the LPS expanders, for certain values of d and n; random graphs do worse). We describe a spectral approach to improving the Moore Bound with abelian lifts. Our main result is to describe a edge colouring problem, such that a significant improvement over a greedy colouring result would lead to an asymptotic improvement in the Moore Bound. (Unfortunately, we have no results on the colouring problem at present. . .)

Optimal Configuration of Points in Quaternionic Projective Spaces

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A set of points in a quaternionic projective space is an "optimal configuration" if it minimizes a certain potential function depending on the pairwise distances between points. Equiangular lines and mutually unbiased bases (MUBs) are important examples of such optimal configurations. We formulate a common generalization of several results in real and complex spaces that also hold in the quaternionic space. We also provide intriguing examples of such optimal configurations.

Partial Circulant Hadamard Matrices

Robert Craigen
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When I started working on partial circulant Hadamard matrices things I considered it a lark, and I only did it because I had a lull in things I was interested in, and these guys interested in statistical cryptography of stream-cipher codes were unable to get good results on the question and pleaded with me to help them. After a summer working on it with a student I realised that a slight generalization of their problem was quite fundamental, and may even be the missing step in solving a number of important questions about Hadamard matrices. Since then we have made considerable progress in several directions by studying these objects.

Rational Decomposition of Graphs

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Given a graph G, an H-decomposition of G is a partition of its edge set into subgraphs isomorphic to H. A rational H-decomposition of G is a nonnegative rational weighting of the copies of H in G such that the total weight on any edge of G equals 1. The study of graph decompositions plays an important role in graph theory and combinatorics and has numerous applications. We will present a proof of the fact that any sufficiently large circulant (under several mild conditions) admits a rational decomposition into copies of any nontrivial graph on at most k vertices. This will showcase a linear algebraic connection between decomposition of these graphs and families with dominant differences.

Rational Decomposition of Almost Complete Graphs

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Let H be a subgraph of G. A rational H-decomposition of G is a nonnegative rational weighting of the copies of H in G such that every edge of G has total inherited weight equal to 1.

Motivated by applications in design theory and statistics, we discuss the existence problem for rational H-decompositions of graphs G which have high minimum degree. Estimates on eigenvalues in the Johnson scheme play a central role.

Tuesday May 26 ⋄ *mardi* 26 *mai*
10:20 – 12:25 Z-330

CTS-06

Words II ⋄ *Mots* II

Van der Waerden's Theorem and Avoidability in Words

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Joint work with J. Shallit

Pirillo and Varricchio, and independently, Halbeisen and Hungerbuhler considered the following problem: does there exist an infinite word w over a finite subset of $\mathbb{Z}$ such that w contains no two consecutive blocks of the same length and sum? We consider two possible attacks on this problem and prove they cannot work, using van der Waerden's theorem on arithmetic progressions.

Avoiding Overlaps with the GreedyAlgorithm

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Joint work with J. Shallit

Given a pattern and an (ordered) alphabet, if there are arbitrarily long words which avoid the pattern, then there is a lexicographically least infinite word which avoids the pattern, and a natural problem is to describe its structure.

In the case of overlaps over the natural numbers, this word can be generated letter by letter using the greedy algorithm, and it ends up having a very regular but intricate structure, which I describe.

Critical Exponent of Words over 3 Letters

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A finite word u over a finite alphabet has exponent r if it can be written $u = p^k e$, where e is a prefix of p, and $|u| = r|p|$. The critical exponent of an infinite word w is the supremum of the exponents of its subwords. Currie and Rampersad showed that for any real number $\alpha \geq 2$, there exists an infinite binary word with critical exponent α. We will prove the following result: for any real number $\alpha \geq \frac{7}{4}$, there exists an infinite word over the 3-letter alphabet, with critical exponent α.

Repetitions in Words Associated with Parry Numbers

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For certain classes of Parry numbers β, we compute the exact value or at least bounds for the *index* of the infinite word u_β, i.e., the supremum of the set of exponents of rational powers in u_β, where u_β is the right-sided infinite word coding distinct distances between neighboring nonnegative β-integers. We also determine the maximal powers in u_β realizing this supremum.

Algebraic Structure in a Family of Nim-Like Arrays

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Joint work with Dena Morton (*Xavier University*)

We study the structure shared by a certain family of recursively generated arrays, related to the operation of Nim-addition, from the perspective of quasigroup theory. Our considerations are the issues of monogenicity (being generated by a single element in a nonassociative fashion) and homomorphisms.

Tuesday May 26 ⋄ *mardi* 26 *mai*
10:20 – 12:25 AA-6214

CTS-07

Coloring and Chromatic Number I
Coloration et nombre chromatique I

The Distinguishing Chromatic Number

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Collins and Trenk introduced the distinguishing chromatic number of a graph G, $\chi_D(G)$, as the minimum number of colors needed to color the vertices so that

(1) the coloring is a proper graph coloring and
(2) the only automorphism of the graph which preserves colors is the identity.

Thus the distinguishing chromatic number is closely related to both the chromatic number, $\chi(G)$, and the distinguishing number, $D(G)$ (introduced by Albertson and Collins), of a graph. It is straightforward to see that

$$\chi(G), D(G) \leq \chi_D(G) \leq \chi(G) * D(G)$$

and that the lower bounds are tight. In this talk, we will present infinite families of graphs that achieve the upper bound, and, in contrast, families of graphs with an upper bound on χ_D that depends instead on the automorphism group of the graphs.

Circular Chromatic Index of Cubic Graphs with Girth Six

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Joint work with Daniel Král', Jan Mazak, and Jean-Sébastien Sereni

We show that the circular chromatic index of a cubic graph having a 2-factor which contains no 5-cycle is at most $\frac{7}{2}$. As a consequence, the circular chromatic index of a (sub)cubic graph with girth at least six is at most $\frac{7}{2}$.

The Bichromatic Number of a Graph

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A (k, l)-colouring of a graph G is a covering of its vertex set by k independent sets and l cliques, generalizing both the colouring and clique covering of a graph. The bichromatic number of G is defined as the minimum integer r, such that G is (k, l)-colourable for all $k + l = r$. We will investigate some fundamental properties of the bichromatic number and its connection to well-known graph parameters, like the chromatic number and the maximum degree.

Distinguishing Chromatic Numbers for Bipartite Graphs

Karen Seyffarth
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A colouring of the vertices of a graph G is distinguishing provided no automorphism of G, other than the identity, preserves the colours of the vertices. The distinguishing chromatic number of G, $\chi_D(G)$, is the minimum number of colours required to colour $V(G)$ so that the resulting colouring is both proper and distinguishing. We prove that, except for $K_{\Delta,\Delta}$ and $K_{\Delta-1,\Delta}$, any bipartite graph G with $\Delta \geq 3$ has $\chi_D(G) \leq 2\Delta - 2$.

Asymptotics of the Chromatic Number for Claw-Free Graphs

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Joint work with Bruce Reed (McGill University)

In 1996, Kahn proved that for any line graph G, $\chi(G) = (1 + o(1))\chi_f(G)$, i.e., that the fractional and integer chromatic numbers agree asymptotically. We prove that this bound holds for any connected claw-free graph G with $\alpha(G) \geq 4$. For general claw-free graphs we conjecture that $\chi \leq \lceil \frac{6}{5}\chi_f \rceil$; this bound would be best possible. We note that $\chi_f(G)$ can be computed in polynomial time for claw-free G.

Tuesday May 26 ⋄ *mardi* 26 *mai*
10:20 – 12:25 AA-5340

CTS-08

Miscellaneous Graph Theory
Sujets variés en théorie des graphes

Optimal Broadcasting in Complete Weighted-Vertex Graphs

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The weighted-vertex broadcast communication model is defined on networks in which nodes are assigned some weights representing the internal process they should perform before sending data to their neighbouring nodes. This model has real world applications in parallel computation and satellite terrestrial networks. We consider the problem of broadcasting in complete weighted-vertex graphs; and present an algorithm to find an optimal broadcast scheme and hence the minimum broadcast time of complete graphs with arbitrary weights on the vertices.

Cycle Decompositions of $3K_m$

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The problem of determining necessary and sufficient conditions for the existence of a decomposition of the complete multigraph λK_m into cycles of length k remains open in general. Notably, necessary and sufficient conditions are known if $\lambda = 1$ or 2 (Alspach, Gavlas, Šajna, Verrall), but have not been determined for greater values of λ. In this talk, we discuss progress towards the case $\lambda = 3$.

Snarks with Given Circular Flow Number

Martin Škoviera
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Joint work with Robert Lukotka

We show that for each rational number r such that there exist infinitely many cyclically 4-edge-connected cubic graphs of girth at least 5 (that is, snarks) whose circular flow number equals r. This answers a question posed by Pan and Zhu [*Construction of graphs with given circular flow numbers*, J. Graph Theory **43** (2003), 304 – 318].

Radially Moore Digraphs

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Given the values of the maximum degree and the diameter of a digraph, there is a natural upper bound, known as the Moore bound, for its number of vertices. Digraphs attaining such a bound are called Moore digraphs. It is well known that Moore digraphs only exist for trivial cases. In this talk, we introduce a digraph operator which allow us to construct digraphs "close" to the Moore ones, called radially Moore digraphs.

Forbidden Substructure Characterization for Interval Digraphs/Bigraphs

Ashok Kumar Das
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Joint work with Sandip Das (Indian Statistical Institute Kolkata), Malay Sen (North Bengal University), and Douglas West (University of Illinois at Urbana-Champaign)

An interval digraph is a directed graph representable by assigning each vertex v a pair of intervals (Sv, Tv) on a real line so that uv is an edge if and only if Su intersects Tv. An interval bigraph is a bipartite graph representable by assigning each vertex an interval so that vertices in opposite partite sets are adjacent if and only if their intervals intersects. These two models are essentially equivalent. In these paper we discuss (di/bi)graphs in terms of adjacency matrices and give a forbidden substructure characterization of such matrices.

Tuesday May 26 ⋄ *mardi* 26 *mai*
14:00 – 14:50 S1-151

PT-04

Plenary Talk ⋄ *Conférence plénière*

Graph Decomposition

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János Barát and I made the following conjecture: For every tree T, there is a natural number k_T such that every k_T-edge-connected graph of size divisible by $|E(T)|$ has an edge-decomposition into subgraphs each isomorphic to T. The conjecture is trivial when T has at most two edges. When we made the conjecture we could not prove it for one single tree with three or more edges. However, we showed that the conjecture holds for the claw (the star with three edges) provided Tutte's 3-flow conjecture is true. I have now verified the conjecture for two trees.

Tuesday May 26 ⋄ *mardi* 26 *mai*
15:20 – 17:50 S1-151

IM-05

Graph Theory II
Théorie des graphes II

Packing and Covering in Hypergraphs

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For a fixed r-uniform hypergraph J, we denote by $\nu_J(H)$ the maximum size of a set of edge-disjoint copies of J in the r-uniform hypergraph H. The parameter $\tau_J(H)$ is defined to be the minimum size of an edge cover of the copies of J in H, that is, a set C of edges such that $H - C$ contains no copy of J. We consider the problem of finding upper bounds on $\tau_J(H)$ in terms of $\nu_J(H)$ for certain classes of J and H. In particular we study the case in which J is a complete hypergraph and H has certain geometric properties.

Adjusted Interval and Proper Interval Digraphs

Pavol Hell
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All results are joint with A. Rafiey, and some also with T. Feder and J. Huang

I will discuss certain digraph analogues of interval and proper interval graphs, motivated by computational problems for graph homomorphisms. Obstruction characterizations of these digraphs shed new light also on undirected interval and proper interval graphs.

On Hadwiger's Conjecture and Hajos' Conjecture — Structure and Algorithms

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We discuss the following graphs:

(1) Minimal counterexample G for Hadwiger's conjecture (for the case of K_t).
(2) Minimum counterexample G for Hajos' conjecture (for the K_5 case).

In (1), we prove that G has at most $f(t)$ vertices. In (2), we prove that G has bounded tree-width. We actually hope to prove that G has at most c vertices for some absolute constant c.

As a spinoff of the proofs, we can decide in polynomial time (actually in time $O(n^2)$):

(1) whether or not any given graph G satisfies Hadwiger's conjecture for the case K_t, and
(2) whether or not any given graph G satisfies Hajos' conjecture for the K_5 case.

Excluded Minors for Bicircular Matroids

Luis GODDYN
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Joint work with Matt DeVos

Two matroids are naturally defined on the edge set of a graph G. The familiar "cycle matroid" $M(G)$ has as its circuits, the edge sets of cycles in G. The less common "bicycle matroid" $B(G)$ has as its circuits, the edge sets of bicycles in G (a bicycle is a minimal connected subgraph containing at least two cycles in G).

Bicircular matroids are odd creatures; for example the cycle matroid of K_4 is not bicircular. Yet, they feel strangely familiar; the matroid minor operations of deletion and contraction in $B(G)$ correspond (more or less) to edge deletion and contraction in G. Bicircular matroids appear to form an important class of matroids. For example Johnson, Robertson, and Seymour conjecture (1999) that every matroid of large enough branch-width contains a minor isomorphic to either $U_{k,2k}$ or $M(G)$ or $B(G)$ where G is a k by k grid.

I describe recent work on determining the set X of excluded minors for bicircular matroids. That is, X consists of those non-bicircular matroids whose proper minors are all bicircular. For example, every excluded minor has bounded rank and X is almost certainly finite. We believe that we are close to precisely determining X; there are about 20 excluded minors, each having rank at most five. In contrast, there are just five excluded minors for the class of cycle matroids (Tutte 1959).

An Eberhard-Like Theorem for Pentagons and Heptagons

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Joint work with Agelos Georgakopoulos (Universität Hamburg), Bojan Mohar and Matt DeVos (Simon Fraser University)

For a cubic planar graph let p_k be the number of k-gons. By Euler's theorem $\sum(6-k)p_k = 12$. Not all sequences (p_k) satisfying this come from a cubic planar graph (are "realizable") and characterizing those that do is wide open. Eberhard proved that by increasing p_6 (number of hexagons) we may always find a realizable sequence. We extend this result in two ways: we allow adding 5-gons and 7-gons (instead of 6-gons). Also, we extend the result for general surfaces.

A Tribute to the Memory of Michael O. Albertson (1946 – 2009)

Joan P. HUTCHINSON
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Co-authors of Mike Albertson will highlight his most significant contributions to the field of graph theory and will present several of the many conjectures that he has left us for continuing work.

Tuesday May 26 ⋄ *mardi* 26 *mai*
15:20 – 17:25 Z-220

IM-06

Combinatorial Design Theory I
Combinatoire des plans d'expérience I

Strongly Regular Graphs with Nontrivial Automorphisms

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Joint work with Majid Behbahani

A strongly regular graph with parameters (v, k, λ, μ) is a graph on v vertices, regular of degree k, and such that any two distinct vertices have λ common neighbors when they are adjacent, and μ common neighbors when they are nonadjacent.

The CRC Handbook on Combinatorial Designs gives a table of strongly regular graphs on at most 280 vertices, and there are quite a few whose existence are unknown.

In design theory, there are methods to construct a design by assuming an automorphism. We will discuss how these methods can be adapted to the construction of strongly regular graphs. We will also present some preliminary results.

Butterfly Factorizations of K_n

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Butterfly factorizations are defined and three methods of construction are described.

Properties of the Steiner Triple Systems of Order 19

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Joint work with A.D. Forbes, M.J. Grannell, T.S. Griggs, P. Kaski, D.A. Pike, and O. Pottonen

Mathon, Phelps, and Rosa published an extensive study of properties of Steiner triple systems (STSs) up to order 15 in the early 1980s. Although it is not possible to list properties of each of the 11,084,874,829 STSs of order 19 in a similar manner, a recently released electronic catalogue of these STSs makes it possible to consider any property that can be determined efficiently. Properties considered in this work include almost parallel classes, chromatic number, chromatic index, existential closure, and subconfigurations.

Existence of Directed BIBDs with Block Size 7 and Related Codes

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Joint work with R.J.R. Abel (University of New South Wales)

A *directed* $(v, k, 2\lambda)$-BIBD or alternatively a DBIBD(v, k, λ), is a pair $(X, \mathcal{B})$ where X is a v-set of *points* and $\mathcal{B}$ is a collection of ordered k-tuples $(a_1, a_2, \ldots, a_k)$ of elements of X (called *blocks*) with the property that every ordered pair of distinct points occurs λ times amongst the pairs (a_i, a_j): $i < j$ and $(a_1, a_2, \ldots, a_k) \in \mathcal{B}$. J. Wang and J. Yin (IEEE Trans. Inform. Theory **52** (2006), 3676 – 3685) have established the existence of a DBIBD$(v, 7, 1)$ for all $v \equiv 1, 7 \pmod{42}$ except for $v = 22$ and possibly for 68 other cases. In this paper, we reduce the number of possible exceptions to 4, namely $v = 274$, 358, 400, 526. Correspondingly, for all such v, our results establish the existence of a $\mathrm{T}(2, 7, v)$-code or equivalently a perfect 5-deletion-correcting code with words of length 7 over an alphabet of size v, where all the coordinates must be different. In the process, we also reduce the possible exceptions for the existence of $(v, 7, 2)$-BIBDs to 2 cases, $v = 274$ and 358 (in addition to the nonexistent $(22, 7, 2)$-BIBD).

Embedding and Colouring Odd Cycle Systems

David A. Pike
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Joint work with Daniel Horsley

An m-cycle system of order v is a partition of the edges of the complete graph K_v into m-cycles, whereas a partial m-cycle system of order v is a packing of K_v with edge-disjoint m-cycles. A (possibly partial) m-cycle system S is said to be weakly k-colourable if its vertices may be partitioned into k sets called colour classes such that no m-cycle in S has all of its vertices in the same colour class. The smallest value of k for which a (partial) cycle system is weakly k-colourable is called its chromatic number. We study weak colourings of odd cycle systems (i.e., m-cycle systems for which m is odd), and show that for any integers $m \geq 5$ and $k \geq 2$ there is an m-cycle system with chromatic number k. Our main proof technique is to show that a k-chromatic partial m-cycle system P can be embedded within a k-chromatic m-cycle system S of some order greater than the order of P.

Tuesday May 26 ⋄ *mardi* 26 *mai*
15:20 – 17:25 **Z-310**

CTS-09

Geometry ⋄ *Géométrie*

The Plane-Width of Graphs

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Joint work with Marcin Kaminski and Martin Milanic

Map vertices of a graph to (not necessarily distinct) points of the plane so that two adjacent vertices are mapped at least a unit distance apart. The plane-width of a graph is the minimum diameter of the image of the vertex set over all such mappings. We establish a relation between the plane-width of a graph and its chromatic number, and connect it to other well-known areas, including the circular chromatic number and the problem of packing unit discs in the plane.

Minimum-Area Venn Diagrams

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PolyVenn diagrams are drawn using polyominoes on the integer lattice, where the curves are perimeters and the intersections are smaller polyominoes. Minimum-area Venn diagrams occur when each region in the full diagram is exactly one unit square.

We show such diagrams exist in bounding boxes of dimension $2^r \times 2^c$ whenever $0 < c < 2r + 2$. We also show that we can expand an existing minimum area Venn diagram to produce another that fits into a $2^{r+1} \times 2^{c+2}$ bounding box.

Graph Automorphisms and Polynomial Ideals

Mohamed Omar
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Joint work with J. De Loera, C. Hillar, and P. Malkin

We study various statistics of graph automorphisms using polynomial ideals and real algebraic geometry. In particular, we investigate the size of a given graph's automorphism group, and test for rigidity algebraically.

Surjections on Grassmannians Preserving Pairs of Elements with Bounded Distance

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Let m and k be fixed integers such that $m > k \geq 2$. Let V be a left vector space over a division ring with dimension at least $m + k + 1$. Let $G_m(V)$ be the Grassmannian consisting of all m-dimensional subspaces of V. We characterize surjective mappings T from $G_m(V)$ onto itself such that $d(A, B) \leq k$ if and only if $d(T(A), T(B)) \leq k$ for any A, B in $G_m(V)$ where $d(A, B) := m - dim(A \cap B)$.

Tuesday May 26 ⋄ *mardi* 26 *mai*
15:20 – 17:00 Z-330

CTS-10

Enumeration I ⋄ *Énumeration* I

Isoperimetric Sequences for Infinite Complete Binary Trees and Their Relation to Meta-Fibonacci Sequences and Signed Almost Binary Partitions

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Joint work with Anita Das and Sunil Chandran

We consider here some isoperimetric problems on the infinite binary tree $\mathcal{T}$ whose leaves are all at the same level. The main quantity of interest is $\delta(n)$, the minimum number of edges in a cut that has n vertices of $\mathcal{T}$ on one side and the rest of $\mathcal{T}$ on the other. A simple recurrence relation for $\delta(n)$ is derived, giving rise to an algorithm that also uses $O(n)$ arithmetic operations to evaluate $\delta(n)$. We also show that $\delta(n)$ is equal to the least number of parts in any partition of n into parts that are of the form $\pm P$, where P is one less than a power of 2.

Analysis of Label-Dependent Parameters in Increasing Trees and Generalizations

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Combinatorial families of increasing trees were introduced by Bergeron, Flajolet and Salvy 1992. These tree models are used, e.g., to describe the spread of epidemics, for pyramide schemes, and as a simplified growth model of the www.

Here we present a general approach for analyzing label-dependent parameters as the degree, the subtree-size, or the depth of node j. Our exact and limiting distribution results give a very precise description of the behaviour of specific nodes in such trees.

Revisiting an Integral Formula for Counting Bipartite Matchings

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Joint work with Erin Emerson

How many perfect matchings are contained in a given bipartite graph? An exercise in Godsil's 1993 *Algebraic Combinatorics* solicits proof that this question's answer is an integral involving a certain rook polynomial. Though not widely known, this result appears implicitly in Riordan's 1958 *An Introduction to Combinatorial Analysis*. It was stated more explicitly and proved independently by S.A. Joni and G.-C. Rota [J. Combin. Theory Ser. A **29** (1980), 59 – 73] and C.D. Godsil [Combinatorica **1** (1981), 257 – 262]. Another generation later, perhaps it's time both to simplify the proof and to broaden the formula's reach.

Two-Connected Graphs with Prescribed Three-Connected Components

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Joint work with Andrei Gagarin, Gilbert Labelle, and Pierre Leroux

We adapt the classical decomposition of any 2-connected graph into 3-connected components to simple graphs (no loops or multiple edges) to count labeled and unlabeled 2-connected graphs all of whose 3-connected components that are actually 3-connected graphs belong to a given class of such graphs. We thus count various isomorphism classes of graphs including nonplanar toroidal $K(3,3)$-free graphs.

Strong Vertex-Magic Total Labelings of 2-Regular Graphs

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It is well known that a 2-regular graph can have a strong vertex-magic total labeling (SVMTL) only if it has odd order. It is well known that every odd cycle has a SVMTL, however not much is known regarding other 2-regular graphs. We show how Kotzig arrays can be used to provide SVMTLs for many 2-regular graphs and conjecture that all of them (save three exceptions) possess SVMTLs.

Tuesday May 26 ⋄ *mardi 26 mai*
15:20 – 17:50 AA-6214

CTS-11

Domination and Order
Domination et ordre

On Maximal F-Free Subsets of a Finite Poset

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Joint work with Jia Shen

We find all finite posets F so that every maximal F-free subset of every finite poset P contains a maximal antichain of P. Time permitting, we may discuss the corresponding results when "antichain" is replaced by "chain" or by "element."

TP_2 Completion Problem

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Joint work with Charles R. Johnson

A partial matrix is one in which some entries are specified and the remaining unspecified entries are free to be chosen. Such a matrix is called partial TP_2 if all 1-by-1 and 2-by-2 specified minors are positive. If there exist values for the unspecified entries such that the result is TP_2, then the matrix is called TP_2 completale. We consider the question of which patterns for the specified entries ensure that a partial TP_2 matrix has a TP_2 completion. Using Bruhat order on permutations, some necessary conditions are given for a partial TP_2 matrix to be TP_2 completable.

On Covering Graphs of Partial Orders

Elaine M. Eschen
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Joint work with Jeremy P. Spinrad (Vanderbilt University) and R. Sritharan (The University of Dayton)

The problem: Given an undirected graph G, does G admit an acyclic orientation that is the transitive reduction of some partial order P?, is known to be NP-complete. We consider this problem when P is restricted to special classes of partial orders. We present some results, including results on heredity and forbidden induced subgraphs, when P is a weak order, semi-order, series-parallel order, and a cycle-free order.

The Diameter of Domination Vertex-Critical Graphs

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Joint work with Gary MacGillivray

A graph G is γ-vertex-critical if $\gamma(G - v) < \gamma(G)$ for every vertex $v \in V(G)$ (where $\gamma(G)$ denotes the domination number of G). Fulman, Hanson and MacGillivray showed that the diameter, d, of a γ-vertex-critical graph G satisfies $d \leq 2(\gamma(G) - 1)$ and provided graphs which show that this bound is sharp. We employ their technique to find an upper bound on the diameter of independent domination vertex-critical, total domination vertex-critical, and paired domination vertex-critical graphs. We also present graphs which attain equality in the bounds.

Domination in Butterfly Graphs

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Butterfly graphs are widely used in communication networks. Total domination number of butterfly graphs $\mathrm{BF}(n)$ is obtained for $n = 2, 3, 4$ and then the result is extended for the values $n = 4k, 4k+1, 4k+2$, and $4k + 3$. This generalized result is compared with the domination number of $\mathrm{BF}(n)$ and applications of total domination number is discussed at the end.

Total Well-Dominated Trees

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Let $G = (V, E)$ be a graph with no isolated vertex. A set D of vertices is called a total dominating set for G if each vertex in G is adjacent to a vertex in D. If all minimal total dominating sets in G have the same cardinality then G is said to be a total well-dominated graph. In this work we study the total well-dominated trees.

Wednesday May 27 ◇ *mercredi 27 mai*
9:00 – 9:50 S1-151

PT-05

Plenary Talk ◇ *Conférence plénière*

Two Geometric Algorithms and Their Many Applications in Discrete Optimization

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This a survey of results contained in papers joint work with various subsets of the following people: R. Hemmecke, M. Koeppe, S. Onn, U. Rothblum, and R. Weismantel.

It is common knowledge that the understanding of the geometry of convex bodies and polyhedra has helped speed up algorithms in discrete optimization. For example, cutting planes and facet-description of polyhedra have been crucial in the success of branch-and-bound algorithms for mixed integer programming. Another example, is how the ellipsoid method can be used to prove polynomiality results in combinatorial optimization.

In the past 5 years two beautiful geometric algorithms on polyhedra have been used to prove unexpected new complexity results on the computation of integer programs (both linearly and nonlinearly constrained). The first is Barvinok's algorithm for polytopes, the second is the Graver bases algorithm on polyhedral cones. I will describe these two algorithms and explain why we can now prove theorems that were beyond our reach before. I will also describe attempts to use these two algorithms in practical computation, not just in theoretical results.

Wednesday May 27 ◇ *mercredi 27 mai*
10:20 – 12:50 S1-125

IM-07

Discrete and Computational Geometry
Géométrie discrète et algorithmique

A Computational Approach to Bounding Polytope Diameters

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Work in progress with Lars Schewe (*TU Darmstadt*)

The Hirsch conjecture is the 50 year old conjecture that the diameter of the edge-vertex graph of a convex d-polytope with n-facets is at most $n - d$. In this talk I will discuss recent work on a computational attack on this conjecture. The main tools are a (partial) classification of the simplicial complexes whose dual graph is a path, oriented matroids, and fast Boolean satifiability solvers.

On the Maximum Number of Touching Pairs in Packings of Given Number of Congruent Balls

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Harborth (1974) settling a conjecture of Reuter (1972) found an explicit formula for the maximum number of times the minimum distance can occur among n points in the Euclidean plane. Agarwal and Pach (1995) raised the higher-dimensional analogue question calling the attention to the fact that besides trivial upper bounds nothing seems to be known about this problem. By improving some earlier estimates of the speaker (2001) we give a proof of the following theorem. The number of touching pairs in an arbitrary packing of n congruent balls in Euclidean 3-space is always less than $6n - 1.57n^{2/3}$.

Computing Knock out Strategies in Metabolic Networks
Tamon STEPHEN
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Metabolic networks are sets of metabolites that can be interconverted by biochemical reactions. We consider the problem of enumerating the minimal knock out strategies, that is, the sets of reactions whose removal blocks a target reaction from operating in a steady state. When the elementary modes (minimal functional subsystems) of the network are given, the knock out strategies can be computed via a simple algorithm, which is a substantial improvement over the existing algorithm. We argue that algorithms based on the ideas of Fredman and Khachiyan are conceptually well suited to this problem, since they generate both the knock out sets and the elementary modes directly from the description of the network. We implement a version of this algorithm with a linear programming oracle and we provide initial computational results.

Hyperplane Arrangements with Large Average Diameter
Antoine DEZA
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Joint work with Feng Xie (*McMaster University*)

The largest possible average diameter of a bounded cell of a simple hyperplane arrangement is conjectured to be not greater than the dimension. We prove that this conjecture holds in dimension 2, and is asymptotically tight in fixed dimension. We give the exact value of the largest possible average diameter for all simple arrangements in dimension 2, for arrangements having at most the dimension plus 2 hyperplanes, and for arrangements having 6 hyperplanes in dimension 3. In dimension 3, we give lower and upper bounds which are both asymptotically equal to the dimension.

A Continuous d-Step Conjecture for Polytopes
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Joint work with Antoine Deza (*McMaster University*) *and Tamás Terlaky* (*Lehigh University*)

The curvature of a polytope, defined as the largest possible total curvature of the associated central path, can be regarded as the continuous analogue of its diameter. We prove the analogue of the result of Klee and Walkup. Namely, we show that if the order of the curvature is less than the dimension d for all polytope defined by 2d inequalities and for all d, then the order of the curvature is less that the number of inequalities for all polytopes.

Wednesday May 27 ⋄ *mercredi 27 mai*
10:20 – 12:25 Z-210

CM-06

Graph Theory with Applications I
Théorie des graphes et applications I

Graph Theoretical Conjectures of Graffiti.pc
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Graffiti.pc is a graph theoretical conjecture-making computer program. One of its heuristics allows a user to query the program for upper (or lower) bounds on a particular graph invariant and the program responds with a list of bounds on the selected invariant. As of 2001, fifteen of Graffiti.pc's lists (composed of 276 conjectures) have been announced with selected graph invariants, such as the order of certain largest induced subgraphs (bipartite, forest, tree and such) in a connected graph, the matching number of bipartite graphs, and the connected domination and total domination numbers of connected graphs. In this talk, I revisit the highlights of some of these lists of conjectures and discuss a couple of re-executions of the more thoroughly resolved lists.

Classification and Generation of Nanocones
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Joint work with Nicolas Van Cleemput

In this talk we will give a classification of nanocones similar to that of nanotubes. The classification is by the boundary structure of a patch we call nanocone cap that corresponds to the cap in a nanotube. These nanocone caps are pseudoconvex in the sense that they do not contain two neighbouring vertices of degree 3 in the boundary and can be described by the lengths of the paths connecting parts of two neighbouring vertices with degree 2 in the boundary. Such a classification has been given before, independently by Douglas Klein and Claudia Justus. The present approach uses classification results for disordered 2-dimensional tilings by Ludwig Balke based on the theory of Delaney – Dress symbols and generalizes easily to all kinds of locally disordered tilings. Furthermore we give an algorithm to generate all nanocone caps for a given parameter and present results of this algorithm.

A Catalog of Self-Dual Plane Graphs with Maximum Degree 4

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Joint work with Elizabeth J. Hartung

Self-dual plane graphs have been studied extensively. In 1992, Archdeacon and Richter [*Construction and classification of self-dual spherical polyhedra*, J. Combin. Theory Ser. B **54** (1992), 37 – 63] described a method for constructing all self-dual plane graphs; a second construction was produced by Servatius and Servatius [*Self-dual graphs*, Discrete Math. 149 (1996), 223 – 232]. In both cases the construction is inductive. In this paper, we construct a catalog of self-dual plane graphs with maximum degree 4 (self-dual spherical grids). 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. A catalog, as opposed to a method of construction, yields direct access to individual self-dual spherical grids without constructing all smaller self-dual spherical grids first.

Drawing Graphs on the Plane, Torus, Projective Plane and Sphere

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Groups & Graphs is a software package for graphs, digraphs, and their automorphism groups. Currently it can draw graphs on the plane, sphere, torus, and projective plane. A description of the algorithms used will be given.

Continuing the Search for Torus Obstructions

Jennifer Woodcock
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A torus is a surface shaped like a doughnut. A topological obstruction for the torus is a graph G with minimum degree three that is not embeddable on the torus but for all edges e, $G-e$ is torus embeddable. A minor order obstruction has the additional property that for all edges e, G contract e is also torus embeddable. The long-term goal of our research is to find all the obstructions to the torus, thereby formulating a Kuratowski-type theorem for non-toroidal graphs. In this talk, we will provide an overview of the research to date and discuss recent progress, including exhaustive searches, corrections to previous results, and structural characterizations that will likely guide our focus for finding and proving complete the set of all torus obstructions.

Wednesday May 27 ⋄ *mercredi 27 mai*
10:20 – 12:25 Z-260

CM-07

Graph Classes and their Structures
Familles de graphes et leurs structures

Induced Trees and Monophonic Convexity

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Joint work with J. Cáceres and M.L. Puertas

Let $G = (V, E)$ be a connected graph and S a set of vertices of G. A subgraph T of G containing U is an induced U-tree if T is a tree and if every vertex of $V(T) \setminus U$ is a cut-vertex of the subgraph induced by $V(T)$. The monophonic interval of U is the collection of all vertices of G that belong to some induced U-tree. A set S of vertices in a graph is k-monophonic convex if S contains the monophonic interval of every subset of k vertices in S. A vertex v of a k-monophonic set S is an extreme vertex of S if $S \setminus \{v\}$ is still k-monophonic. If W is any set of vertices in G, then the convex hull of W is the smallest k-monophonic subset of G that contains W. If every k-monophonic set has the property that it is the convex hull of its extreme vertices, then the collection of k-monophonic sets form a convex geometry. Several graph convexities are defined using induced U-trees and structural characterizations of graph classes for which the corresponding collection of convex sets is a convex geometry are characterized.

Pentangulated Graphs

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One fundamental way to characterize chordal graphs — sometimes still called "triangulated graphs" — is that every cycle C with $|C| \geq 3$ is the sum of $|C|-2$ distinct triangles (3-cycles, where 'sum' means the symmetric difference as sets of edges), or equivalently that every cycle C with $|C| \geq 4$ is the sum of a triangle and a $(|C|-1)$-cycle. Define a graph to be *pentangulated* if every cycle C with $|C| \geq 5$ is the sum of $|C|-4$ distinct pentagons (5-cycles). Is this equivalent to every cycle C with $|C| \geq 6$ being the sum of a pentagon and a $(|C|-1)$-cycle? There are additional analogies between triangulated and pentangulated, in which distance-hereditary graphs play a central role.

The Problem of Deciding Whether a Graph Contains a Sun Is NP Complete

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The sun is a special graph that plays an important role in the study of strongly chordal graphs. We prove the problem of deciding whether a graph contains a sun in NP complete.

Navigating in a Graph by Aid of its Spanning Tree

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Joint work with Martin Matamula

Let $G = (V, E)$ be a graph and T be a spanning tree of G. We consider the following strategy in advancing in G from a vertex x towards a target vertex y: from a current vertex z (initially, $z = x$), unless $z = y$, go to a neighbor of z in G that is closest to y in T (breaking ties arbitrarily). In this strategy, each vertex has full knowledge of its neighborhood in G and can use the distances in T to navigate in G. Thus, additionally to standard local information (the neighborhood $N_G(v)$), the only global information that is available to each vertex v is the topology of the spanning tree T (in fact, v can know only a very small piece of information about T and still be able to infer from it the necessary tree distances). For each source vertex x and target vertex y, this way, a path, called a greedy routing path, is produced. Denote by $g_{G,T}(x, y)$ the length of a longest greedy routing path that can be produced for x and y using this strategy and T. We say that a spanning tree T of a graph G is an *additive r-carcass* for G if $g_{G,T}(x, y) \leq d_G(x, y) + r$ for each ordered pair $x, y \in V$. In this paper, we investigate the problem, given a graph family $\mathcal{F}$, whether a small integer r exists such that any graph $G \in \mathcal{F}$ admits an additive r-carcass. We show that rectilinear $p \times q$ grids, hypercubes, distance hereditary graphs, dually chordal graphs (and, therefore, strongly chordal graphs and interval graphs), all admit additive 0-carcasses. Furthermore, every chordal graph G admits an additive $(\omega(G) + 1)$-carcass (where $\omega(G)$ is the size of a maximum clique of G), each 3-sun free chordal graph admits an additive 2-carcass, each chordal bipartite graph admits an additive 4-carcass. In particular, any k-tree admits an additive $(k + 2)$-carcass. All those carcasses are easy to construct.

Leaf Powers: Recent Results and Open Problems

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Joint work with Christian Hundt, Van Bang Le, and Peter Wagner

Motivated by the search for underlying phylogenetic trees, Nishimura, Ragde and Thilikos defined the following notion: A graph $G = (V, E)$ is a *k-leaf power* if there is a tree T whose set of leaves is V and such that two vertices are adjacent in G if and only if their distance in T is at most k. Then T is a *k-leaf root* of G. G is a *leaf power* if it is a k-leaf power for some $k \geq 2$. The *leaf rank* of a leaf power G is the smallest k such that G is a k-leaf power. It is known that the class of leaf powers is a proper subclass of strongly chordal graphs, and every ptolemaic graph as well as every interval graph is a leaf power.

This talk presents some recent results on leaf powers and its variants and discusses some main open problems in this field of research such as the characterization and recognition of leaf powers as well as determining the leaf rank of leaf powers.

Wednesday May 27 ⋄ *mercredi 27 mai*
10:20 – 12:25 Z-345

CM-08

Asymptotic Enumeration II
Énumération asymptotique II

On a Random Graph Evolving by Degrees

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We consider a random (multi)graph growth process $\{G_m\}$ on a vertex set $[n]$, which is a special case of a more general process proposed by Laci Lovász in 2002. G_0 is empty, and G_{m+1} is obtained from G_m by inserting a new edge e at random. Specifically, the conditional probability that e joins two currently disjoint vertices, i and j, is proportional to $(d_i+\alpha)(d_j+\alpha)$, where d_i, d_j are the degrees of i, j in G_m, and $\alpha > 0$ is a fixed parameter. The limiting case $\alpha = \infty$ is the Erdős – Rényi graph process. We show that whp G_m contains a unique giant component iff $c := 2m/n > c_\alpha = \alpha/(1+\alpha)$, and the size of this giant is asymptotic to

$$n\left[1-\left(\frac{\alpha+c^*}{\alpha+c}\right)^{\alpha}\right],$$

where $c^* < c_\alpha$ is the root of $c/(\alpha+c)^{2+\alpha} = c^*/(\alpha+c^*)^{2+\alpha}$. A phase transition window is proved to be contained, essentially, in $[c_\alpha - An^{-1/3}, c_\alpha + Bn^{-1/4}]$, and we conjecture that $\frac{1}{4}$ may be replaced with $\frac{1}{3}$. For the multigraph version, $\{MG_m\}$, we show that MG_m is connected whp iff $m \gg m_n := n^{1+\alpha^{-1}}$. We conjecture that, for $\alpha > 1$, m_n is the threshold for connectedness of G_m itself.

TBA

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TBA

Maximum Stirling Numbers of the Second Kind

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Joint work with Rod Canfield, Graeme Kemkes, Donatella Merlini, and Carl Pomerance

Let's say an integer is n is *exceptional* if the maximum Stirling number of the second kind $S(n,k)$ occurs for two (of necessity consecutive) values of k. We prove that the number of exceptional integers less than or equal to x is $O(x^\epsilon)$ for any $\epsilon > 0$. There is a similar result for partitions of n into exactly k integers.

Geometric Configurations in Vector Spaces over Finite Fields

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We prove that a suitably large subset of a d-dimensional vector space over a finite field contains a copy of a given k-point configuration.

Asymptotics of Some Convolutional Recurrences

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Based on joint work with Bender, Richmond and Wormald.

There are many examples in the literature of sequences defined recursively using a convolution. It often seems difficult to determine the asymptotic behaviour of such sequences. In this talk we study the asymptotic behaviour of the terms in sequences satisfying recurrences of the form $a_n = a_{n-1} + \sum_{k=d}^{n-d} f(n,k)a_k a_{n-k}$ where, very roughly speaking, $f(n,k)$ behaves like a product of reciprocals of binomial coefficients. We prove subexponential growth by using an iterative method that may be useful for other recurrences. Applications will be given for sequences arising from map enumerations, Painlevé I equations, Airy constants, and Wiener index of Catalan trees.

Wednesday May 27 ⋄ *mercredi 27 mai*
10:20 – 12:25 Z-350

CTS-12

Coloring and Chromatic Number II
Coloration et nombre chromatique II

$L(2,1)$-Graph Colorings

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Joint work with Jobby Jacob

In an $L(2,1)$-coloring of a graph G, colors of adjacent vertices are at least 2 apart, and colors of vertices at distance two are distinct. This assumes a definition of distance between colors. We consider what happens if colors are vertices of a graph H (usually the complement of a path). We provide bounds and connections with other coloring concepts, and algorithms such as self-stabilization.

Triangulations of the Torus with Two Odd Degree Vertices

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We will classify and describe the triangulations of the torus that have exactly two vertices with odd degree. We also confirm Grunbaum conjecture for this class of graphs.

On 3-Choosability of Triangle-Free Planar Graphs

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Joint work with Zdeněk Dvořák and Riste Škrekovski

A graph is k-choosable if it can be colored whenever every vertex has a list of at least k available colors. We prove that every triangle-free planar graph such that 4-cycles do not share edges with other 4- and 5-cycles is 3-choosable. This strengthens the Thomassen's result that every planar graph of girth at least 5 is 3-choosable. In addition, this implies that every triangle-free planar graph without 6- and 7-cycles is 3-choosable.

Counterexample to the Conjecture of Grunbaum

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By a classical result of Tait, the four-color theorem is equivalent with the statement that each 2-edge-connected 3-regular planar graph has a 3-edge-coloring. An embedding of a graph in a surface is called polyhedral if its dual has no multiple edges and loops. A conjecture of Grunbaum, presented in 1968, states that each 3-regular graph with a polyhedral embedding in an orientable surface has a 3-edge-coloring. With respect to the result of Tait, it aims to generalize the four color theorem for any orientable surface. We present a negative solution of this conjecture, showing that for each orientable surface of genus at least 5, there exists a 3-regular non 3-edge-colorable graph with a polyhedral embedding in the surface.

Totally Silver Graphs

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Joint work with Ebad Mahmoodian (Sharif University of Technology)

Colouring squares of graphs is of significance in graph theory and its applications. The chromatic number of the square of a graph with maximum degree Δ is between $\Delta+1$ and Δ^2+1. Wegner conjectured a linear upper bound for planar graphs (1977). It is also conjectured that the square of a cubic graph other than the Petersen graph is always 8-colourable. We study *totally silver* graphs, namely regular graphs whose square is $(\Delta+1)$-colourable. We give a complete characterization of these graphs and present some open problems regarding special cases.

Wednesday May 27 ◇ *mercredi 27 mai*
14:00 – 14:50 S1-151

PT-06

Plenary Talk ◇ *Conférence plénière*

Discrete Geometry and Word Combinatorics

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The aim of this lecture is to show how discrete geometry and word combinatorics can interact through the study of the most basic objects in discrete geometry, namely arithmetic discrete planes. In word combinatorics, Sturmian words and regular continued fractions are known to provide a very fruitful interaction between arithmetics, discrete geometry and symbolic dynamics. Recall that Sturmian words are infinite words which code irrational discrete lines over a two-letter alphabet. Most combinatorial properties of Sturmian words can be described in terms of the continued fraction expansion of the slope of the discrete line that they code. Our aim here is to show how to extend this interaction to higher dimensions. Special focus will be given to a generation method for discrete planes based on a formalism extending to the multidimensional case morphisms of the free monoid. The role played respectively by words and classical continued fractions will be played by stepped surfaces (which are discretizations of two-dimensional surfaces embedded in the three-dimensional space) and generalized unimodular Euclidean algorithms. We will use the fact that we can describe an arithmetic discrete plane either as a tiling of the plane by three kinds of lozenges (after projection), or else, as a multidimensional word over a three-letter alphabet (after coding).

Wednesday May 27 ◇ *mercredi 27 mai*
15:20 – 17:25 S1-125

IM-08

Combinatorics on Words
Combinatoire des mots

Logarithmic Frequency in Morphic Sequences

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Let Σ be a finite alphabet and let ϕ be a morphism from the free semigroup generated by Σ to itself. We say that a right infinite word on Σ is *pure morphic* if it is a fixed point of ϕ. A word is *morphic* if it is the image of a pure morphic word under a map which sends elements of Σ to elements of another alphabet (not necessarily $1-1$). Easy examples show that the ordinary frequency of a letter $x \in \Sigma$ need not exist in a morphic word; we show, however, that the logarithmic frequency of letters and words in a morphic word must always exist, answering a question of Allouche and Shallit.

On the Number of α-Power-Free Words for $2 < \alpha \leq \frac{7}{3}$

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Joint work with Vincent Blondel and Raphaël Jungers

Let $u_\alpha(n)$ be the number of binary words of length n that contain no fractional power of exponent α or more. Karhumäki and Shallit proved that it grows polynomially when $2 < \alpha \leq \frac{7}{3}$, and exponentially when $\frac{7}{3} < \alpha$.

In 1993, we proved that the number of overlap-free words oscillates between two polynomial functions, the exponents of which are not exactly known, but are different from each other and can be approximated. We revisit that paper, and show how to extend the method to deal with $u_\alpha(n)$ in the polynomial case.

We show that it is a 2-regular function (in the sense of Allouche and Shallit) when α is rational. This provides an algorithm that computes the number $u_\alpha(n)$ in logarithmic time. Then we express the extremal exponents using joint spectral quantities of a pair of matrices. For $\alpha = \frac{7}{3}$, we compute the automaton and give sharp estimates for the asymptotic behaviour of $u_\alpha(n)$.

Suffix-Based Text Indices, Construction Algorithms, and Applications

Frantisek Franek
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Historically, the most used full-text indices are so-called reversed files. Suffix trees have become the focus of many studies since their introduction in 1976 by McCreight as a simplification of position trees of Weiner. The main advantage of suffix trees is their facilitation of efficient executions of various text queries — and pattern matching in particular — while the main disadvantages are the complex construction and query-performing algorithms and the high storage required. This may be the reason why despite guaranteeing better performance than reversed files, use of suffix trees in real life is relatively low. Several suffix-tree construction algorithms, including Farach's linear-time algorithm, are discussed together with the strategies for performing queries.

The storage disadvantage of suffix trees was meliorated by suffix arrays introduced by Manber and Myers in 1993, as they require much less storage. However, for some time after their introduction, all suffix-array construction algorithms exhibited worst complexity in comparison to the best suffix-tree construction algorithms, and also the performance of queries was slower. Nevertheless, the suffix arrays awoke a very strong interest among researchers, and consequently, suffix arrays and trees have become the most studied full-text indices, especially since Abouelhoda et al. showed that all queries that can be performed with suffix trees can be performed with the enhanced suffix arrays with the same asymptotic worst-case time complexity. Several suffix-array construction algorithms, including the recursive linear-time algorithms, are discussed together with the strategies for performing queries.

The presentation concludes with a discussion of various enhancements of suffix arrays such as linearized or compressed suffix arrays addressing various weaknesses of the standard suffix arrays.

Periodicity and Repetitions in Automatic Sequences

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Joint work with Jean-Paul Allouche and Narad Rampersad

A sequence is said to be *automatic* if it is the image, under a coding, of the fixed point of a uniform morphism. Alternatively, it is automatic if the nth term can be computed by feeding the base-k expansion of n into an automaton, and reading off the output associated with the last state reached. A typical example is the famous Thue-Morse sequence $01101001\ldots$, which can be generated by iterating the morphism $0 \to 01$, $1 \to 10$. In this talk I will consider several decision problems about automatic sequences, of which the following is a typical example: given an automatic sequence, does it contain squares? (A square is a factor of the form xx.) I will show that this, and many other problems, are decidable.

Finite Colorings of Factors of Words

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Based on joint work with A. de Luca and T. Brown

Via a well-known theorem of Ramsey, one can show that given any infinite word W and any finite coloring of all nonempty factors of W, there exists a factorization $W = VU_0U_1U_2\cdots$ such that all the factors $U_iU_{i+1}\cdots U_{i+j}$ (with $i, j \geq 0$) have the same color.

I plan to discuss various related questions:
Question 1. Given an infinite nonperiodic word W, does there exist a finite coloring of its factors such that for every factorization $W = U_1U_2U_3\cdots$ we have that for some $i \neq j$ the color of U_i is different from that of U_j?
Question 2. Given any infinite word W and any finite coloring of all nonempty factors of W, does W admit a factor of the form $U_1U_2\cdots U_k$ such that the U_i each have the same color and the same length?

I will discuss some partial answers to these and other questions.

Wednesday May 27 ⋄ *mercredi* 27 *mai*
15:20 – 17:25 Z-210

CM-09

Graph Theory with Applications II
Théorie des graphes et applications II

A Linear-Time Algorithm for Finding a Maximum Independent Set on a Fullerene

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Fullerenes are cubic planar graphs having twelve pentagonal faces and all remaining faces hexagonal. These graphs model fullerene molecules and finding a maximum independent set is of interest from mathematical, computational, and chemical points of view. The problem of determining the maximum independent set order is NP-hard for general cubic planar graphs and the complexity for the fullerene subclass was previously unknown. This talk sketches a linear-time algorithm for solving the maximum independent set problem for fullerenes.

Graph-Theoretic Indicators of Fullerene Stability

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Fullerenes are polyhedral molecules made exclusively of carbon atoms. They are modelled by fullerene graphs: planar, 3-regular and 3-connected graphs, twelve of whose faces are pentagons, and any remaining faces are hexagons. It is well known that there are far more fullerene graphs than there are experimentally realized fullerene molecules: while the number of all possible fullerene structures with n atoms grows rapidly with n, only a handful of them have ever been experimentally confirmed. This fact presents us with the problem of characterizing and/or predicting the structures which are most likely to be observed, i.e., which correspond to the most stable isomers. As the exact theoretical treatment of this problem is severely challenged by the fullerene size, it is worthwhile to develop graph-theoretic models and indicators of their stability. Quite a number of graph invariants were examined, but all of them have deficiencies to date. We propose here to consider new invariants, based on the partition of pi-electrons among the faces of polyhedral graphs, which should be sensitive also to the local aspects of fullerene structures. It is found that their performance on the test space of experimentally verified structures indicates that the new invariants have a significant stability-predicting potential.

Features of the System ChemoGraphiX

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Joint work with Pierre Hansen and Damir Vukisevic

The authors recently obtained a characterization of matrices $M = \{m_ij\}$, such that there exists a graph $G = (V, E)$ with m_ij equal to the number of edges with end degrees i and j in G. The corresponding nonlinear conditions led to a polynomial algorithm to recognize such graphs. Moreover, it was observed that for chemical graphs and given numbers n of vertices (and possibly m of edges), the feasibility problem for G can be expressed as a mixed integer program without an objective function. Finally, it was also observed that a large variety of chemical graph optimization problems were amenable to the same format. The sole, but important, restriction is that the indices appearing in the objective function depend only on the degrees of the vertices of G. It is easily seen that this is the case for quite a few graph invariants which include the Randic index and its generalizations, the first and second Zagreb indices and their generalizations, the sum of squared degrees, their variance and their discrepancy as well as several others. Various problems assessed by CGX will be presented.

Characteristic Polynomials and Electron Conduction

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Conduction of an electron through a single-molecule electronic device can be modelled with Hueckel theory. The standard Hueckel problem is equivalent to determining the spectrum of the adjacency matrix of a molecular graph. For conduction, we solve the (continuous) eigenvalue problem under modified source-and-sink boundary conditions. Transmission varies strongly with energy but is fully determined by four characteristic polynomials: those of the molecular graph and of the vertex-deleted subgraphs where one or both contact atoms are removed. Ideas from graph theory lead to closed formulas for families of graphs and composite graphs, predict equiconduction, and yield startlingly simple selection rules (with a clear chemical basis) for opacity and conduction.

Substitution-Reaction Posets in Chemistry

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So-called substitution posets used to represent a chemical reaction placing substituents at different locations of a molecular skeleton may be described in a general mathematical manner. Let G be a permutation group acting on the members of a finite set S, and consider the orbits x of subsets C of S as mediated by G. Then the substitution partial ordering is such that $x > y$ if there are x in C and y in C' with C a proper subset of C'. In chemistry the members of such a poset represent isomers based on a skeleton S of symmetry G, and the associated Hasse diagram represents a substitution-reaction network. A classic (13-member) chemical example is the substitution-reaction poset for benzene. The consequent posets $P(S, G)$ are observed: to have unique maximum and minimum elements; to be self dual; to be ranked; and to have a coincidence of three different metrics. Schemes for interpolating functions on such posets are of interest in interpolating properties of the molecular structures corresponding to the different members of the poset. A first such scheme is a splinoid fitting method, a second is a cluster-expansion method; and a third is a flow-network fitting method.

Wednesday May 27 ⋄ *mercredi 27 mai*
15:20 – 17:50 Z-260

CM-10

Degree Sequences of Graphs and Digraphs
Suites de degrés dans les graphes et les digraphes

Tournament Score Sequences with k-Partition Transitive Realizations

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A sequence S of nonnegative integers is a *score sequence* if there is a tournament T such that the out-degrees of the vertices of T are the terms of S, and T is called a *realization* of S. A tournament $T = (V, A)$ is called *m-partition transitive* if there is a partition $V = X_1 \ldots X_2 \ldots \cdots \ldots X_m$ such that the subtournaments induced by each X_i are all transitive, and T is *m-partition k-transitive* if $\max |X_i| = k$. We show that for any score sequence S, there is a realization T which is m-partition k-transitive if and only if there is a realization T' which contains a transitive subtournament of order at least k.

Forbidden-Graph Classes Characterized by Their Degree Sequences: The Nonminimal Triple Case

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Given a set $\mathcal{F}$ of graphs, a graph G is $\mathcal{F}$-free if G does not contain any member of $\mathcal{F}$ as an induced subgraph. We say that $\mathcal{F}$ is a degree-sequence-forcing set if, for each graph G in the class $\mathcal{C}$ of $\mathcal{F}$-free graphs, every realization of the degree sequence of G is also in $\mathcal{C}$.

This definition is motivated by the well-studied class of split graphs. In this talk, we will focus on the case of non-minimal degree-sequence-forcing sets of cardinality 3, providing a complete characterization.

Packings of Degree Sequences
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Let $\pi_1 = (d_1^{(1)}, \ldots, d_n^{(1)})$ and $\pi_2 = (d_1^{(2)}, \ldots, d_n^{(2)})$ be graphic sequences. We say that π_1 and π_2 *pack* if there exist graphs $G_1 = G(\pi_1)$ and $G_2 = G(\pi_2)$ with $V(G_1) = V(G_2) = \{v_1, \ldots, v_n\}$ such that the following properties hold: (i) $G = G_1 \cup G_2$ is a simple graph, and (ii) $d_G(v_i) = d_i^{(1)} + d_i^{(2)}$.

Perhaps the best-known result about packings of degree sequences is Kundu's k-factor theorem, which is stated as follows: Let $k \geq 1$ be an integer and let π be a graphic sequence with all terms equal to either k or $k-1$. Then for any graphic sequence π_2, π_1 and π_2 pack provided $\pi_1 + \pi_2$ is graphic. In this talk, we will discuss some new results pertaining to packings of degree sequences, including several extensions of Kundu's k-factor theorem.

Realizations of Near-Graphical Sequences with Maximum Saturation and Minimum Deficiency
David KIRKPATRICK
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Based on joint work with Nhan Nguyen

Graphical degree sequences have been extensively studied and admit several elegant characterizations. In earlier work (joint with Pavol Hell), we showed how to extend these characterizations to arbitrary sequences of target degrees (even sequences of target degree intervals) by introducing a natural measure of "near-graphical." This was done in the context of minimum deficiency (g, f)-factors of complete graphs. Our main result was a simple linear-time greedy algorithm for constructing minimum deficiency (g, f)-factors in complete graphs that generalizes the method of Hakimi and Havel (for constructing 0-deficiency (f, f)-factors in complete graphs, when possible), with the added advantage of producing a certificate of minimum deficiency (through a generalization of the Erdős – Gallai characterization of 0- deficient (f, f)-factors in complete graphs) at no additional cost.

In this talk, we describe more recent work that addresses the question of finding an $(0, f)$-factor of a complete graph that maximizes the saturation (that is, the number of vertices v whose degree equals $f(v)$. The corresponding problem for arbitrary host graphs is known to be NP-hard. We show that for complete graphs (i) it is always possible to find a maximum saturation $(0, f)$-factor that simultaneously has minimum deficiency; and (ii) such factors can be constructed efficiently. As an immediate corollary, we can find, for any sequence of target degrees, an approximate graphical realization for which the number of unrealized degrees, as well as the total deviation from the target sequence, is minimized.

Strongest Monotone Degree Conditions and Bounds
Nathan KAHL
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In 1972, Chvatal gave a condition on the degree sequence of a graph that ensured the graph was hamiltonian, and was "stronger" than all previous known conditions, i.e., Chvatal's condition included all previous results as corollaries. Moreover, Chvatal demonstrated the strength of his result not by directly comparing it with previous conditions, but by identifying a quality inherent in his condition that guaranteed its strength relative to the others. We call such degree conditions "weakly optimal." Shortly thereafter, Boesch noted that an earlier degree condition of Bondy's, ensuring k-connectivity, was weakly optimal with regard to this graph property, but after that the idea seemed to go unnoticed – despite that fact that many, many other degree conditions have appeared for various graph properties. In this talk we provide a framework to show how the weakly optimal idea can be used to find strongest monotone degree conditions for other graph properties, e.g., being 2-edge-connected, having a perfect matching, and having a 2-factor. We also show how this framework can be used to identify the best monotone degree bounds for various graph parameters, e.g., chromatic number, clique number, and independence number.

A Lower Bound for Potentially H-Graphic Sequences
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Let π be an n-element graphic sequence, and $\sigma(\pi)$ be the sum of the terms in π, that is the degree sum. Let H be a graph. We wish to determine the smallest m such that any n-term graphic sequence π having

$\sigma(\pi) \geq m$ has some realization containing H as a subgraph. Denote this value m by $\sigma(H, n)$. For an arbitrarily chosen H, we construct a graphic sequence $\pi^*(H, n)$ such that $\sigma(\pi^*(H, n)) + 2 \leq \sigma(H, n)$. Furthermore, we conjecture that equality holds in general, as this is the case for all choices of H where $\sigma(H, n)$ is currently known. We support this conjecture by examining those graphs that are the complement of triangle-free graphs, and showing that the conjecture holds despite the wide variety of structure in this class.

Wednesday May 27 ⋄ *mercredi 27 mai*
15:20 – 17:50 Z-345

CM-11

Graph Protection
Protection dans les graphes

Red, White and Blue Protection

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Based on joint work with Bresar, Dorbec, Goddard, Henning, Klavzar, and Rall

Given a network G, some of the nodes are assigned a colour (either red or blue) with the restriction that no red node is adjacent to a blue one. We have three groups of policemen, a set of uniformed ones (the white unit) that are to protect/dominate the entire graph, a red unit that will protect the red nodes and a blue unit that will guard the blue nodes. A node of G can be occupied by more than one policeperson. What is the largest number required, regardless of G, to protect the entire network by uniformed police, the red nodes by members of the red unit and the blue nodes by personnel from the blue unit? This problem and its connection to a search for a possible counterexample to Vizing's Conjecture on the domination number of the Cartesian product of two graphs will be outlined.

Guarding a Subgraph as a Tool in Pursuit-Evasion Games

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Joint work with Gordana Radić

One of the pursuit-evasion games is the game of cops and a robber, which is played on a graph $G = (V, E)$. The robber and the cop move alternatively, the former trying to position himself on the same vertex as the latter. Aigner and Fromme proved that, if P is a shortest path between two vertices in G, then one cop guarantees that the robber will be caught, if he steps onto P. A very similar result is from 2001, when Fitzpatrick and Nowakowski proved that one cop will catch the robber if he steps on some isometric path P' in G. In the context of the game of guarding a subgraph, P and P' can be guarded by one guard (cop) against the intruder (robber). In this talk, we generalize the concept of guarding to arbitrary subgraphs of a graph. We introduce the shadow of the intruder, which maps the location of the intruder to the set of vertices of G, from which a guard can prevent the intruder from entering the guarded subgraph. We describe the characteristic properties of this function and prove that a single guard can guard the subgraph if and only if he is in the shadow of the intruder.

Domination of Generalized Cartesian Products

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Joint work with Kieka Mynhardt

For graphs G, H and a permutation π acting on $V(G)$, we define a *generalized Cartesian product* $G \boxed{\pi} H$. This graph product is the Cartesian product $G \,\square\, H$ when π is the identity and the generalized prism πG when H is the graph K_2. In 2004, Burger, Mynhardt and Weakley characterized *universal doublers*, i.e., graphs for which $\gamma(\pi G) = 2\gamma(G)$ for any π. We characterize graphs G for which $\gamma(G \boxed{\pi} K_n) = n\gamma(G)$ for any π, calling such graphs *universal multipliers*.

A Characterization of Radial Trees

Sarada Herke
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Joint work with Kieka Mynhardt

A *broadcast* on a graph G is a function $f\colon V \to \{0, \ldots, \operatorname{diam} G\}$ such that for each $v \in V$, $f(v) \leq e(v)$ (the eccentricity of v). The *broadcast number* of G is the minimum value of $\sum_{v \in V} f(v)$ among all broadcasts f for which each vertex of G is within distance $f(v)$ from some vertex v having $f(v) \geq 1$. This number is bounded above by the radius of G as well as by its domination number. Graphs for which the broadcast number is equal to the radius are called *radial*; we provide a characterization of radial trees as well as a geometrical interpretation of our characterization.

Trees with Equal Broadcast and Domination Numbers

Ernie Cockayne
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Joint work with Kieka Mynhardt

The definitions of a broadcast on a graph G, the broadcast number of G, and radial graphs, can be found in the abstract of the talk “A Characterization of Radial Trees” by Sarada Herke. The broadcast number of a graph is bounded above by its radius and by its domination number. We discuss properties of trees whose broadcast and domination numbers are equal.

On the Surviving Rates of a Graph

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Joint work with W. Wang and P. Wang

Let G be a connected graph with $n \geq 2$ vertices. Suppose that a fire breaks out at a vertex v of G and a firefighter then protects a vertex not yet on fire. Afterwards, the fire spreads to all its unprotected neighbours in each time interval. The fire and firefighter take turns until the fire can no longer spread.

The survival rate of G is the expected proportion of vertices the firefighter can save when a fire breaks out at a random vertex. We will discuss recent results on the surviving rate for various classes of graphs.

Wednesday May 27 ⋄ *mercredi* 27 *mai*
15:20 – 17:50 Z-350

CTS-13

Optimization ⋄ *Optimisation*

Covering via Packing and LP-Relative Approximation

David Pritchard
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We present a generic approximation algorithm for packing integer programs. For vertex-capacitated multicommodity flow in trees we get a $1 + O(1/u)$-approximation algorithm where u is the minimum capacity; this new result is asymptotically best possible. More generally, when “iterated relaxation” applies to $\max\{cx \mid Ax \leq b, x \leq d\}$ we get a $1 + O(1/b_{\min})$-approximation for large enough $b_{\min}$. The key is using an LP-relative approximation algorithm for $\min\{cx \mid Ax \geq b', x \leq d'\}$ to counteract the additive violation introduced by iterated relaxation.

Lower Bounds and Hardness of Approximation for the Propagation Problem

Ashkan Aazami
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The Propagation problem is a new graph covering problem that have applications in different contexts including rank of adjacency matrices, controlling quantum networks, and monitoring electric power networks. (In the linear algebra literature the problem is called the Zero Forcing Set problem.) We show that the path-width parameter from the graph minor theory is a lower bound for the optimal value. We present a strong hardness of approximation result for the Propagation problem.

Graph Balancing via Weighted Eulerian Orientations

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Joint work with Julia Chuzhoy (Toyota Technological Institute at Chicago) and Sanjeev Khanna (University of Pennsylvania)

Given a weighted undirected graph we consider the problem of finding the orientation of edges which maximizes the minimum weighted in-degree. If the graph is unweighted this problem can be solved in polynomial time. However, in the weighted case we show that it is NP-hard to approximate the optimum to a factor better than 2. We give a factor 2 algorithm for this problem and the main technical tool is a generalization of Eulerian orientations to weighted graphs.

Maximum Cardinality Resonant Sets and Maximal Alternating Sets of Hexagonal Systems

Khaled Salem
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Joint work with Sandi Klavzar and Andrej Taranenko

In hexagonal systems, maximum cardinality resonant sets and maximal alternating sets are canonical and the proofs are analogous and lengthy. A conjecture is proposed and it is shown that the validity of the conjecture allows two short proofs of the aforementioned two results. A proof of the conjecture for catacondensed hexagonal systems is given. Also, the conjecture is verified on computer for normal hexagonal systems up to nine hexagons.

Minor-Embedding in Adiabatic Quantum Computation

Vicky Choi
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Adiabatic Quamtum Computation was proposed by Farhi et al. in 2000. In this talk, we will discuss some graph minor related problems. In particular, we will show how to solve the NP-hard quadratic unconstrained binary optimization problem on a graph G by reduction through minor-embedding of G in an adiabatic quantum computer that implements an Ising spin-$\frac{1}{2}$ Hamiltonian. We will also discuss the minor-universal quantum architecture design problem.

Lit-Only and Regular Switching in a Graph

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Each vertex in a graph is on or off. In the open (closed) sigma-game, you can "toggle" a vertex v which changes the state of each vertex in the open (closed) neighborhood of v. The object is to minimize the number of on vertices by a sequence of toggles. In the lit-only variations of these games only on vertices can be toggled. We show this restriction makes essentially no difference in the closed game, but a big difference in the open game.

Wednesday May 27 ⋄ *mercredi 27 mai*
15:20 – 17:25 S1-131

CTS-14

Matchings ⋄ *Couplages*

Blockers and Transversals

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Given an undirected graph $G = (V, E)$ with matching number $\nu(G)$, we de fine d-blockers as subsets of edges B such that $\nu\big((V, E/setminusB)\big) \leq \nu(G) - d$. We de fine d-transversals T as subsets of edges such that every maximum matching M has $|M \cap T| \geq d$. We explore connections between d-blockers and d-transversals. Special classes of graphs are examined which include complete graphs, regular bipartite graphs, grid graphs and trees, and we construct minimum d-transversals and d-blockers in these special graphs.

2-Factors of Bipartite Graphs with Asymmetric Minimum Degrees

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Joint work with L. DeBiasio and H. Kierstead

We discuss minimum degree conditions for a bipartite graph to contain an arbitrary 2-factor. In particular, we present ideas used to show that a balanced bipartite graph G on $2n$ vertices in which the sum of minimum degrees is at least $n + k$ contains any 2-factor with k components. Our proof uses the regularity lemma and the blow-up lemma.

Disjoint Matchings in Cubic Graphs

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For $i = 1, 2, 3$ and a cubic graph G let $\nu_i(G)$ denote the maximum number of edges that can be covered by i matchings. We show that $\nu_2(G) \geq \frac{4}{5}|V(G)|$, $\nu_3(G) \geq \frac{7}{6}|V(G)|$ and

$$\nu_2(G) + \nu_3(G) \geq 2|V(G)|.$$

which implies that there is no a single graph attaining the last two bounds.

Our methodology allows us to prove that $\nu_2(G) \leq \big(\nu_1(G) + \nu_3(G)\big)/2$ provided that G contains a perfect matching.

An Elementary Enumeration of Perfect Matchings on $2 \times n$ Grid Graphs on Surfaces

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It is well known that the number of edge-labeled perfect matchings of a $2 \times n$ planar grid graph is the $(n + 1)$st Fibonacci number. The number of edge-labeled perfect matchings of grid graphs on surfaces has been computed using Pfaffians, matching polynomials, and generating functions. In this talk we will present an elegant and elementary approach to enumerating edge-labeled perfect matchings of $2 \times n$ grid graphs on surfaces.

A New Characterization of König – Egervary Graphs

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A König – Egervary (KE) graph is one where the independence number α and matching number μ sum to the number of vertices of the graph. These graphs include the bipartite graphs and were first characterized by Deming in 1979.

The critical independence number α' of a graph is the cardinality of a maximum independent set I, where $|I| - |N(I)| \geq |J| - |N(J)|$, for any independent set J.

DeLaVina's program Graffiti.pc conjectured that a graph is KE if, and only if, $\alpha' = \alpha$. We give a proof of this conjecture.

Thursday May 28 ⋄ *jeudi* 28 *mai*
9:00 – 9:50 S1-151

PT-06

Plenary Talk ⋄ *Conférence plénière*

Modular Ranks and Smith Normal Forms of some Incidence Matrices

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The results discussed here are mainly from the joint work of David Chandler, Peter Sin and myself.

In this talk, we will survey some recent results on p-ranks and Smith normal forms of some incidence matrices arising from combinatorial design theory and finite geometry.

Let V be an $(n+1)$-dimensional vector space over GF(q), where $q = p^t$, p is a prime. For $1 < r \leq n$, let $A^n_{1,r}(q)$ be the $(0,1)$-incidence matrix with rows and columns respectively indexed by the r- and 1-dimensional subspaces of V, and with (X, Y)-entry equal to one if and only if the 1-dimensional subspace Y is contained in the r-dimensional subspace X. We will discuss recent work on the complete determination of the Smith normal form of $A^n_{1,r}(q)$.

Furthermore assume that $n+1 = 2m \geq 4$ and equip V with a nonsingular alternating bilinear form $\langle \cdot, \cdot \rangle$. Let $\mathcal{I}_r$ denote the set of totally isotropic r-dimensional subspaces of V with respect to $\langle -, - \rangle$, where $1 \leq r \leq m$. The *symplectic polar space* Sp$(2m, q)$ is the geometry with flats $\mathcal{I}_r$, $1 \leq r \leq m$. We will discuss recent results on the p-ranks of the incidence matrices between points and flats of Sp$(2m, q)$.

Thursday May 28 ⋄ *jeudi* 28 *mai*
10:20 – 12:25 S1-151

IM-09

Combinatorial Design Theory II
Combinatoire des plans d'expérience II

Constructions and Bounds on $(m, 3)$-Splitting Systems

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Let m and t be positive integers with $t \geq 2$. An (m, t)-*splitting system* is a pair $(X, \mathcal{B})$ where $|X| = m$ and $\mathcal{B}$ is a collection of subsets of X called *blocks*, such that, for every $Y \subseteq X$ with $|Y| = t$, there exists a block $B \in \mathcal{B}$ such that $|B \cap Y| = \lfloor t/2 \rfloor$. An (m, t)-splitting system is *uniform* if every block has size $\lfloor m/2 \rfloor$. We review some of the old constructions and give some new constructions.

Searching for Steiner Triple System with no Parallel Classes

Ben Li
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In this talk, I will discuss my search for STS with no parallel classes. I will discuss what is known currently, and illustrate some of the techniques that I have used to find such designs. Finally, I will discuss search techniques that I have applied to seek out these designs.

Combinatorial Batch Codes

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Based on joint work with M. Paterson and R. Wei

This talk concerns batch codes, which were introduced by Ishai, Kushilevitz, Ostrovsky and Sahai at STOC 2004. A batch code specifies a method to distribute a database of n items among m devices (servers) in such a way that any k items can be retrieved by reading at most t items from each of the servers. It is of interest to devise batch codes that minimize the total storage, denoted by N.

We restrict out attention to batch codes in which every server stores a subset of the items. This is purely a combinatorial problem, so we call this kind of batch code a "combinatorial batch code." We only study the special case $t = 1$, where, for various parameter situations, we are able to present batch codes that are optimal with respect to the storage requirement, N. We also study uniform codes, where every item is stored in precisely c of the m servers. Interesting new results are presented in the cases $c = 2$, $k-2$ and $k-1$. In addition, we obtain improved existence results for arbitrary fixed c using the probabilistic method.

Skolem Sequences: From Coloured Blocks to Communication Networks

Catharine Baker
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A Skolem sequence is an integer sequence $(s_1, \ldots, s_{2n})$ with entries taken from the set $A = \{1, 2, \ldots, n\}$ such that for each $a \in A$, there exists a unique i with $a = s_i = s_{i+a}$. Historically, Skolem sequences have been used to construct cyclic Steiner triple systems. We discuss other more general Skolem-type sequences and examine their relationships with designs and with graph-labeling.

Decomposing Triples into Cyclic Designs

R. Wei
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Joint work with Z. Tian (Hebei Normal University)

Motivated by the construction of cyclic simple designs, we consider how to decompose all the triples of Z_v into cyclic triple systems. Furthermore, we define a large set of cyclic triple systems to be the decomposition of triples of Z_v into indecomposable cyclic designs. Constructions of decompositions and large sets are given. Some infinite classes of decompositions and large sets are obtained from these constructions. Large sets of small v with odd $v < 97$ are also given, many of which are obtained by some computer algorithms. The results are used to construct cyclic simple triple systems which can be applied for optical orthogonal codes.

Thursday May 28 ⋄ *jeudi* 28 *mai*
10:20 – 12:25 Z-310

CM-12

Constraint Satisfaction Problems
Satisfaction de contraintes

Constraint Satisfaction Problems of Bounded Width I & II

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Establishing local consistency is one of the basic principles for solving constraint satisfaction problems (CSPs). A characterisation of relational structures B such that one can always decide the existence of a homomorphism from a given structure A to B by establishing some (fixed) level of local consistency on (A, B) was a long-standing open problem in the theory of CSP. Equivalently, such structures B have bounded tree-width duality, which means that, for any structure A not homomorphic to B, there is a structure C of bounded tree-width such that C is homomorphic to A, but not to B. The Larose – Zadori conjecture (in one of its forms) states that a structure B has bounded tree-width duality iff it has a sequence of certain algebraic operations (weak near-unanimity polymorphisms) that preserve the structure. In this talk, we present our recent (positive) solution of this conjecture.

The Complexity of Global Cardinality Constraints

Andrei Bulatov
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Joint work with Daniel Marx

In a constraint satisfaction problem (CSP) the goal is to find an assignment of a given set of variables subject to specified constraints. A global cardinality constraint is an additional requirements that prescribes how many variables must be assigned a certain value. We study the complexity of the problem CCSP(Γ), the constraint satisfaction problem with global cardinality constraints that allows only relations from the set Γ. The main result of this paper characterizes sets Γ that give rise to problems solvable in polynomial time, and states that the remaining such problems are NP-complete. We also characterized the corresponding counting problems solvable in polynomial time.

Arc Consistency and Friends

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Joint work with Berit Grussien, Manuel Bodirsky, and Victor Dalmau

I hope to give an overview of a line of work that studies arc consistency and extensions thereof. This line has roots in (Feder & Vardi) and (Dalmau & Pearson '99) and has continued, for example, in (Chen & Dalmau '04), (Bodirsky & Chen, PAC), and (Chen, Dalmau & Grussien, forthcoming). One notable and fairly unique feature is that algebraic characterizations are given for many of these algorithms (by which we mean, the condition of the algorithm solving CSP(B) can be described as a simple algebraic condition on B), which highly facilitates understanding the class of structures on which the algorithm works and the application of algebraic techniques. I would like to discuss the various algorithms and the relationships among them, a recent general result (singleton arc consistency solves bounded-width conservative CSPs), and give an outlook on future research in this direction.

The Complexity of the List Homomorphism Problem for Graphs

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Joint work with Andrei Krokhin, Benoit Larose, and Pascal Tesson

We completely characterize the class of graphs for which the list homomorphism problem is in Logspace. Together with previous results, it implies that for every graph H, the list homomorphism problem is either NP-complete, NL-complete, L-complete or has finite duality. The central result is an inductive definition of graphs whose list homomorphism problem is solvable in Logspace. We obtain both algebraic and combinatorial characterizations. A characterization by forbidden (induced) subgraphs is given as well. In particular, the reflexive graphs whose list homomorphism problem is in Logspace are the trivially perfect graphs, or equivalently the graphs that contain no induced path of length three and no cycle of length four. In the irreflexive case, an analogous result is obtained: those with a list homomorphism problem in Logspace are the bipartite graphs that contain no induced path of length five and no cycle of length six. The general case can also be characterized by a set of forbidden subgraphs.

Thursday May 28 ⋄ *jeudi* 28 *mai*
10:20 – 12:25 Z-350

CM-13

Broadcasting and Gossiping in Graphs
Diffusion et échange total dans les graphes

Topics Involving Broadcasts in Graphs

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We say that a function $f\colon V \to \{0, 1, \ldots, \mathrm{diam}(G)\}$ is a *broadcast* if for every vertex $v \in V$, $f(v) \le e(v)$, where diam(G) denotes the diameter of G and $e(v)$ denotes the eccentricity of vertex v. The *cost* of a broadcast is the value $f(V) = \sum_{v \in V} f(v)$. In this talk we discuss (i) the minimum costs of several types of broadcasts in graphs, including dominating, independent and efficient broadcasts, reflecting joint work by Dunbar, Erwin, Haynes, S.M. Hedetniemi and the author; (ii) the recent discovery by Heggernes and Lokshtanov that the minimum cost of a broadcast in an arbitrary graph, called the *broadcast domination number*, can be computed in $O(n^6)$ time; (iii) the development by Dabney, Dean and the author, of a sophisticated algorithm for computing the broadcast domination number of any tree in linear time, and (iv) a recent characterization by Herke and Mynhardt of the class of *radial* trees, whose minimum cost broadcast can be achieved by placing one broadcast vertex at the center of a tree. Time permitting we will also discuss the *broadcast chromatic number* $\chi_b(G)$ of a graph G, introduced by Goddard, S.M. Hedetniemi, Harris, Rall and the author, where $\chi_b(G)$ equals the minimum value k such that there exists a broadcast coloring function $C\colon V \to \{1, 2, \ldots, k\}$ such that if $C(u) = C(v)$ then the distance between u and v satisfies $d(u, v) > C(u)$.

Broadcasting from Multiple Originators: A Census

Dana Richards
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Joint work with Art Liestman

We begin an investigation of broadcasting from multiple originators, a variant of broadcasting in which any k vertices may be the originators of a message in a network of n vertices. The requirement is that the message be distributed to all n vertices in minimum time. In particular, we consider multiple originator minimum broadcast graphs. We provide a census of cases for which exact results are known.

Epidemics in Communication Networks

Joseph Peters
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Joint work with Francesc Comellas and Margarida Mitjana

The two main characteristics of small-world networks are significant local clustering and small diameter. These two characteristics are desirable properties in communication networks because typical communication patterns show large amounts of local communication and a small amount of nonlocal communication that must be completed quickly. Unfortunately, the structural characteristics of small-world networks also allow computer viruses and other epidemics to spread quickly.

In this talk, I will use a parameterized deterministic model that can be adjusted to model different ways that a virus can spread in a communication network. Several previously studied models of broadcasting in communication networks are special cases. I will concentrate on a class of circulant graphs that can be augmented to produce small-world networks. I will present lower bounds on the minimum time for a virus to spread to all nodes of these graphs and optimal infection patterns that achieve these bounds. I will also consider the problem of stopping an epidemic after it has started. I will show that every pattern by which an epidemic can spread will infect all nodes.

On Broadcasting, Neighbourhood Broadcasting, and Whitney Numbers of the Second Kind

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Joint work with E. Cheng and Z. Shen

In various communication schemes such as broadcasting and neighbourhood broadcasting, one needs to compute certain bounds. For example, in the k-neighbourhood broadcasting, one such bound is the minimum time required for such a broadcasting. This requires us to know the number of nodes at distance i, for $1 \leq i \leq k$, to the broadcasting node.

These numbers are referred to as the Whitney numbers of the second kind. We discuss the problem of computing these numbers in general and present results for some of the interconnection networks. In addition, we will describe several approaches to this problem that are general enough to be applied to other networks.

Construction of Broadcast Graphs

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Some of the reported results presented in joint works with A. Liestman and X. Xu

Broadcast graph or bg on n vertices is a graph that has broadcast time $\log n$ – minimum possible broadcast time for a graph on n vertices. Minimum broadcast graph or mbg is a broadcast graph with minimum possible number of edges. This minimum possible number of edges is denoted by $B(n)$. mbg represent the cheapest possible network in which broadcast time is theoretical minimum. It is difficult to find $B(n)$ for an arbitrary value of n. Here we will present some methods to construct broadcast graphs for any value of n that actually give upper bounds on $B(n)$. Some of these bounds seem to be tight.

Thursday May 28 ⋄ *jeudi* 28 *mai*
10:20 – 12:25 AA-6214

CTS-15

Graph Colouring and Algorithms
Coloration des graphes et algorithmes

Star Avoiding Ramsey Numbers

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For graph Ramsey number $R(G, H) = r$ what is the largest star such that we can leave its edges uncolored in two coloring the complete graph on r vertices and still force a red G or blue H? For G and H complete this is not interesting, all edges must be colored. We determine values for some special cases of G and H (paths, cycles) where $R(G, H)$ is known.

Counting as an Efficient Method for Computing the Distinguishing Numbers of Graphs

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A vertex k-coloring of graph G is distinguishing if it destroys all non-trivial automorphisms of G. The distinguishing number of G, $D(G)$, is the smallest k so that G has a distinguishing k-coloring.

We consider a technique for computing $D(G)$ that finds the smallest k for which the number of inequivalent distinguishing k-colorings of G is nonzero. We sketch how it can be implemented and why it leads to efficient algorithms for computing $D(G)$ when G is a planar or interval graph.

On Graphs that are Determined by their Chromatic Polynomials

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Let G be a finte graph having neither loops nor multiple edges. Let $P(G;\lambda)$ denote its chromatic polynomial. Two graphs are said to be *chromatically equivalent* if they share the same chromatic polynomial. The *chromatic equivalence class* of a graph G is the set of all graphs having the same chromatic polynomial as that of G. We shall present some recent results concerning the chromatic equivalence classes of graphs.

Recognizing Overlap Graphs of Paths in a Tree with Fixed Maximum Degree

Jessica Enright
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Joint work with Martin Pergel (Charles University in Prague)

A graph $G = (V,E)$ is the overlap graph of a set family $\mathcal{S}$ if there is a bijection $f\colon V \to \mathcal{S}$ such that vertices $u, v \in V$ are adjacent if and only if $f(u)$ overlaps $f(v)$. We prove that, for a fixed integer $k \geq 3$, deciding if a graph is the overlap graph of paths in some tree with maximum degree k is NP-complete.

Smallest Odd Holes in Claw-Free Graphs

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Joint work with Shimon Shrem and Martin Golumbic

In this talk we present theoretical results that lead to a polynomial algorithm for detecting smallest odd holes in claw free graphs. We define and prove structural properties of shortcuts and minimal shortcuts of a hole. These structural properties are the main basis of the algorithm. The technical aspect of the algorithm is based on a variation of a BFS on the Gallai forcing of a graph.

Thursday May 28 ⋄ *jeudi* 28 *mai*
10:20 – 12:25 AA-5340

CTS-16

Matroids, Spectral Methods, Extremal Graph Theory
Matroïdes, méthodes spectrales et théorie extrémale des graphes

On Even-Cycle-Free Subgraphs of the Hypercube

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Joint work with Zoltán Füredi

Given graphs P and Q, the generalized Turan number $\mathrm{ex}(Q,P)$ denotes the maximum number of edges of a P-free subgraph of Q. Erdős (1984) conjectured that $\mathrm{ex}(Q_n,C_4) = \big(\frac{1}{2} + o(1)\big)e(Q_n)$, where $e(Q_n)$ is the number of edges in the hypercube Q_n. Fan Chung showed an upper bound $0.623\,e(Q_n)$ and that $\mathrm{ex}(Q_n,C_6) \geq 0.25\,e(Q_n)$, moreover that $\mathrm{ex}(Q_n,C_{4k}) = o\big(e(Q_n)\big)$ for $k \geq 2$. There are further results by Alon et al., Axenovich et al., Thomason et al., and more. We show that $\mathrm{ex}(Q_n,C_{4k+2}) = o\big(e(Q_n)\big)$ for $k \geq 3$. The case $\mathrm{ex}(Q_n,C_{10})$ remains open.

On Packing Bases in Matroids

Robert Bailey
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We consider matroids where the size of the smallest minimal cocircuit is equal to the maximum number of disjoint bases, and provide a description of the structure of such matroids.

This generalises earlier work for graphs where the edge-connectivity is equal to the maximum number of edge-disjoint spanning trees.

Lower Bounds for Boxicity

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Joint work with L. Sunil Chandran and Naveen Sivadasan

An axis-parallel b-dimensional box is a Cartesian product $R_1 \times R_2 \times \cdots \times R_b$, where R_i is a closed interval of the form $[a_i, b_i]$ on the real line. Suppose G is an undirected simple graph, its boxicity $\mathrm{boxi}(G)$ is the minimum dimension b, such that G is representable as the intersection graph of boxes in b-dimensional space. We have developed lower bounds for boxicity based on the concepts of (1) interval completion and (2) isoperimetric properties of a graph. Applying this method we derive several results, some of which are listed below:

(1) The boxicity of a graph on n vertices with no universal vertices and minimum degree δ is at least $n/2(n-\delta-1)$. We construct an example to demonstrate the tightness of the result. Some immediate consequences of this result are as follows: (1) The boxicity of $(n-k-1)$-regular coplanar graphs is at least $n/8$. (2) The boxicity of the complement of a cycle on n vertices is at least $n/3$.

(2) Consider the $\mathcal{G}(n,p)$ model of random graphs. Let p be such that $c_1/n \leq p \leq 1 - c_2(\log n)/n^2$, where c_1 and c_2 are predetermined constants. Then, for almost all $G \in \mathcal{G}(n,p)$, $\mathrm{boxi}(G) = \Omega(np(1-p))$. On setting $p = \frac{1}{2}$ we immediately infer that almost all graphs have boxicity $\Omega(n)$. This is interesting considering the fact that boxicity of any graph is at most $n/2$.

(3) Applying spectral methods, we show that the boxicity of random k-regular graphs on n vertices (where k is fixed) is $\Omega(k/\log k)$.

A Base Exchange Property for Regular Matroids

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In 1978, White conjectured that for any two bases B and B' of a regular matroid, there is an element $e \in B$ such that there is a unique element $f \in B'$ for which both $(B \setminus \{e\}) \cup \{f\}$ and $(B' \setminus \{f\}) \cup \{e\}$ are bases of M. In this talk, we outline a proof of this conjecture.

On Graham's Tree Reconstruction Conjecture

Bill Kay
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Joint work with Joshua Cooper

Suppose G is a tree. If we are given only the integer sequence $(|V|, |V^1|, |V^2|, \dots)$ where $V^k = V(L^k(G))$ is the kth iterated line graph's vertex set, is it possible to determine the original tree? This question ("Graham's Tree Reconstruction Conjecture") has only been answered for very limited classes of graphs. We study a closely related problem: Define A_G, the *adjacency matrix* of a graph G on n vertices, as the $n \times n$ matrix $\{a_{i,j}\}_{i,j=1}^n$ with $a_{ij} = 1$ if $\{i,j\} \in E(G)$, 0 otherwise. Denote by W_k the quantity $\mathbf{1}^\mathsf{T} A_G^k \mathbf{1}$, where $\mathbf{1}$ is the all 1's vector, i.e., the number of walks of length k in G. Call the sequence $\{W_k\}_{k=0}^\infty$ the *walk sequence* of a graph. We conjecture that if T_1 and T_2 are trees, then they have identical walk sequences iff they are isomorphic. We apply ideas from spectral and fractional graph theory to obtain results about this question and its connection to the original problem.

Thursday May 28 ⋄ *jeudi* 28 *mai*
14:00 – 14:50 S1-151

PT-08

Plenary Talk ⋄ *Conférence plénière*

Program Obfuscation and One-Time Programs

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Program obfuscation is the process of taking a program as an input and modifying it so that the resulting program has the same I/O behavior as the input program but otherwise looks 'completely garbled' to the entity that runs it, even if this entity is adversarial and has full access to the program. Impossibility results, originating with the work of Barak et al. in 2001, have been proved that assert that several strong (albeit natural) formulations of obfuscation are impossible to achieve for general programs. That is, there is no generic mechanism that can successfully obfuscate large classes of programs.

Yet, even more recent results by Goldwasser, Kalai, and Rothblum have pointed out a way in which, in spite of these generic impossibility results, the basic concept of program obfuscation is obtainable in certain settings. One setting on which we will elaborate is of *one-time programs*: programs that can be executed only a restricted and pre-specified number of times. Naturally, these programs cannot be achieved using software alone. We show how to build them using 'simple' and 'universal' secure memory components.

One-time programs serve many of the same purposes of program obfuscation, the obvious one being software protection. However, the applications of one-time programs go well beyond those of obfuscation, since one-time programs can only be executed once (or more generally, a limited number of times) while obfuscated programs have no such bounds. For example, one-time programs lead naturally to temporary delegation of cryptographic ability, electronic token schemes such as subway tokens, and to "one-time proofs":proofs that can only be verified once and then become useless and unconvincing. We show how to use a classical witness and simple secure memory to efficiently construct such "one-time proofs" for any NP statement.

Thursday May 28 ⋄ *jeudi* 28 *mai*
15:20 – 17:25 S1-151

CM-14

Colourings, Homomorphisms, and Beyond
Colorations et homomorphismes

Colourings, Homomorphisms, and Constraint Satisfaction Problems Overview

Richard BREWSTER
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Generalized graph colourings are well studied objects with an extensive literature. The (unifying) language of graph homomorphisms captures many of these generalizations including colouring extensions, restricted colourings, and list colourings. However, graph homomorphisms are natural mathematical objects in their own right, of which colouring is but one application. Moreover, graph homomorphisms may be viewed as specific examples of a still more general setting, namely Constraint Satisfaction Problems, or CSPs.

In this talk we will give a brief introduction to graph homomorphisms and their basic properties. We emphasize the place of graph homomorphisms within the contexts of generalized colourings and CSPs.

On Distance-*t* Edge Colourings and Induced Matchings

Ross KANG
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Joint work with Putra Manggala

Given a graph G and a nonnegative integer t, we consider the distance-t chromatic index of G, which is defined as follows. A *distance-t edge colouring of G* is an edge colouring of G such that edges at distance at most t are required to take different colours. Note that for $t = 0$ this is simply proper edge colouring, while the case $t = 1$ is known as strong edge colouring. The distance-t chromatic index $\chi'_t(G)$ of G is the least number of colours needed in a distance-t edge colouring of G. (Equivalently, $\chi'_t(G)$ is the chromatic number of the t-th power of the line graph of G.)

We wish to propose a distance-t analogue of the Erdős – Nešetřil conjecture (on the strong chromatic index), as well as present some related results on random graphs.

The Canonical Coloring Graph

Ruth HAAS
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Given a graph G, a Canonical Coloring Graph Can(G) has vertex set the set of all nonisomorphic colorings of the graph G, where the representative of each set of isomorphic colorings are chosen according to a canonical ordering. There is an edge between two colorings if they are identical on $V(G - x)$ for some $x \in V(G)$. Can(G) varies depending on the choice of canonical representatives. In this talk we explore properties of Can(G).

Injective Colourings and Homomorphisms of Oriented Graphs

Nancy CLARKE
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There are several possible definitions of an injective homomorphism of a digraph G to a digraph H. Each of them leads to a colouring parameter for oriented graphs by defining the injective oriented chromatic number of an oriented graph G to be the smallest number of vertices in an oriented graph H for which there is an injective homomorphism of G to H. One possible choice leads to colourings (proper or not) that are injective on both in-neighbourhoods and out-neighbourhoods separately. We will consider these possibilities and the associated colouring parameters that arise from them in terms of complexity, obstructions, critical graphs and bounds.

Weak Near-Unanimity Functions and NP–Completeness

Jacobus SWARTS
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Joint work with Gary MacGillivray

If H is a digraph, the problem of deciding whether a given digraph G has a homomorphism to H is known as the H-colouring problem. During the last decade a new approach to studying the complexity of the

H-colouring problem has emerged. This approach focuses attention on so-called weak near-unanimity functions (WNUFs). A conjecture of Bulatov, Jeavons and Krokhin states that if a digraph H has a WNUF, then the H-colouring problem is in P, otherwise (if it doesn't have one) H-colouring is NP-complete (the latter part is already known).

While we don't prove this conjecture, we provide some evidence that suggests it is true. In particular we show that the polynomial cases of H-colouring identified by Gutjahr, Woeginger and Welzl all have a WNUF. On the other hand we develop analogs of the indicator and sub-indicators of Hell and Nešetřil, tailored to WNUFs. This has the interesting implication that every NP-completeness proof of H-colouring now has a no-WNUF proof provided we can show that the base cases (where NP-completeness is proved directly) can be handled separately. We then apply this idea to give another proof that the conjecture is true for undirected graphs, and also for several classes of digraphs.

Thursday May 28 ⋄ *jeudi* 28 *mai*
15:20 – 17:25 Z-310

CM-15

On Graphs with Crossings
Sur les croisements dans les graphes

Crossings, Colorings, and Cliques

Daniel W. CRANSTON
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Joint work with Michael O. Albertson and Jacob Fox

Albertson conjectured that if graph G has chromatic number r, then the crossing number of G is at least that of the complete graph K_r. This conjecture in the case $r = 5$ is equivalent to the four color theorem. It was verified for $r = 6$ by Oporowski and Zhao. Here we prove the conjecture for $7 \leq r \leq 12$ using results of Dirac; Gallai; and Kostochka and Stiebitz that give lower bounds on the number of edges in critical graphs, together with lower bounds by Pach et al. on the crossing number of graphs in terms of the number of edges and vertices.

Geometric Homomorphisms, Part I

Sally COCKBURN
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Joint work with Debra Boutin

A *geometric graph* $\overline{G}$ is a simple graph G together with a fixed straightline drawing in the plane. A *geometric realization* of an abstract graph G is a geometric graph whose underlying abstract graph is G. This talk refines the notion of graph homomorphism to that of geometric graph homomorphism. Each abstract graph G has a *homomorphism poset* which displays how its geometric realizations are homomorphic to each other. This talk will provide homomorphism posets for certain small complete and complete bipartite graphs. It will also provide criteria for a geometric graph $\overline{G}$ to be geometrically homomorphic to particular geometric realizations of $K_{2,2}$ and $K_{3,3}$.

Geometric Homomorphisms, Part II

Debra BOUTIN
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Joint work with Sally Cockburn

A *geometric graph* $\overline{G}$ is a simple graph G together with a fixed straightline drawing in the plane. A *geometric realization* of an abstract graph G is a geometric graph whose underlying abstract graph is G. This talk continues the introduction to geometric graph homomorphism begun in Part I above. The *geochromatic number* of a geometric graph is the smallest integer n so that there is a geometric homomorphism from $\overline{G}$ to some geometric realization of K_n. In this talk, we will provide both necessary conditions and sufficient conditions for a geometric graph to have geochromatic number at most 4. Examples will be given to show that none of the these sets of conditions is both necessary and sufficient. Further, this talk will refine the notion of graph homomorphism duality to that of geometric graph homomorphism duality and rephrase certain results from Part I and Part II in terms of duality.

Coloring Plane Graphs with Independent Crossings

Daniel KRÁL'
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Joint work with Ladislav Stacho (*Simon Fraser University*)

The famous Four Color Theorem asserts that every graph that can be drawn in the plane with no crossings is 4-colorable. It is natural to ask what number of colors is needed to color graphs that can be embedded in the plane with a restricted number of crossings, e.g., it is known that six colors suffice if every edge is crossed by at most one edge. In this talk, we consider the following strengthening of the previous condition: two distinct crossings are independent if the end-vertices of the crossed pair of edges are mutually different. In particular, if all crossings are independent, then each edge is crossed by at most one other edge. Albertson in 2008 conjectured that every graph that can be drawn in the plane with all its crossings independent is 5-colorable. We prove this conjecture.

Thursday May 28 ⋄ *jeudi 28 mai*
15:20 – 17:25 Z-350

CTS-17
Designs and Codes
Codes et plans d'expérience

How to Construct $(v, k, \cdot)$-Designs Fast and Easily

Anamari Nakic
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Combining two well-known different methods of construction, we were able to get new $(v, k, \cdot)$-designs. We used mainly the Kramer – Mesner method, as well as particular information gained from tactical decompositions attained by actions of assumed automorphism groups. We observed mostly nonabelian automorphism groups (for example of order 21) and using GAP and the software developed by V. Krcadinac, we were able to construct many new examples of 2-designs.

Switching Operations and Binary Codes of Hadamard Matrices

William Orrick
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Each Hadamard matrix of size 8k is associated with a certain self-orthogonal binary linear code. Words in the code of weight 4 correspond to structures in the Hadamard matrix that can be modified by switching operations to produce nonequivalent Hadamard matrices. Furthermore, switching operations affect the code in predictable ways. I present some partial classification results based on these ideas.

Ghost Symmetries of Group Codes and their Projections

David Richter
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A proper projection of a group code may have symmetries not present in the symmetry group of the code. These are known as a "ghost symmetries." Moreover, in some circumstances, one may generate the symmetry group by considering symmetries of proper projections of a group code. This is the "symmetry-recovery property." Definitions and examples concerning these phenomena are provided. (This is a continuation of a talk given at the SIAM conference on Discrete Mathematics in June 2008.)

Circular Costas Arrays and Cyclotomic Permutations

Qiang Wang
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Costas arrays arise in sonar and radar applications and they also have applications to other combinatorial designs such as Tuscan arrays etc. In 1996 Golomb and Moreno showed that an $m \times m$ circular Costas array exisits if and only if an $m \times (m+1)$ polyogonal path circular Tuscan-m arrays exists. Using an existence result of $m \times (m+1)$ polyogonal path circular Tuscan-m arrays by Etzion, Golomb, and Taylor in 1984, they also obtained that an $m \times m$ circular Costas array exists if and only if $m+1$ is prime and conjectured that all circular Costas arrays are given by the well-known Welch construction. In this talk I explain a way of studying circular Costas arrays in terms of cyclotomic permutations and obtain some interesting necessary conditions on the indices of cyclotomic permutations that define circular Costas arrays.

Thursday May 28 ⋄ *jeudi 28 mai*
15:20 – 17:25 AA-6214

CTS-18
Labelings and Games
Jeux et étiquettes dans les graphes

Cops and Robber with Road Blocks

Matthew Musson
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Joint work with Adrian Tang

In this paper we examine the game of Cops and Robber with a new approach. This new approach will be the use of what we call road blocks for the Cops to use in their pursuit of the Robber. We present results for several trivial cases, provide a classification for trees which require zero road blocks, trees that require only one road block, extend the work to determine the road block number for complete bipartite graphs $K_{m,n}$, discuss the problems and obstacles of extending this work to arbitrary graphs, and discuss obstacles in developing an algorithm for searching trees.

Chasing Robbers on Random Graphs: Zigzag Theorem

Pawel Pralat
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We study the vertex pursuit game of Cops and Robbers where cops try to capture a robber loose on the vertices of the graph. The minimum number of cops required to win on a given graph G is the cop number of G. We present an asymptotic results for the game of Cops and Robber played on a random graph $G(n;p)$ for a wide range of $p = p(n)$. It has been shown that the cop number as a function of an average degree $d = d(n) = pn$ forms an intriguing zigzag shape.

(k,d) γ-Labeling

Grady Bullington
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In graph labeling, γ-labeling is a recent area of study. In this talk, we introduce a generalization of γ-labeling defined in a way that is natural to those familiar with (k,d)-graceful labelings. Among the results that will be presented, people outside the area may most enjoy the links between (k,d) γ-labelings, polygonal numbers, and the Connell sequence.

On Minimum and Maximum Values of γ-Labelings of Graphs

Linda Eroh
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Joint work with Grady Bullington and Steven J. Winters

A γ-labeling of a graph G of order n and size m is any labeling of the vertices with integers from the set $\{0, 1, 2, \ldots, m\}$, so that no label is used more than once. A γ-labeling induces a labeling of the edges. If $f(u)$ is the label assigned to vertex u, the edge uv has the induced label $|f(u) - f(v)|$. The value of a γ-labeling is the sum of the induced labels of its edges. For a graph G, $\mathrm{val}_{\max}(G)$ is the maximum value over all possible γ-labelings of G and $\mathrm{val}_{\min}(G)$ is the minimum value over all possible γ-labelings of G. The $\mathrm{val}_{\min}$ and $\mathrm{val}_{\max}$ were introduced by Chartrand, Erwin, VanderJagt, and Zhang. This talk presents some results about $\mathrm{val}_{\min}$ and $\mathrm{val}_{\max}$.

A Sequential Locating Game on Graphs

Suzanne Seager
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Consider the game of locating a marked vertex on a connected graph by repeatedly choosing a vertex of the graph as a probe, and receiving the distance from the probe to the marked vertex. The goal is to minimize the number of probes required. The static version of this game is the well-known problem of finding the metric dimension of the graph. We study the sequential version of this game, and the corresponding sequential location number.

Thursday May 28 ⋄ *jeudi* 28 *mai*
15:20 – 17:25 AA-5340

CTS-19

Enumeration II ⋄ *Énumération* II

Some Combinatorics Related to Central Binomial Coefficients: Grand-Dyck Paths, Coloured Noncrossing Partitions and Signed Pattern Avoiding Permutations

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We give some interpretations to certain integer sequences in terms of parameters on Grand-Dyck paths and coloured noncrossing partitions, and we find some new bijections relating Grand-Dyck paths and signed pattern avoiding permutations. Next we transfer a natural distributive lattice structure on Grand-Dyck paths to coloured noncrossing partitions and signed pattern avoiding permutations, thus showing, in particular, that it is isomorphic to the structure induced by the (strong) Bruhat order on a certain set of signed pattern avoiding permutations.

Enumerating Flat Folds

Thomas Hull
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We will survey recent progress on the problem of counting the number of ways a given origami crease pattern can fold flat (i.e., the number of valid mountain-valley assignments that exist for the creases). Surprising aspects of the single-vertex case and its configuration space will be included, as well as the challenges that arise with multiple-vertex crease patterns.

Chung – Feller Property in View of Generating Functions

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The classical Chung – Feller theorem is an elegant proof for enumerating of the Catalan number $c(n)$. The proof's scheme shows that the set of Dyck n-paths is one of $n+1$ blocks, which uniformly partition the class of free Dyck n-paths. It is trivial that the class of free Dyck n-paths has $(2n)!/n!n!$ elements; therefore $c(n) = (2n)!/n!(n+1)!$. In this work, our interests is less in the enumeration but more in the phenomenon that a sup-structure set can be equally partitioned such that one of the partition blocks is (isomorphic to) a well-known structure set. We call this phenomenon the Chung – Feller property. From a viewpoint of generating functions, we re-prove several known examples about Chung – Feller property, and also introduce many new examples, including the Catalan paths, the Motzkin paths, the large and the little Schroder paths.

A Quasisymmetric Decomposition of Schur Functions

Sarah Mason
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Joint work with Jim Haglund, Kurt Luoto, and Steph van Willigenburg

In this work, we define a new basis for quasisymmetric functions which is obtained from a specialization of nonsymmetric Macdonald polynomials. We describe several properties of this basis which are analogous to properties of the Schur functions including a multiplication rule that refines the Littlewood – Richardson Rule.

***k*-Flaw Preference Sets**

Jean Yeh
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In this paper, let $P(l;n;s;k)$ denote a set of k-flaw preference sets $(a_1; a_2; a_3; \ldots ; a_n)$ with n parking spaces satisfying that $1 \leq a_i \leq s$ for any i and $a_1 = l$ and $p(l;n;s;k) = |P(l;n;s;k)|$. We use a combinatorial approach to the enumeration of k-flaw preference sets by their leading terms. The approach relies on bijections between the k-flaw preference sets and labeled rooted forests. Some bijective results between certain sets of k-flaw preference sets of distinct leading terms are also given. We derive some formulas and recurrence relations for the sequences $p(l;n;s;k)$ and give the generating functions for these sequences.

Speaker Index ◇ *Index des présentateurs*

Monday May 25 ◇ *Lundi 25 mai*

	Z-315	Z-317	Z-337	Z-345	Z-350	S1-131
9:00	Opening Remarks ◇ *Ouverture* (S1-151)					
9:15	Sylvie Corteel (S1-151)					
10:05	Coffee Break ◇ *Pause-café*					
10:25	Gessel	Cioaba	Janssen	Novick	Cibulka	Anstee
10:50	Alvarez	Elzinga	Leskovec	Stacho	Reutenauer	Moura
11:15	Fusy	Williford	Percus	MacGillivray	Paquin	Gosselin
11:40	Irving	Meagher	Pržulj	S. Klein	Ar. Bergeron & Labbé	Phillips
12:05	Zeilberger	Newman	D'Souza		Labbé	Mamroth
12:30	Lunch ◇ *Dîner*					
14:00	Dannie Durand (S1-151)					
14:50	Coffee Break ◇ *Pause-café*					
15:20	An. Bergeron	Mohar	Bender	Jacobson	Meszaros	
15:45	Sankoff	Yu	Canfield	Navarra	Sawada	
16:10	Blanchette	Kostochka	Martínez	Owen	Williams	
16:35	Lajoie	Norine	Viola	Boudhar	K. Cameron	
17:00	El-Mabrouk	Král'	Panario	Szeto	Sajna	
17:25	Ouangraoua	Lesniak				
18:00	Reception ◇ *Réception* (Agora Morris et Rosalind Goodman)					

Tuesday May 26 ◇ *Mardi 26 mai*

	S1-151	Z-220	Z-310	Z-330	AA-6214	AA-5340
9:00	Joel Spencer (S1-151)					
9:50	Coffee Break ◇ *Pause-café*					
10:20	Moser	Hulbert	Friedman	Au	Collins	Kamali
10:45	Frieze	Herscovici	Khatirinejad	Guay-Paquet	Macajova	Burgess
11:10	Bohman	Milans	Craigen	Vaslet	Epple	Škoviera
11:35	Fountoulakis	Bekmetjev	Garaschuk	Klouda	Seyffarth	López
12:00	McDiarmid	Godbole	Dukes	Abrams	King	Das
12:25	Lunch ◇ *Dîner*					
14:00	Carsten Thomassen (S1-151)					
14:50	Coffee Break ◇ *Pause-café*					
15:20	Haxell	Lam	Medvedev	Ruskey	Sands	
15:45	Hell	Stanton	Bultena	Panholzer	Nasserasr	
16:10	Kawarabayashi	Östergård	Omar	Kayll	Eschen	
16:35	Goddyn	Bennett	McQuillan	Walsh	Edwards	
17:00	Samal	Pike	Lim		Kelkar	
17:25	Hutchinson				A. Finbow	

S1: Pavillon Jean-Coutu   Z: Pavillon Claire-McNicoll   AA: Pavillon André-Aisenstadt

Wednesday May 27 ◇ *Mercredi 27 mai*

	S1-125	Z-210	Z-260	Z-345	Z-350	S1-131
9:00	Jesús A. De Loera (S1-151)					
9:50	Coffee Break ◇ *Pause-café*					
10:20	Bremner	DeLaVina	Oellermann	Pittel	Goddard	
10:45	Bezdek	Brinkmann	McKee	P. Cameron	Verdian-Rizi	
11:10	Stephen	Graver	Hoàng	Richmond	Lidický	
11:35	Deza	Kocay	Dragan	Iosevich	Kochol	
12:00	Zinchenko	Woodcock	Brandstädt	Gao	Ghebleh	
12:25	Lunch ◇ *Dîner*					
14:00	Valérie Berthé (S1-151)					
14:50	Coffee Break ◇ *Pause-café*					
15:20	Bell	Daugherty	Busch	Hartnell	Pritchard	Ries
15:45	Cassaigne	Došlić	Hartke	Bokal	Aazami	Czygrinow
16:10	Franek	Caporossi	Ferrara	Benecke	Chakrabarty	Mkrtchyan
16:35	Shallit	Fowler	Kirkpatrick	Herke	Salem	Belcastro
17:00	Zamboni	D. Klein	Kahl	Cockayne	Choi	Larson
17:25			Schmitt	S. Finbow	J. Goldwasser	
19:00	Open Problem Session ◇ *Séance de problèmes* (Thomson House, McGill University)					
21:30	Jason Brown (Thomson House, McGill University)					
21:30	Student Reception ◇ *Réception des étudiants* (Thomson House, McGill University)					

Thursday May 28 ◇ *Jeudi 28 mai*

	S1-151	Z-310	Z-350	AA-6214	AA-5340
9:00	Qing Xiang (S1-151)				
9:50	Coffee Break ◇ *Pause-café*				
10:20	van Rees	Barto	Hedetniemi	Isaak	Özkahya
10:45	Li	Kozik	Richards	Cheng	Bailey
11:10	Stinson	Bulatov	Peters	Chia	Adiga
11:35	Baker	Chen	Qiu	Enright	McGuinness
12:00	Wei	Egri	Harutyunyan	Stern	Kay
12:25	Lunch ◇ *Dîner*				
14:00	Shafi Goldwasser (S1-151)				
14:50	Coffee Break ◇ *Pause-café*				
15:20	Brewster	Cranston	Nakic	Musson	Ferrari
15:45	Kang	Cockburn	Orrick	Pralat	Hull
16:10	Haas	Boutin	Richter	Bullington	Y. Yeh
16:35	Clarke	Král'	Wang	Eroh	Mason
17:00	Swarts			Seager	J. Yeh
17:25	Conference ends ◇ *Fin du congrès*				
19:00	Survivors' Party ◇ *Fête des survivants* (O PATRO VÝŠ)				

S1: Pavillon Jean-Coutu Z: Pavillon Claire-McNicoll AA: Pavillon André-Aisenstadt

Social Activities ◇ *Activités sociales*

Monday May 25 ◇ *lundi 25 mai*

Université de Montréal, Pavillon Jean-Coutu, Agora Morris et Rosalind Goodman

18:00: Reception ◇ *Réception*

Wednesday May 27 ◇ *Mercredi 27 mai*

McGill University, Thomson House, 3650 McTavish, Montréal

19:00: Open Problem Session ◇ *Séance de problèmes*

20:30: Lecture ◇ *Conférence*

Mathematics and Music
Jason Brown
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Mathematics and music are a match made in heaven. The ancient Greeks elevated both to the same level, and even the most unschooled rock musician uses more mathematics than he or she realizes. In this talk I'll survey some of the most interesting connections between mathematics and music, including:

- trigonometric identities and tunings
- small fractions and musical intervals
- circular seating arrangements, scales and rhythm guitar
- derivation of the blues and graph colourings
- the musical art of being ambiguous (or not)
- musical and mathematical transformations

I'll end off the talk with some applications of mathematics to musical mysteries surrounding The Beatles.

21:30: Student Reception ◇ *Réception des étudiants*

Thursday May 28 ◇ *Jeudi 28 mai*

O PATRO VÝŠ, 356 Mont-Royal Est, Montréal

19:30: Survivors' Party ◇ *Fête des survivants* (live music ◇ *musique* live)

CanaDAM 2009

SITE DE LA CONFÉRENCE / CONFERENCE SITE