40th Australasian Conference on Combinatorial Mathematics and Combinatorial Computing

Newcastle, Australia
12–16 December 2016

WELCOME

Welcome to 40ACCMCC—the 40th Australasian Conference on Combinatorial Mathematics and Combinatorial Computing. The organisers would particularly like to welcome participants who have travelled a long way to be here. 13 different countries are represented at the conference, and we hope many of you get the chance to have a look around Newcastle, and perhaps further afield, during your visit to Australia.

This conference follows the usual format of the annual ACCMCC series, which is overseen by the Combinatorial Mathematics Society of Australasia. A history of previous conferences in this series appears near the back of this booklet. This year we have nine invited talks and 81 contributed talks, of which 30 will be presented by students.

The Conference Dinner will be held on the evening of Thursday 10th December at NOAH's on the Beach, situated directly opposite spectacular Newcastle Beach, which is a 20 minutes walk from the conference venue.

The conference organisers include Brian Alspach, Thomas Kalinowski, Judy-anne Osborn and several local postgraduate students. We are also extremely grateful for the help given to us from many academic and administrative staff at the University of Newcastle, especially Juliane Turner and David Allingham. We'd also like to thank our sponsors for their generous support of the conference:

- the NSW Department of Industry,
- the office of the Deputy Vice Chancellor Research and Innovation at the University of Newcastle,
- the Institute for Combinatorics and Applications (ICA),
- the Combinatorial Mathematics Society of Australasia (CMSA),
- the PRC Computer Assisted Research Mathematics and Applications (CARMA).

All the organisers are grateful to you the participants for supporting the conference with your attendance, and for the many talks offered. We especially thank the invited speakers, some of whom have travelled from far away to be here, and the 30 students attending the conference. We wish you all a most enjoyable and constructive time here.

Thomas Kalinowski and Judy-anne Osborn, Directors, 40ACCMCC

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SUNDAY 11 DECEMBER

4:00 pm	**Welcome reception** 11 Nesca Parade, The Hill

MONDAY 12 DECEMBER

8:50 pm	**Opening address** UNH416		
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10:00 am	Morning Tea		
Room/ Chair	UNH416 Daniel Horsley	UNH419 Kerri Morgan	UNH421 Joe Ryan
10:30 am	**Rajko Nenadov** *Size-Ramsey numbers of bounded-degree triangle-free graphs* (p. 35)	**Bohao Yao** *Smallest 4-chromatic graph with odd-girth 7* (p. 50)	**Debi Oktia Haryeni** *Partition resolvability of homeomorphic trees* (p. 22)
11:00 am	**Rebecca Robinson** *Topological containment of the 5-clique minus an edge in 4-connected graphs.* (p. 39)	**Kiki A. Sugeng** *Antiadjacency Spectrum of Regular and Line (Di-)Graphs* (p. 45)	**Cyriac Grigorious** *Metric Dimension of Circulant Graphs* (p. 22)
11:30 am	**David Wood** *Edge-Maximal Graphs on Surfaces* (p. 49)	**Paul Manuel** *Propagation in carbon and boron nanotubes* (p. 32)	**Sudeep Stephen** *The zero forcing number of graphs with given girth* (p. 44)
12:00 pm	Lunch		
2:00 pm	**Nathan Clisby** *A self-avoiding talk* (p. 9) UNH416 · Chair: Judy-anne Osborn		
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3:30 pm	**Robert Coulter** *Algebraic substructures of planar ternary rings* (p. 18)	**Muhammad Adib Surani** *Sets on a Plane* (p. 46)	**Rachel Wulan Nirmalasari Wijaya** *Q_d-Supermagic Labeling of The d-Dimensional Grid Graph* (p. 48)
4:00 pm	**David Pike** *Twofold triple systems with 2-intersecting Gray codes* (p. 38)	**Kyle Rosa** *Invariable Generation of Finite Permutation Groups* (p. 39)	**Susilawati Nurdin** *On the Vertex Irregular Total Labeling for Subdivision of Trees* (p. 36)
4:30 pm	**Daniel Horsley** *Resolvability for infinite designs* (p. 24)	**Novi Herawati Bong** *Maximum Degree-Diameter Bounded Subgraphs Problem on Hyperdiamond* (p. 16)	**Dushyant Tanna** *Reflexive Vertex Irregular Labeling of Ladders* (p. 47)
5:00 pm	**CMSA Annual General Meeting** UNH416		

Tuesday 13 December

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9:30 am	**Matthew Fahrbach** *Approximately Sampling Elements with Fixed Rank in Graded Posets* (p. 20)	**Florian Lehner** *The reconstruction problem for infinite graphs* (p. 28)	**Rakhi Singh** *Lower bounds on the sizes of t-(v, k, λ) coverings* (p. 43)
10:00 am	**Richard Brent** *A Fast Algorithm for the Kolakoski Sequence* (p. 16)	**Toru Hasunuma** *Completely independent spanning trees in the powers of sparse graphs* (p. 23)	**Darcy Best** *Transversals in Latin Arrays with Many Symbols* (p. 15)
10:30 am	Morning Tea		
Room/ Chair	UNH416 Rajko Nenadov	UNH419 Thomas Britz	UNH421 Rebecca Stones
11:00 am	**John Bamberg** *Extremal configurations in regular near polygons* (p. 15)	**Anita Liebenau** *Excluding hooks and their complements* (p. 29)	**Mohammed Aeyed Alqahtani** *The Maximum Clique Problem* (p. 13) Update
11:30 am	**Charles Semple** *Constructing tree-child networks from distance matrices* (p. 42)	**Dan Hawtin** *2-neighbour transitive codes - some context* (p. 23)	**Kevin Hendrey** *Sparse Graphs of high Gonality* (p. 24)
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Wednesday 14 December

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THURSDAY 15 DECEMBER

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6:30 pm	**Conference Dinner** *NOAH'S On The Beach*, corner of Shortland Esplanade and Zaara St, Newcastle East		

Friday 16 December

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10:30 am	**Jennifer Seberry** *Two Infinite Families of Symmetric Hadamard Matrices* (p. 41)		
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11:30 am	**Judy-anne Osborn** *Education, Combinatorics and the Modern World* (p. 37)		

ABSTRACTS OF INVITED TALKS

(listed alphabetically by surname)

ROOM UNH416 MON 2:00 PM

A SELF-AVOIDING TALK

Nathan Clisby
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Self-avoiding walks (SAWs) are the set of walks on a graph (typically a regular lattice) that are self-avoiding. They are a fundamental model of long molecules, or polymers, as they exactly capture the essential physics of polymers in a good solvent. Despite the extreme simplicity of their definition, and the fact that physicists, chemists, and mathematicians have been studying them for over 60 years, many things we "know" about SAWs remain unproved, and SAWs continue to inspire research in enumerative combinatorics, mathematical physics, probability, and polymer physics.

I will give an overview of the topic, with a focus on my own work which largely involves developing efficient algorithms for counting and sampling self-avoiding walks.

ROOM UNH416 WED 2:00 PM

AN INTRODUCTION TO COMBINATORICS ON WORDS: BALANCED WORDS, LYNDON WORDS, AND PALINDROMES

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A *word* is a finite or infinite sequence of symbols (called *letters*) taken from a (usually finite) non-empty set (called an *alphabet*). *Combinatorics on words* lies on the border of discrete mathematics and theoretical computer science, with applications not only in these two areas (e.g., transcendental number theory, pattern recognition, data compression), but also in other fields, such as theoretical physics (e.g., quasicrystal modelling) and molecular biology (e.g., DNA sequences).

The mathematical study of words exploits two features: discreteness and non-commutativity, and it is the latter that makes this area of research a challenging one. Many problems, however, can be easily formulated, which also makes it an enticing area in which to work. Of particular interest to mathematicians and computer scientists alike are problems concerning the occurrences of regularities in words (e.g., repetitions, periodicities, palindromes) and properties that characterise families of words. In this talk, I will survey what is known (as well as conjectured) about some of these kinds of problems, with particular focus on three of my most favourite types of words — *balanced words*, *Lyndon words*, and *palindromes* — and relations between them.

ROOM UNH416 TUE 2:00 PM

WHEN THE CHROMATIC NUMBER BECOMES FRACTIONAL

Bojan Mohar
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(Joint work with Hehui Wu)

Fractional versions of the following three graph coloring problems will be discussed.

(1) Erdős and Hajnal Conjecture (1969): For every g and k there exists an integer $h(g,k)$ such that every graph G with $\chi(G) \geq h(g,k)$ contains a subgraph with chromatic number k and girth at least g. This conjecture has been solved by Rödl for $g = 4$ in 1977 and is still open for every $g \geq 5$.

(2) Erdős and Neumann-Lara Conjecture (1979): For every k there exists an integer $c(k)$ such that the dichromatic number of every graph G with $\chi(G) \geq c(k)$ is at least k. This conjecture has been solved for $k = 2$ and is open for every $k \geq 3$.

(3) Boris Bukh Problem: What is the expected chromatic number of a random subgraph of a given graph?

Full or partial solutions of the fractional versions of these problems will be presented. Although the problems look quite different, their solutions use the same general setup.

ROOM UNH416 THU 2:00 PM

SEMIDEFINITE PROGRAMMING IN EXTREMAL GRAPH THEORY – ADVANCES ON THE FLAG ALGEBRA METHOD

Florian Pfender
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University of Colorado, Denver

The flag algebra method is a technique recently developed by Razborov, and it has revolutionized parts of extremal combinatorics. The method draws from the theory of graph limits, analysis, probability and optimization. We will quickly present the fundamental ideas and then show a number of diverse applications. Somewhat counter intuitively, one can even use it to show statements about relatively small graphs, and we will show how it can be used to find new bounds on graph Ramsey numbers.

ROOM UNH416 TUE 8:30 AM

SAMPLING PATHS, PARTITIONS AND PERMUTATIONS

Dana Randall
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Random sampling is ubiquitous across the sciences and engineering as a means of studying properties of large sets. Often these sets are exponentially large, and to be useful we need to be able to sample elements from a target distribution in polynomial time. Markov chains that walk among the elements of the set have proven useful tools for this purpose in many cases. We will look at how a simple "mountain-valley" chain on monotonic lattice paths can be used as the basis for algorithms arising in self-assembly, combinatorics and computing. Examples we will discuss include sampling lozenge tilings, biased permutations, and integer partitions.

ROOM UNH416 MON 9:00 AM

TESTING MEMBERSHIP IN MINOR CLOSED CLASSES IN LINEAR TIME

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National Institute of Informatics, Tokyo

In seminal work spanning over 20 papers, Robertson and Seymour developed, for any fixed graph H, a structural characterization of graphs which do not contain H as a minor. They used this characterization to obtain an $O(n^3)$ algorithm to test membership in any minor closed class of graphs. I will discuss a linear time algorithm for testing membership in minor closed classes, which relies heavily on their results. I will focus on an iterative compaction technique which may be of independent interest.

ROOM UNH416 FRI 9:00 AM

MIRKA MILLER: A RESEARCH PROFILE

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Many people know Mirka Miller through her results in, at least one of, Security of Statistical Databases, Eccentric Digraphs, Graph Labeling or her beloved Degree Diameter Problem. In each of these areas, Mirka contributed substantial results, supervised PhD students to completion, authored articles and, in some cases, initiated conferences that are still successfully continuing. However not many people know of Mirka's involvement in all of these topics.

In this retrospective, I will present some of Mirka's results in each of these fields and, if time permits, some other areas in which she had interest. During this talk I will mention some of Mirka's many collaborators and co-authors however her research network was so vast that I will inevitably leave some out. To those people I apologise in advance.

ROOM UNH416 WED 8:30 AM

CYCLES IN GRAPHS WITH FORBIDDEN SUBGRAPHS

Benny Sudakov
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ETH Zurich

(Joint work with J. Verstraete and in part with S. Kostochka)

The notion of cycle is one of the basic notions in Graph Theory and their study has long been fundamental. Many central questions in this area ask to show that graphs with certain properties have some particular range of cycle length. In this talk we discuss several such old problems, focusing on the graphs with forbidden subgraphs.

ROOM UNH416 THU 8:30 AM

TANGLES AND THE MONA LISA

Geoff Whittle
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(Joint work with Reinhard Diestel (University of Hamburg))

Tangles were introduced by Robertson and Seymour to capture the notion of a highly connected region of a graph. They were used to great success in their Graph Minors Project. But tangles extend to other, much more general structures such as matroids and they play a similar role there. To date it appears that tangles have only played a role in theoretical investigations, but why shouldn't they be used in more practical situations? In this talk I will discuss an application of tangles to image recognition problems.

ABSTRACTS OF CONTRIBUTED TALKS

(listed alphabetically by surname)

ROOM UNH421 TUE 11:00 AM

THE MAXIMUM CLIQUE PROBLEM

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(Joint work with Guanglu Zhou)

The combinatorial optimization problem is one of the most fertile research areas in operation research, graph theory, management, Engineering and Computer Science, amongst many others. Many combinatorial optimization problems are still hard to solve thus making it difficult and challenging to calculate the complexity of such issues as maximum clique problem, maximum graph matching, and vertex cover problems. The maximum clique problem (MCP) is a well-known example of combinatorial optimization, which has core concepts of different applications in different domains. The MCP has proven to be NP-Hard [1] and no polynomial algorithm is expected to be found; hence it has acquired a prominent place in the area of combinatorial optimization because of its ability to work in different fields and complexities involved in its calculations. However, its complexity makes exact algorithms (such as explicit and implicit enumerations) to return a solution only if time increases exponentially with the number of vertices in the graph. Therefore, it poses a challenge when it comes to applications with large-scale size problems. Much theory and research papers into the clique problem show that the MCP is in fact very difficult to solve, even in detecting satisfactory approximate solutions. Due to these negative findings, determining large cliques in graphs has long been the concern of many researchers. In this paper, we will present a new equivalent formulation for the clique problem. In addition, we will develop efficient and effective computational algorithms for the maximum clique problem, in particular, the alternating direction method of multipliers. We will then apply the proposed methods to solving the popular DIMICS benchmark, the most frequently used to evaluate the performance of MCP algorithms in order to achieve the optimium/best values for $\omega(G)$.

Bibliography

[1] M. R. Garey and D. S. Johnson. Computers and Intractability: A Guide to the Theory of NP-Completeness. W. H. Freeman & Co., New York, NY, USA, 1979.

ROOM UNH419 WED 9:30 AM

THE FRIEDLANDER-GORDON-MILLER CONJECTURE IS TRUE

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(Joint work with Donald L. Kreher and Adrian Pastiné)

Gordon defined a group G to be *sequenceable* if its elements could be written as a sequence $g_1, g_2, \ldots, g_n$ so that the products

$$g_1, g_1g_2, g_1g_2g_3, \ldots, g_1g_2g_3 \cdots g_n$$

are distinct. He proved that an abelian group is sequenceable if and only if its Sylow 2-subgroup is cyclic and not the identity group. A group G is R-*sequenceable* if its non-identity elements can be written as a sequence $g_2, g_3, \ldots, g_n$ so that the products

$$g_2^{-1}g_3, g_3^{-1}g_4, \ldots, g_{n-1}^{-1}g_n, g_n^{-1}g_2$$

are distinct. Friedlander, Gordon and Miller (1975), conjectured that an abelian group is either sequenceable or R-sequenceable (but not both) and we complete a proof that the conjecture is true.

ROOM UNH421 THU 11:00 AM

FREEZING IN HYPERGRAPH COLOURING

Peter Ayre
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(Joint work with Catherine Greenhill)

A hypergraph colouring is an assignment of colours to the vertices of a hypergraph so that no edge is monochromatic. This talk reports on work in progress which aims to locate the "freezing threshold" for the problem of colouring hypergraphs with a linear number of edges.

At the freezing threshold the geometry of the solution space of colours changes quite remarkably. In particular, above the freezing threshold it is necessary to change the colour of linearly many vertices at a time in order to produce a new colouring. These changes in the geometry of the solution space have been hypothesised to be the cause of the algorithmic barrier faced by naive algorithms.

ROOM UNH416 TUE 11:00 AM

EXTREMAL CONFIGURATIONS IN REGULAR NEAR POLYGONS

John Bamberg
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School of Mathematics and Statistics, The University of Western Australia

In this talk, an introduction to the basics of regular near polygons will be given together with a summary of the work of Bart De Bruyn and Frédéric Vanhove (2011). In joint work with Jesse Lansdown and Melissa Lee, the speaker will present some recent work which improves some of the results of De Bruyn and Vanhove. No knowledge of finite geometry or regular near polygons will be required, but some basic linear algebra will be assumed.

ROOM UNH421 WED 3:30 PM

UNIFORM CYCLE DECOMPOSITIONS OF COMPLETE MULTIGRAPHS

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(Joint work with D. Bryant, M. Dean, B. Maenhaut)

We examine the notion of uniformity in the context of cycle decompositions of complete multigraphs. A decomposition $\mathbb{D} = \{F_1, F_2, ..., F_t\}$ of a graph is *uniform* if $F_i \cup F_j$ is isomorphic to $F_k \cup F_l$ for $1 \leq i < j \leq t$, $1 \leq k < l \leq t$. Outside of 1-factorisations, questions concerning the existence of uniform decompositions have not been considered previously. We prove that uniform m-cycle decompositions of the complete multigraph μK_n exist only when $m = n$, when $\mu = 2$ and $m = n - 1$, when $\mu = 1$ and $m = \frac{n-1}{2}$, and possibly when $\mu = 1$ and $2m(m+1) = n(n-1)$.

ROOM UNH421 TUE 10:00 AM

TRANSVERSALS IN LATIN ARRAYS WITH MANY SYMBOLS

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(Joint work with Kevin Hendrey, Ian Wanless, Tim Wilson, David Wood)

A transversal of a latin square of order n is a set of n entries picked in such a way that no row, column or symbol is present more than once. As you add more symbols to a latin square, you expect the number of transversals to increase. We show that once the number of symbols reaches a certain threshold, the square is guaranteed to have a transversal.

ROOM UNH419 MON 4:30 PM

MAXIMUM DEGREE-DIAMETER BOUNDED SUBGRAPHS PROBLEM ON HYPERDIAMOND

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(Joint work with Joe Ryan, Yuqing Lin)

Maximum degree and diameter-bounded subgraph (MaxDDBS) problem is a generalisation of the degree diameter problem (DDP), which aims to determine the maximum order in a graph. In this case, the graph should lie in a given host graph or architecture. Some architectures such as mesh, triangular network and butterfly networks have been considered as the hosts. In particular, we will investigate MaxDDBS problem based on the honeycomb networks. Holub et al. have determined the maximum subgraph in 2-dimensional honeycomb network and its generalisation in 3 dimension.

In this talk, we will focus on MaxDDBS problem in hyperdiamond, which is a more natural generalisation of honeycomb network in higher dimension.

ROOM UNH416 TUE 10:00 AM

A FAST ALGORITHM FOR THE KOLAKOSKI SEQUENCE

Richard Brent
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(Joint work with Judy-anne Osborn)

The *Kolakoski sequence* 1221121221221121122... is the unique countable $\{1,2\}$-sequence $k_1k_2k_3\ldots$ such that $k_1 = 1$, whose j-th block has length k_j. We shall briefly survey what is known and conjectured about this sequence (OEIS A000002).

Define the *Kolakoski discrepancy function* $\delta(n) := \sum_{1\le j\le n}(-1)^{k_j}$. It is an open question whether $\delta(n) = o(n)$, i.e. whether the density of 1's in k is $\frac{1}{2}$.

The obvious algorithm to compute $\delta(n)$ takes linear time and space. Nilsson (2012) gave an algorithm for computing $k_1 \ldots k_n$ (and hence $\delta(n)$) in time $O(n)$ and space $O(\log n)$. We shall give an algorithm that computes $\delta(n)$ faster, using a space-time tradeoff. It is conjectured that the algorithm runs in time $O(n^\alpha)$ and space $O(n^\alpha)$, where $\alpha = \log(2)/\log(3) \approx 0.631$.

Using our algorithm, we have computed $\delta(n)$ for various $n \le 5 \times 10^{17}$. The results provide numerical evidence for the conjecture that $\delta(n) = O(n^{1/2+\varepsilon})$. We have also extended the computation of the related sequence OEIS A042942.

ROOM UNH416 WED 9:30 AM

COLOURING GRAPHS WITH CONNECTIVITY CONSTRAINTS

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(Joint work with Pierre Aboulker, Frédéric Havet, Dániel Marx, Nicolas Trotignon)

It is well-known that deciding if a graph has a proper vertex k-colouring is NP-complete for any fixed $k \geq 3$. On the other hand, Brooks' theorem tells us that, given a graph of maximum degree k, it is easy to find a k-colouring, or determine that none exists, in polynomial time. Restricting the maximum degree can be thought of as a kind of connectivity constraint. In this talk we consider: are there more general classes – containing graphs that are not, in a sense, "highly connected" – for which one can recover a polynomial-time algorithm for k-colouring?

In particular, a graph is said to have maximal local edge-connectivity k if no two vertices have $k+1$ edge-disjoint paths between them; we show that there is a Brooks-type theorem that characterises when such graphs are k-colourable. We also consider the complexity of colouring for related classes defined by similar connectivity constraints, such as minimally k-connected graphs. Finally, we show that the parameterisation of k-colouring by the number of vertices of degree at least $k+1$ is fixed-parameter tractable.

ROOM UNH416 TUE 4:30 PM

A NICE PROOF OF WEI'S DUALITY THEOREM

Thomas Britz
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The Tutte polynomial was once an esoteric object known only to the then small community of combinatorialists. That changed when Greene (1976) pointed out the connection between this polynomial and weight enumerators, and how that connection provided a beautifully simple proof of the MacWilliams Identity (MacWilliams 1963) of coding theory fame. The Tutte polynomial is now of wide interest and appeal to the broader mathematical community who have found it lurking disguised in numerous areas of mathematics. Despite its present prominence, few are aware of how the Tutte polynomial provides another beautifully simple proof of a second celebrated duality theorem from coding theory, namely Wei's Duality Theorem (Wei 1991). This proof, due to Duursma (2004), deserves better exposure, so this talk will present Duursma's proof.

ROOM UNH416 WED 4:30 PM

BI-CAYLEY GRAPHS

Marston Conder
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(Joint work with Yanquan Feng, Jinxin Zhou and Mi-mi Zhang (Beijing))

Cayley graphs form an important class of vertex-transitive graphs, which have been the object of study for many decades. These graphs admit a group of automorphisms that acts regularly (i.e. sharply-transitively) on vertices. On the other hand, there are many important vertex-, edge- or arc-transitive graphs that are not Cayley graphs, such as the Petersen graph, the Gray graph, and the Hoffman-Singleton graph.

In this talk, I will describe some recent developments in the theory of *bi-Cayley graphs*, which are graphs that admit a group H of automorphisms acting semi-regularly on the vertices, with two orbits (of the same length). These include the Petersen graph and the Gray graph, and many more besides.

We focus mainly on the case where the group H is normal in the full automorphism group of the graph, and have produced infinite families of examples in each of three sub-classes of bi-Cayley graphs, namely those that are arc-transitive, half-arc-transitive or semisymmetric, respectively.

In doing this, we found the answer to a number of open questions about these and related classes of graphs, posed by Li (in *Proc. American Math. Soc.* 133 (2005)), Marušič and Potočnik (in *European J. Combinatorics* 22 (2001)) and Marušič and Šparl (in *J. Algebraic Combinatorics* 28 (2008)). Also we found and corrected an error in a recent paper by Li, Song and Wang (in *J. Combinatorial Theory, Series A* 120 (2013)).

ROOM UNH416 MON 3:30 PM

ALGEBRAIC SUBSTRUCTURES OF PLANAR TERNARY RINGS

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We will discuss two inter-related areas of the theory of projective planes; namely, the study of central collineations, and the coordinatisation method. The interplay between these two topics has played an important role in the study of projective planes, particularly the classification problem, more or less since Hall's introduction of the coordinatisation method in 1943. The key results on which the great majority of all subsequent work relies were established by Pickert in the 1950s, building on the work of Hall and others. Essentially, Pickert's results illustrate a relationship between transitive groups of central collineations and properties of the algebraic object the coordinatisation method produces. We will present similar results without assuming transitivity, recovering all of Pickert's famous results as corollaries plus we get a new result in the style of Pickert as a bonus.

ROOM UNH421 WED 11:00 AM

ON A HIGHER DIMENSIONAL ANALOGUE OF THE VAN DER WAERDEN CONJECTURE

William Crawford

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A non-negative matrix is called *doubly stochastic* if all rows and columns sum to 1. One of the most celebrated results on doubly stochastic matrices, known as the Van der Waerden conjecture, is that the permanent has a unique minimum among doubly stochastic matrices at J_n/n, where J_n is the order n matrix of ones. Dow and Gibson conjectured an analogue of the Van der Waerden conjecture for the permanent of higher dimensional matrices. Namely, that amongst the convex hull of higher dimensional matrices with a single 1 in each hyperplane, the unique minimum of the permanent is at $n^{1-d}J_{d,n}$. We present results showing this conjecture fails in many cases.

ROOM UNH419 THU 4:30 PM

EFFECT OF GROMOV-HYPERBOLICITY PARAMETER ON CUTS AND EXPANSIONS IN GRAPHS AND SOME ALGORITHMIC IMPLICATIONS

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(Joint work with Marek Karpinski, Nasim Mobasheri, Farzaneh Yahyanejad)

δ-hyperbolic graphs, originally conceived by Gromov in 1987, occur often in many network applications; for fixed δ, such graphs are *simply called hyperbolic graphs* and include non-trivial interesting classes of "non-expander" graphs. The main motivation of this paper is to investigate the effect of the hyperbolicity measure δ on expansion and cut-size bounds on graphs, and the asymptotic ranges of δ for which these results may provide *improved* approximation algorithms for related combinatorial problems. To this effect, we provide *constructive* bounds on node expansions for δ-hyperbolic graphs as a function of δ, and show that many witnesses (subsets of nodes) for such expansions can be computed efficiently even if the witnesses are required to be nested or sufficiently distinct from each other. To the best of our knowledge, these are the first such constructive bounds proven. We also show how to find a large family of s-t cuts with *relatively small* number of cut-edges when s and t are sufficiently far apart. We then provide algorithmic consequences of these bounds and their related proof techniques for two problems for δ-hyperbolic graphs (where δ is a function f of the number of nodes, the exact nature of growth of f being dependent on the particular problem considered).

ROOM UNH416 TUE 9:30 AM

APPROXIMATELY SAMPLING ELEMENTS WITH FIXED RANK IN GRADED POSETS

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(Joint work with Prateek Bhakta, Ben Cousins, Dana Randall)

Graded posets frequently arise throughout combinatorics, where it is natural to try to count the number of elements of a fixed rank. These counting problems are often #**P**-complete, so we consider approximation algorithms for counting and uniform sampling. We show that for certain classes of posets, biased Markov chains that walk along edges of their Hasse diagrams allow us to approximately generate samples with any fixed rank in expected polynomial time. Our arguments do not rely on the typical proofs of log-concavity, which are used to construct a stationary distribution with a specific mode in order to give a lower bound on the probability of outputting an element of the desired rank. Instead, we infer this directly from bounds on the mixing time of the chains through a method we call *balanced bias*.

A noteworthy application of our method is sampling restricted classes of integer partitions of n. We give the first provably efficient Markov chain algorithm to uniformly sample integer partitions of n from general restricted classes. Several observations allow us to improve the efficiency of this chain to require $O(n^{1/2}\log(n))$ space, and for unrestricted integer partitions, expected $O(n^{9/4})$ time. Related applications include sampling permutations with a fixed number of inversions and lozenge tilings on the triangular lattice with a fixed average height.

ROOM UNH419 TUE 3:30 PM

POWERFUL SETS AND CODES: BINARY FUNCTIONS WITH TUTTE-WHITNEY POLYNOMIALS

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(Joint work with Yezhou Wang (University of Electronic Science and Technology of China))

A set $S \subseteq \{0,1\}^E$ of binary vectors, with positions indexed by E, is said to be a *powerful code* if, for all $X \subseteq E$, the number of vectors in S that are zero in the positions indexed by X is a power of 2. By treating binary vectors as characteristic vectors of subsets of E, we say that a set $S \subseteq 2^E$ of subsets of E is a *powerful set* if the set of characteristic vectors of sets in S is a powerful code.

Powerful codes include linear codes over GF(2), but much more besides.

In previous work [1], the author introduced a transform that takes a binary code and constructs from it a function analogous to the rank function of a matroid. In the special case of a binary *linear* code, the transform yields its corresponding binary matroid rank function. But if the code is nonlinear, the corresponding rank-like function may not even be integer-valued. Our interest in powerful codes is that they are precisely the binary codes for which the corresponding rank-like function is integer-valued, which ensures that they have Tutte-Whitney polynomials.

We describe fundamental properties of powerful sets including how to extend them to make larger ones, how to combine them, and some bounds on how many there are of a given order.

[1] G E Farr, A generalization of the Whitney rank generating function, Math. Proc. Cambridge Philos. Soc. 113 (1993) 267-280.

ROOM UNH419 TUE 4:00 PM

LINEAR CODES FROM MATRICES: INTERTWINING CODES

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(Joint work with Cheryl E. Praeger, Bahattin Yildiz, Patrick Solé, Adel Alahmadi)

I will report on new classes of linear codes constructed using matrices. The codes are reminiscent of $\mathrm{Hom}(V, W)$ in representation theory. I will elucidate the dimension and minimal distance of these codes giving bounds and exact values.

ROOM UNH416 THU 4:00 PM

A THRESHOLD RESULT FOR LOOSE HAMILTONICITY IN RANDOM REGULAR UNIFORM HYPERGRAPHS

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(Joint work with Daniel Altman, Mikhail Isaev, Reshma Ramadurai)

A hypergraph is s-uniform if every edge contains s vertices, and it is r-regular if every vertex is contained in r edges. We work with the uniform model of random r-regular s-uniform hypergraphs on n vertices, and are interested in Hamilton cycles in this model.

A loose Hamilton cycle is a cycle which contains every vertex, such that successive edges overlap in exactly one vertex. A necessary condition for an s-uniform hypergraph on n vertices to contain a loose Hamilton cycle is that $s - 1$ divides n. When r and s are fixed integers, we establish a threshold result for the property of containing a loose Hamilton cycle. This partially verifies a conjecture of Dudek, Frieze, Ruciński and Šileikis (2015).

The proof involves the small subgraph conditioning method introduced by Robinson and Wormald (1992, 1994) and also provides the asymptotic distribution of the number of loose Hamilton cycles for degrees r above the threshold.

ROOM UNH421 MON 11:00 AM

METRIC DIMENSION OF CIRCULANT GRAPHS

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(Joint work with Thomas Kalinowski, Joe Ryan, Sudeep Stephen)

A subset W of the vertex set of a graph G is called a resolving set of G if for every pair of distinct vertices u, v of G, there is a vertex $w \in W$ such that $d(w, u) \neq d(w, v)$. The cardinality of a smallest resolving set is called the metric dimension of G, denoted by $\dim(G)$. In this paper we determine the metric dimension of circulant graphs $G = C(n, \pm\{1, 2, 3, 4\})$ as follows:

$$\dim(G) = \begin{cases} 4 & \text{for } n \equiv 4 \pmod 8, \\ 5 & \text{for } n \equiv \pm 2,\ \pm 3 \pmod 8, \\ 6 & \text{for } n \equiv 0,\ \pm 1 \pmod 8. \end{cases}$$

ROOM UNH421 MON 10:30 AM

PARTITION RESOLVABILITY OF HOMEOMORPHIC TREES

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(Joint work with Edy Tri Baskoro, Suhadi Wido Saputro, Joe Ryan)

For a disconnected graph G, let $\Xi = \{E_1, E_2, \ldots, E_t\}$ be a partition of $V(G)$. If the distance $d(v, E_i)$ of a vertex v to E_i is finite for all $v \in V(G)$, then the representation of $v \in V(G)$ with respect to Ξ is $r(v|\Xi) = (d(v, E_1), d(v, E_2), \ldots, d(v, E_t))$. A partition Ξ is a resolving partition of G if $r(v|\Xi) \neq r(w|\Xi)$ for any two vertices $v, w \in V(G)$. The smallest cardinality of a resolving partition Ξ of G is called partition dimension of G and is denoted by $pdd(G)$. If there is no integer t in which G has a resolving t-partition, then $pdd(G) = \infty$. In this paper, we will determine the partition dimension of a disconnected graph G containing homeomorphic graphs. In particular, we derived the upper bound of partition dimension for two homeomorphic trees.

ROOM UNH419 TUE 10:00 AM

COMPLETELY INDEPENDENT SPANNING TREES IN THE POWERS OF SPARSE GRAPHS

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Completely independent spanning trees $T_1, T_2, \ldots, T_k$ in a graph G are spanning trees such that for any two distinct vertices u and v in G, the k paths between them in the spanning trees are pairwise openly disjoint, i.e., any two paths in the k paths have no common edge and no common vertex except for u and v. Let $\theta(G)$ be the maximum number of completely independent spanning trees in G. For any two vertices u and v in G, we denote by $d_G(u,v)$ the distance of u and v in G, i.e., the length of a shortest path between u and v. Let $N_G(v;i) = \{w \in V(G) \mid d_G(v,w) = i\}$ for any vertex v in G and any nonnegative integer i. The k-th power of G denoted by G^k is the graph with the same vertex set as G and in which two distinct vertices u and v are adjacent if and only if $d_G(u,v) \leq k$.

We show the following results on completely independent spanning trees in the k-th powers of trees, cycles, and unicyclic graphs, where C_n denotes the cycle with n vertices, $t = n \bmod k$, and $k \leq \frac{n}{2}$.

• $\theta(T^k) \geq \lfloor \frac{k+1}{2} \rfloor$ for any tree T and any $k < n$, and $\theta(T^k) \geq \lfloor \frac{2k+1}{3} \rfloor$ for any tree T which has a leaf r such that $|N_T(r;i)| = 1$ for each $i \leq \lfloor \frac{k}{6} \rfloor$ and $|N_T(r;2k)| \neq 0$.

• $\theta(C_n^k) = k$ if $t \in \{0,1\}$, $\theta(C_n^k) \geq \lceil \frac{k+t}{2} \rceil$ if $t > 1$ is even, and $\theta(C_n^k) \geq \lceil \frac{k+t}{2} + \frac{1}{2}\lfloor \frac{k-t}{t} \rfloor \rceil$ if $t > 1$ is odd.

• $\theta(U^2) \geq 2$ for any unicyclic graph U with at least 4 vertices.

Besides, we present a sufficient condition for a unicyclic graph U to hold that $\theta(U^k) \geq k$.

ROOM UNH419 TUE 11:30 AM

2-NEIGHBOUR TRANSITIVE CODES - SOME CONTEXT

Dan Hawtin

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The speaker will discuss various results from his nearly completed PhD thesis, giving a description of what are thought to be newly discovered families of codes, and some background about the history of symmetry in coding theory.

Let C be a code in a Hamming graph $H(m,q)$ and C_s be the set of vertices of $H(m,q)$ which are distance s from C. We say C is 2-neighbour transitive if the sets C, C_1 and C_2 are each orbits of some fixed subgroup of the automorphism group of C. The results discussed will mainly concern attempts to classify 2-neighbour transitive codes.

ROOM UNH421 TUE 11:30 AM

SPARSE GRAPHS OF HIGH GONALITY

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The *gonality* of a graph is a parameter that can be defined and analysed in terms of a simple game played with chips on a graph. The concept of gonailty comes from algebraic topology, where there is an analogous definition of the gonality of a curve. In a recent survey, Norine [Surveys in Combinatorics, 2015] posed three open problems relating graph gonality to graph minor theory. We resolve each of these problems. In this talk, I will introduce the concept of graph gonality and briefly discuss these results. No background knowledge is assumed.

ROOM UNH419 THU 11:30 AM

HAMILTON DECOMPOSABLE INFINITE CIRCULANT GRAPHS

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(Joint work with Darryn Bryant, Barbara Maenhaut, Bridget Webb)

It is conjectured that every connected $2k$-regular (finite) circulant graph has a decomposition into k edge-disjoint hamilton cycles. We consider the analagous problem for infinite circulant graphs, where the natural infinite analogue of a (finite) hamilton cycle is a connected 2-regular spanning subgraph (a two-way infinite hamilton path). An infinite circulant graph is hamilton decomposable if its edge set can be partitioned into two-way infinite hamilton paths. We present necessary conditions for an infinite circulant graph of finite valency to be hamilton decomposable and prove that these conditions are sufficient in many cases.

ROOM UNH416 MON 4:30 PM

RESOLVABILITY FOR INFINITE DESIGNS

Daniel Horsley

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(Joint work with Peter Danziger, Bridget Webb)

I will give a brief introduction to infinite designs and then discuss some of our work concerning their resolvability. The talk will be aggressively non-technical.

ROOM UNH421 WED 4:00 PM

DECOMPOSING λK_n INTO STARS

Rosie Hoyte
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(Joint work with Darryn Bryant, Daniel Horsley)

It is known exactly when the complete multigraph λK_v can be decomposed into m-stars (Yamamoto et al., 1975 and Tarsi, 1979). If $\lambda = 1$ this result has been extended to decompositions of the complete graph into stars of arbitrary specified sizes $m_1, \ldots, m_t$ (Lin and Shyu, 1996). It is natural to ask when λK_n can be decomposed into stars of arbitrary specified sizes. It turns out that this question doesn't admit an easy answer. In this talk we present some of our initial findings on this problem.

ROOM UNH421 THU 9:30 AM

STRUCTURE AND ALGORITHMS FOR (CAP,EVEN HOLE)-FREE GRAPHS

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(Joint work with Kathie Cameron, Murilo V.G. da Silva, Kristina Vuskovic)

A graph is even-hole-free if it has no induced even cycles of length 4 or more. A cap is a cycle of length at least 5 with exactly one chord and that chord creates a triangle with the cycle. We consider (cap, even hole)-free graphs, and more generally, (cap, 4-hole)-free odd-signable graphs. We give an explicit construction of these graphs. We prove that every such graph G has a vertex of degree at most $\frac{3}{2}\omega(G) - 1$, and hence $\chi(G) \leq \frac{3}{2}\omega(G)$, where $\omega(G)$ denotes the size of a largest clique in G and $\chi(G)$ denotes the chromatic number of G. We give an $O(nm)$ algorithm for q-coloring these graphs for fixed q and an $O(nm)$ algorithm for maximum weight stable set. We also give a polynomial-time algorithm for minimum coloring.

Our algorithms are based on our results that triangle-free odd-signable graphs have treewidth at most 5 and thus have clique-width at most 48, and that (cap, 4-hole)-free odd-signable graphs G without clique cutsets have treewidth at most $6\omega(G) - 1$ and clique-width at most 48.

ROOM UNH416 THU 4:30 PM

BRIDGING THE GAP BETWEEN SPARSE AND DENSE

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(Joint work with B.D. McKay)

The asymptotic number of d-regular graphs on n vertices is known for ranges $d = o(n^{1/2})$ and $c\frac{\log n}{n} < d < n/2$. These results (obtained by B.D. McKay and N.C. Wormald in 1990 and 1991) are strongly distinguished by the type of mathematics used to solve them, which is combinatorial in the sparse range and complex-analytic in the dense range. Our new approach based on cumulant expansions allowed us to significantly enlarge the range of complex-analytic methods to make it overlap with the sparse range. It also applies to many other similar enumeration problems in combinatorics.

ROOM UNH419 THU 10:00 AM

EXTENDED FORMULATIONS FOR CONVEX HULLS OF GRAPHS OF BILINEAR FUNCTIONS

Thomas Kalinowski

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(Joint work with Natashia Boland, Fabian Rigterink, Hamish Waterer)

Consider a function $f : [0,1]^n \to \mathbb{R}$ of the form

$$f(x) = \sum_{1 \leqslant i < j \leqslant n} a_{ij} x_i x_j$$

with coefficients $a_{ij} \in \mathbb{R}$. We wish to characterize the convex hull of the graph of f, that is, the polytope

$$\mathrm{X}(f) = \mathrm{conv}\{(x,z) \in [0,1]^n \times \mathbb{R} : \ z = f(x)\}.$$

The number of facets of $X(f)$ can be exponential in the number of variables n, and in order to get a more compact representation of $X(f)$, one can introduce additional variables y_{ij} representing the bilinear terms $x_i x_j$. In this talk we describe a method to obtain polytopes $P(f) \subseteq \mathbb{R}^{n+n(n-1)/2}$ such that the number of facets of $P(f)$ is small (linear or quadratic in n) and

$$X(f) = \left\{ (x,z) \in [0,1]^n \times \mathbb{R} \ : \ z = \sum_{1 \leqslant i < j \leqslant n} a_{ij} y_{ij}, \ (x,y) \in P(f). \right\}$$

ROOM UNH419 THU 9:30 AM

THE STARS AND STRIPES PROBLEM

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(Joint work with Zazil Santizo Huerta, Melissa S. Keranen, Salvatore Milici)

If X is a connected graph, then an X-factor of a larger graph is a spanning subgraph in which all of its components are isomorphic to X. An n-star factor is an X-factor where $X = K_{1,n}$. The *Stars and Stripes problem* is to determine the quadruples (v, n, r, s) for when the complete graph of order v can be edge decomposed into r (n-star)-factors and s one-factors (stripes). We concentrate on $n = 4$.

ROOM UNH419 THU 4:00 PM

ON LIMITS OF PÓLYA URN MODELS

Kevin Leckey
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Pólya urn models appear in a variety of random processes, such as disease spreading models, reinforced random walks, and random tree models. The urn model is the following: Assume there are balls of q different colors in an urn. Draw a ball at random and denote its color by I. Then return the ball to the urn together with a_{Ij} balls of color $j = 1, \dots, q$, where $(a_{ij})_{i,j=1,\dots,q}$ is some fixed replacement rule. Repeat this drawing process n times and denote by $X_{n,j}$ the number of balls of color j.

Limit laws for $(X_{n,1}, \dots, X_{n,q})$ have been studied for a variety of replacement rules. While some models lead to a Gaussian limit, a lot of Pólya urn models have non-Gaussian limit distributions. These distributions are typically not known explicitly, but can be characterized by some sort of distributional equation.

In this talk we discuss how to deduce properties of limit distributions from their distributional equations. The main result is the existence of smooth, rapidly decreasing density functions. The same result also holds for limits of path lengths in a variety of random trees, such as random recursive trees, random m-ary search trees and random split trees.

ROOM UNH419 TUE 9:30 AM

THE RECONSTRUCTION PROBLEM FOR INFINITE GRAPHS

Florian Lehner
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(Joint work with N. Bowler, J. Erde, P. Heinig, M. Pitz)

An important open question in the theory of finite graphs is whether it is possible to reconstruct any large enough finite graph from the family of subgraphs which can be obtained by removing individual vertices. The same problems for various classes of infinite graphs, such as trees or locally finite connected infinite graphs, has also remained open for the last few decades. We resolve these questions about infinite graphs by exhibiting locally finite trees which are not reconstructible.

ROOM UNH416 WED 11:00 AM

CLASSIFYING BENT FUNCTIONS BY THEIR CAYLEY GRAPHS, USING SAGE

Paul Leopardi
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Australian Government - Bureau of Meteorology

The SageMath software system provides a convenient platform for experimental mathematics, and in particular the exploration of properties of Boolean functions.

This talk describes how SageMath was used to classify the bent functions of dimension 8 and degree 3, via their Cayley graphs. Experimental results prompted conjectures and suggested some proofs.

ROOM UNH421 WED 11:30 AM

THE ENUMERATION OF 321-POLYNOMIAL CLASSES

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(Joint work with Albert, Michael)

We examine enumerating 321-avoiding polynomial classes from a structural description. Given the basis of any 321-avoiding polynomial class, we determine its structure by computing its associating grid class. We then propose an algorithm which enumerates the class when its associating grid class is known.

ROOM UNH416 WED 10:00 AM

ON STRONG EDGE-COLORING OF GRAPHS WITH MAXIMUM DEGREE 4

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(Joint work with Jianbo Lv, Gexin Yu)

The strong chromatic index of a graph G, denoted by $\chi'_s(G)$, is the least number of colors needed to edge-color G so that every path of length 3 uses three different colors. In this paper, we prove that if G is a graph with $\Delta(G) = 4$ and maximum average degree less than $\frac{61}{18}$ (resp.$\frac{7}{2}$, $\frac{18}{5}$, $\frac{26}{7}$, $\frac{51}{13}$), then $\chi'_s(G) \leq 16$ (resp.17, 18, 19, 20), improving the results of Bensmail *et al.* [Strong edge-coloring sparse graphs, Electronic Notes in Discrete Mathematics, 49 (2015) 773-778].

ROOM UNH419 TUE 11:00 AM

EXCLUDING HOOKS AND THEIR COMPLEMENTS

Anita Liebenau
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(Joint work with Krzysztof Choromanski, Dvir Falik, Viresh Patel, Marcin Pilipczuk)

The celebrated Erdos-Hajnal conjecture states that random graphs behave quite differently than H-free graphs in the following sense. It is conjectured that, for a fixed graph H, every H-free graph G contains a polynomial size clique or independent set. On the contrary, a graph chosen uniformly at random from all graphs on n vertices has only cliques and independents sets of size roughly $2 \log n$ with high probability.

The Erdos-Hajnal conjecture is resolved only for very few graphs H. A weaker version of the conjecture states that the polynomial-size clique/independent set phenomenon occurs if one excludes both, H and its complement H^c. It was recently shown by Bousquet, Lagoutte and Thomasse that this weaker conjecture is true if H is a path (of any length). We develop new methods to show that the weaker conjecture holds if H is any path with a pendant edge at its third vertex. It follows in particular that the weaker conjecture holds for all trees on at most 6 vertices.

ROOM UNH421 WED 4:30 PM

FACTORIZATION OF REGULAR GRAPHS

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(Joint work with Hongliang Lu)

A 1-factorization partitions the edges of a graph into disjoint 1-factors. A graph G is said to be 1-factorable if it admits a 1-factorization. Let G be a k-regular graph with 2n nodes. If k is sufficiently large, then G has to be 1-factorable. For example, it is easy to see this is true for trivial cases such as k = 2n -1 or if k = 2n-2. The 1-factorization conjecture is a long-standing conjecture that states that k close to n is sufficient. It was shown by A. J. W. Hilton that G contains around k/3 edge-disjoint 1-factors if k =n, and later CQ Zhang et. at. has improved that result by showing that G contains at least k/2 edge disjoint 1-factors. In this talk, I will present our recent progress made along this direction.

ROOM UNH419 THU 11:00 AM

HAMILTON DECOMPOSITIONS OF LINE GRAPHS

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(Joint work with Darryn Bryant, Ben Smith)

Given a graph G, the line graph of G, denoted $L(G)$, is the graph whose vertices are the edges of G and in which two vertices are adjacent if and only if the corresponding edges of G are adjacent. In 1988, Bermond conjectured that if a graph G has a Hamilton decomposition then $L(G)$ has a Hamilton decomposition, and at the 39ACCMCC Ben Smith presented our proof of Bermond's conjecture. More recent work has led us to the following theorem: If a d-regular graph G is Hamiltonian (for d even) or contains a Hamiltonian 3-factor (for d odd), then $L(G)$ has a Hamilton decomposition.

ROOM UNH419 WED 4:00 PM

ON n-CONNECTED MINORS OF THE es-SPLITTING BINARY MATROIDS

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The es-splitting operation is a natural generalization of line-splitting operation on graphs. Azanchiler (2006) proved that es-splitting operation on a connected binary matroid yields a connected binary matroid. Dhotre et al. (2016), provided a sufficient condition for a 3-connected binary matroid to yield a 3-connected binary matroid using es-splitting operation. As a consequence of the above result they obtained splitting lemma for 3-connected binary matroids. In this paper, we observed that the es-splitting matroid of a 4-connected binary matroid is not 4-connected. Thus, the es-splitting operation on an n-connected binary matroid may not yield an n-connected matroid for $(n \geq 3)$. We provide a sufficient condition for an n-connected binary matroid M so that $M_X^e \setminus e$ and $M_X^e \setminus \gamma$ are n-connected minors of es-splitting matroid M_X^e.

ROOM UNH421 TUE 4:30 PM

MAXIMAL R-MATCHING SEQUENCIBILITY OF COMPLETE GRAPHS

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Alspach (2008) defined the (maximal) matching sequencibility of a graph G as the largest integer s such that there exists a sequence of the edges of G so that every s consecutive edges form a matching. Alspach (2008) also determined the maximal matching sequencibility of K_n. Brualdi et al. (2012) defined the cyclic matching sequencibility as the matching sequencibility where all s cyclically consecutive edges have to be a matching. Brualdi et al. (2012) also determined the cyclic matching sequencibility of K_n and $K_{n,m}$.

In this talk I will provide the following generalisation to matching sequencibility. The r-matching sequencibility of a graph G is defined as the largest integer s such that there exists a sequence of the edges of G so that every s consecutive edges form a graph with maximum degree at most r. I also provide some of my own results, which determine the r-matching sequencibility of complete graphs and k-partite k-graphs.

ROOM UNH419 MON 11:30 AM

PROPAGATION IN CARBON AND BORON NANOTUBES

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In this paper, we study the propagation problem for carbon and boron nanotubes such as armchair carbon nanotube, chiral carbon nanotube, zigzag carbon nanotube, zigzag boron nanotube, and armchair boron nanotube. All five tubes are common in one property that each nanotube is a partition of critical sets. The propagation number of armchair carbon nanotube and chiral carbon nanotube is its perimeter. On the other hand, the propagation number of zigzag carbon nanotube, zigzag boron nanotube and armchair boron nanotube is proportional to its length respectively. The definition of propagation problem is iterative. Another interesting result of this paper is a characterization of propagation problem which leads to a non-iterative definition of propagation problem.

ROOM UNH419 TUE 4:30 PM

THE DIVISIBILITY OF THE NUMBER OF LATIN SQUARES OF FIXED ORDER

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The number of Latin squares of order n, R_n, has been found for $n \leq 11$. An interesting observation about these values of R_n is that they are divisible by a large power of 2. In particular, 2^{35} divides R_{11}. A number of theoretical arguments have been given to find a lower bound on the number of times some prime divides R_n. We will present a number of these arguments, and show how certain modifications and observations allow us to improve the lower bound of the powers of 2 in R_n to $n - O(\log_2 n)$.

ROOM UNH416 THU 10:00 AM

SUBGRAPH COUNTS FOR DENSE GRAPHS WITH SPECIFIED DEGREES

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(Joint work with Catherine Greenhill, Mikhail Isaev)

Consider a uniformly chosen random graph G in the dense range (degrees approximately a constant fraction of the number of vertices). Also consider a graph H on the same vertex vertex. Under certain conditions on the degrees of G and H, we previously obtained the probability that H is a subgraph of G. In the present work we consider the expected number of subgraphs of G isomorphic to H. This involves a difficult summation over permutations, which turns out to be equivalent to the problem of determining the expectation of the exponential of a function of a random permutation. We estimate the expectation using a general theory we developed for the exponential of a martingale. We also extend this result to obtain the expected number of spanning trees.

ROOM UNH416 THU 11:00 AM

A NAVIGATION SYSTEM FOR TREE SPACE

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(Joint work with Sarah Mark, Mike Steel)

The reconstruction of evolutionary trees from data sets on overlapping sets of species is a central problem in phylogenetics. Provided that the tree reconstructed for each subset of species is rooted and that these trees fit together consistently, the space of all parent trees that 'display' these trees was recently shown to satisfy the following strong property: there exists a path from any one parent tree to any other parent tree by a sequence of local rearrangements (nearest neighbour interchanges) so that each intermediate tree also lies in this same tree space. However, the proof of this result uses a non-constructive argument. In this talk we describe a specific, polynomial-time procedure for navigating from any given parent tree to another while remaining in this tree space.

ROOM UNH419 WED 11:30 AM

THRACKLES CONTAINING A STANDARD MUSQUASH

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(Joint work with Dr. Yuri Nikolayevsky)

A thrackle is a drawing of a graph in which each pair of edges meets precisely once. Conway's Thrackle Conjecture asserts that a planar thrackle drawing of a graph cannot have more edges than vertices, which is equivalent to saying that no connected component of the graph contains more than one cycle. We prove that a thrackle drawing containing a standard musquash (standard n-gonal thrackle) cannot contain any other cycle of length three or five.

ROOM UNH416 TUE 4:00 PM

TWO INFINITE FAMILIES OF PAIRS OF TUTTE EQUIVALENT 2-CONNECTED GRAPHS WITH CERTIFICATES

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(Joint work with Graham Farr, Kerri Morgan)

The *Tutte polynomial* counts a number of important structures associated with graphs. Two graphs are *Tutte equivalent* if they have the same Tutte polynomial. A *certificate* for the Tutte polynomial is a sequence of graph operations based on properties of the Tutte polynomial and algebraic properties. Certificates can explain Tutte equivalences without computing Tutte polynomials. Short certificates give proofs of Tutte equivalence which can be verified efficiently. We found two infinite families of pairs of 2-connected Tutte equivalent graphs, which are not covered by the known properties of the Tutte polynomial, and give certificates of constant lengths for these cases.

ROOM UNH416 TUE 3:30 PM

NEW TYPES OF CHROMATIC FACTORISATIONS

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The chromatic polynomial $P(G;\lambda)$ gives the number of ways a graph G can be coloured in at most λ colours. A graph G has a chromatic factorisation with chromatic factors, H_1 and H_2, if $P(G;\lambda) = P(H_1;\lambda) \times P(H_2;\lambda)/P(K_r;\lambda)$ where the chromatic factors have chromatic number at least r and K_r is the complete graph of order r. A graph is said to be clique-separable if it contains a clique whose removal disconnects that graph. It is well-known that any clique-separable graph has a chromatic factorisation. Morgan and Farr (2009) found graphs that are not clique-separable, nor chromatically equivalent to any clique-separable graphs, but factorised in the same way as clique-separable graphs. In all of these cases, the graphs have a factorisation that "behaves" like the factorisation of a clique-separable graph.

In this talk, we present new results on cases where the chromatic polynomial "factorises" but does not "behave" like the factorisation of clique-separable graphs. We give an infinite family of graphs that that have a chromatic factorisation that is "similar" to a clique-separable graph but one of the chromatic factors does not have chromatic number at least r. We also give examples of graphs that have chromatic polynomials $P(G;\lambda) = P(H_1;\lambda) \times P(H_2;\lambda)/P(D;\lambda)$ where D is not a complete graph.

ROOM UNH416 MON 10:30 AM

SIZE-RAMSEY NUMBERS OF BOUNDED-DEGREE TRIANGLE-FREE GRAPHS

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(Joint work with David Conlon)

The size Ramsey number sr(H) of a graph H is the smallest number of edges in a graph G which is Ramsey with respect to H, that is, such that any 2-colouring of the edges of G contains a monochromatic copy of H. A famous result of Beck states that the size Ramsey number of the path with n vertices is at most bn for some fixed constant b > 0. An extension of this result to graphs of maximum degree Δ was recently obtained by Kohayakawa, Rödl, Schacht and Szemerédi, who showed that there is a constant b > 0 depending only on Δ such that if H is a graph with n vertices and maximum degree Δ then $\mathrm{sr}(H) < bn^{2-1/\Delta}(\log n)^{1/\Delta}$. On the other hand, the only known lower-bound on the size Ramsey numbers of bounded-degree graphs is of order $n(\log n)^c$ for some constant c > 0, due to Rödl and Szemerédi.

We make a small step towards improving the upper bound. In particular, we show that if H is a Δ-bounded-degree triangle-free graph then $\mathrm{sr}(H) < bn^{2-1/(?-1/2)} \cdot \mathrm{polylog} n$. In this talk we discuss why $1/\Delta$ is the natural 'barrier' in the exponent and how we go around it, why do we need the triangle-free condition and what are the limits of our approach.

ROOM UNH421 THU 11:30 AM

LARGEST REGULAR MULTIGRAPHS WITH THREE DISTINCT EIGENVALUES

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Let G be a connected k-regular multigraph (V, E), which may have loops. Suppose the adjacency matrix of G has only three distinct eigenvalues. In this talk, we deal with the largest graphs G for given degree k. If $k = 2, 3, 7$, then the Moore graph is largest. If $k \neq 2, 3, 7, 57$, then $|V| \leq q^2 + q + 1$, where $q = k - 1$. If q is a prime power, a graph that attains the bound is obtained from a projective plane.

ROOM UNH421 MON 4:00 PM

ON THE VERTEX IRREGULAR TOTAL LABELING FOR SUBDIVISION OF TREES

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(Joint work with Edy Tri Baskoro, Rinovia Simanjuntak, Joe Ryan)

Let $G = (V, E)$ be a simple, connected and undirected graph with non empty vertex set V and edge set E. A *labeling* of graph is assignment of numbers to the vertex or edges, or both subject to certain condition. We define a labeling $\phi : V \cup E \to \{1, 2, 3, \ldots, k\}$ to be a *vertex irregular total k-labeling* of G if for every two different vertices x and y of G, their weights $w(x)$ and $w(y)$ are distinct, where the weight $w(x)$ of a vertex $x \in V$ is $w(x) = \phi(x) + \sum_{xy \in E(G)} \phi(xy)$. The minimum k for which the graph G has a vertex irregular total k-labeling is called the *total vertex irregularity strength* of G, denoted by $tvs(G)$. The *subdivision* of a graph G on the edge e in r times is a graph obtained from the graph G by replacing the edge $e = uv$ with path $(u, x_1, x_2, \ldots, x_r, v)$.

In this paper we determine the total vertex irregularity strength for subdivision into all of the edges of any trees. We consider the number of vertices of degree two to give the lower bound and we construct the function of the vertex irregular labeling to prove the upper bound.

Keywords: Irregularity strength, total vertex irregularity strength, subdivision, tree.

ROOM UNH421 WED 9:30 AM

ASSOCIATION SCHEMES ALL OF WHOSE SYMMETRIC FUSIONS ARE INTEGRAL

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(Joint work with Mitsugu Hirasaka, Kijung Kim)

Let X be a finite set and S a partition of $X \times X$. We say (X, S) is an association scheme if it satisfies the following conditions; (i) $1_X = \{(x, x) \mid x \in X\} \in S$, (ii) If $s \in S$ then $s^* = \{(y, x) \mid (x, y) \in s\} \in S$, (iii) For all $s, t, u \in S$, the number of $z \in X$ such that $(x, z) \in s$ and $(z, y) \in t$ is constant whenever $(x, y) \in u$.

Let (X, S) be an association scheme. For s in S, the adjacency matrix of s is defined to be the matrix σ_s over $\mathbb{C}$ where $(\sigma_s)_{x,y} = 1$ if $(x, y) \in s$, and 0 otherwise. We say (X, S) is symmetric if σ_s is symmetric for any $s \in S$, and integral if $\mathrm{ev}(\sigma_s) \subset \mathbb{Z}$ for any $s \in S$ where $\mathrm{ev}(\sigma_s)$ is the set of all eigenvalues of σ_s. For an association scheme (X, S), (X, T) is said to be a fusion of (X, S) if for each $t \in T$, $t = \bigcup_{s \in I} s$ for some $I \subseteq S$. In this talk we aim to characterize association schemes all of whose symmetric fusions are integral and classify those obtained from a regular action of a finite group by taking its orbitals.

ROOM UNH416 FRI 11:30 AM

EDUCATION, COMBINATORICS AND THE MODERN WORLD

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In 2014 Mirka Miller got me invited to speak at a meeting jointly hosted by the Indonesian Combinatorial Society and the Islamic University, Malang, Indonesia. The topic of the meeting was an unusual pairing - mathematics education and graph theory: fkipunisma.ac.id/international-workshop-on-graph-masters-and-seminar-on-mathematics-education-and-graph-theory.html

I will forever be grateful to Mirka for that invitation, since not only was it my first invited speakership at an international conference, it also got me thinking and writing for the first time about the opportunities for transformative mathematics education that arise particularly in combinatorics, as opposed to in mathematics generally.

I will reprise a shorter version of the talk that I gave in Malang, emphasising the special role that Combinatorics can play in mathematics education.

ROOM UNH419 WED 4:30 PM

IDENTICALLY SELF-DUAL MATROIDS

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Our study of binary identically self-dual matroids is originally motivated by their connection to projective planes of order 2 mod 4. We have chosen to focus on the intersection of the class of identically self dual matroids with the class of representable matroids, arising from linear dependence of the columns in a matrix, and the class of frame matroids, related to edges of a biased graph. In this talk I will present results related to these two subsets of identically self dual matroids. I will talk about the minors of representable identically self-dual matroids and fully describe the structure of biased graphs which correspond to identically self-dual matroids.

ROOM UNH416 MON 4:00 PM

TWOFOLD TRIPLE SYSTEMS WITH 2-INTERSECTING GRAY CODES

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(Joint work with Aras Erzurumluoglu)

A λ-fold triple system of order v is a design consisting of a v-set V and a collection of 3-subsets (called blocks or triples) of V such that each 2-subset of V occurs in exactly λ of the triples of the design. Given a λ-fold triple system with $\lambda > 1$, we can ask whether its triples can be ordered so that the union of any two consecutive triples consists of four elements of V; when this is possible we have a 2-intersecting Gray code for the design. We will describe some potential applications, give a review of previous existence and non-existence results, and discuss some recent advances concerning the existence of 2-intersecting Gray codes for twofold triple systems. This is joint work with Aras Erzurumluoğlu.

ROOM UNH416 MON 11:00 AM

TOPOLOGICAL CONTAINMENT OF THE 5-CLIQUE MINUS AN EDGE IN 4-CONNECTED GRAPHS.

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(Joint work with Graham Farr)

The topological containment problem is known to be polynomial-time solvable for any fixed pattern graph H, but good characterisations have been found for only a handful of non-trivial pattern graphs. The complete graph on five vertices, K_5, is one pattern graph for which a characterisation has not been found. The discovery of such a characterisation would be of particular interest, due to the Hajós Conjecture. One step towards this may be to find a good characterisation of graphs that do not topologically contain the simpler pattern graph K_5^-, obtained by removing a single edge from K_5. Here we make some progress towards achieving this, by looking at the topological containment of K_5^- in 4-connected graphs.

ROOM UNH419 MON 4:00 PM

INVARIABLE GENERATION OF FINITE PERMUTATION GROUPS

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The University of Western Australia

An invariable generating set for a group G is a collection of conjugacy classes, any choice of representatives from which form a generating set for G. Such generating sets are "invariable" in that generators can be replaced by their conjugates and the resulting set will still fully generate G. In early 2015, Detomi and Lucchini generalised a result of McIver and Neumann on the generating number of permutation groups, and showed that every permutation group except Sym(3) admits an invariable generating set of cardinality no greater than half the degree of the group. I will be presenting the results of my 2015 honours thesis, in which I enumerate the groups which meet this bound strictly, and prove related results on invariable generation.

ROOM UNH416 THU 11:30 AM

CHROMATIC ROOTS, THE GOLDEN RATIO AND B_{10}

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The Golden Ratio $\varphi = (1+\sqrt{5})/2$ and numbers related to it are of particular significance in the study of the real roots of the chromatic polynomials of graphs, especially the chromatic polynomials of planar graphs.

In this talk I will discuss two recent results regarding the chromatic roots (of both planar and non-planar graphs) lying in the real interval $(3,4)$, highlighting the unique role played by the Beraha number $B_{10} = \varphi + 2$.

ROOM UNH416 FRI 11:00 AM

AN ANTIMAGIC GRAPH FOR EACH DEGREE SEQUENCE

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(Joint work with Oudone Phanalasy, Joe Ryan and Mirka Miller)

In 1990 Hartsfield and Ringel introduced the concept of an antimagic graph.

Label the edges of a graph $G = (V, E)$ with $1, 2, \ldots, |E|$, one label per edge. The weight of a vertex is the sum of the labels of the edges incident with the vertex. The labelling is antimagic if the vertex weights are distinct. A graph is antimagic if it has an antimagic labelling.

Hartsfield and Ringel conjectured that every connected graph, except K_2, is antimagic. Many classes of graphs are known to be antimagic, but we seem to be a long way from seeing a proof of the conjecture.

In this talk we show that for every sequence that is the degree sequence of a connected graph, there is an antimagic graph with that degree sequence.

TWO INFINITE FAMILIES OF SYMMETRIC HADAMARD MATRICES

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(Joint work with N. A. Balonin)

A construction method for orthogonal ± 1 matrices based on a variation of the Williamson array called the *propus array*

$$\begin{matrix} A & B & B & D \\ B & D & -A & -B \\ B & -A & -D & B \\ D & -B & B & -A \end{matrix}$$

gives symmetric propus-Hadamard matrices.

We show that for

- $q \equiv 1 \pmod 4$, a prime power, symmetric propus-Hadamard matrices exist for order $2(q+1)$; and
- $q \equiv 1 \pmod 4$, a prime power, and $\frac{1}{2}(q+1)$ a prime power or the order of the core of a symmetric conference matrix (this happens for $q = 89$) symmetric propus-type Hadamard matrices of order $4(2q+1)$ exist.

We give constructions to find symmetric propus-Hadamard matrices for 57 orders $4n$, $n < 200$ odd.

Keywords: Hadamard Matrices, D-optimal designs, conference matrices, propus construction, Williamson matrices; Cretan matrices; 05B20.

ROOM UNH416 TUE 11:30 AM

CONSTRUCTING TREE-CHILD NETWORKS FROM DISTANCE MATRICES

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(Joint work with Magnus Bordewich, Nihan Tokac)

Evolution is not necessarily a tree-like process because of reticulate (non-tree-like) events such as hybridisation and lateral gene transfer. The reticulate evolutionary history of a set of extant taxa is typically represented by a phylogenetic network (a particular type of acyclic directed graph). Although reticulation has long been recognised in evolution, mathematical investigations into understanding the structural properties of phylogenetic networks are relatively new. Originally, the questions and consequent investigations were of a certain type, but now we are seeing an ever-increasing variety of questions being asked. In this talk, we investigate the question of when is an edge-weighted phylogenetic network determined by the path-length distances between its leaves?

ROOM UNH419 WED 3:30 PM

ON THE COVERING NUMBER OF MATROIDS

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(Joint work with Thomas Britz)

The "covering number" of a matroid M on a finite set E, denoted by $\alpha(M)$, is defined by the minimum size of a set of cocircuits of M whose union is E. The covering number of a matroid is strongly related to the critical exponent of a representable matroid over a finite field and the covering dimension of a linear code over a finite field. Therefore, determining the covering number of a given matroid can be seen as a sort of the Critical Problem in matroid theory.

In this talk, we study the covering number of uniform matroids, projective geometries and Steiner systems. And we present a bound on the covering number of a matroid and we give a construction of matroids which attain the bound.

ROOM UNH421 TUE 4:00 PM

BEATTY SEQUENCES AND CHRISTOFFEL WORDS

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Beatty sequences are objects which are studied by number theorists. Christoffel words are important in the combinatorics of words. In the talk I will explain what these two objects are and state some of their properties. I will then reveal that they are really the same thing. I will then show how some of the important properties of Christoffel words can be derived using number theoretic techniques.

ROOM UNH421 TUE 9:30 AM

LOWER BOUNDS ON THE SIZES OF t-(v,k,λ) COVERINGS

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(Joint work with Daniel Horsley)

A t-(v,k,λ) covering is a collection of k-element subsets, called blocks, of a v-set of points such that each t-subset of points occurs in at least λ blocks. If each t-subset of points occurs in exactly λ blocks the covering is a t-(v,k,λ) design. Fisher's inequality famously states that every 2-(v,k,λ) design has at least v blocks. In 1975 Ray-Chaudhuri and Wilson generalised this result to higher t by showing that every t-(v,k,λ) design has at least $\binom{v}{\lfloor t/2 \rfloor}$ blocks, and Wilson gave a streamlined proof of this result in 1982. Horsley (2015) adapted a well-known proof of Fisher's inequality to produce a new lower bound on the number of blocks in some 2-(v,k,λ) coverings. In this talk, we show how ideas from these papers can be combined to obtain an improved lower bound on the number of blocks in t-(v,k,λ) coverings for $t > 2$.

ROOM UNH421 MON 11:30 AM

THE ZERO FORCING NUMBER OF GRAPHS WITH GIVEN GIRTH

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(Joint work with Thomas Kalinowski)

For a two-coloring of the vertex set of a simple graph $G = (V, E)$ consider the following color-change rule: a red vertex is converted to blue if it is the only red neighbor of some blue vertex. A vertex set $S \subseteq V$ is called zero-forcing if, starting with the vertices in S blue and the vertices in the complement $V \setminus S$ red, all the vertices can be converted to blue by repeatedly applying the color-change rule. The minimum cardinality of a zero-forcing set for the graph G is called the zero-forcing number of G, denoted by $Z(G)$. Let G be a graph with minimum degree $\delta \geq 2$ and girth $g \geq 3$. Davila and Kenter conjecture that the zero forcing number $Z(G) \geq (g-3)(\delta-2)+\delta$. This conjecture has recently been proven for $g \leq 10$. The conjecture is also proven when the girth $g \geq 7$ and the minimum degree is sufficiently large. In this paper, we prove the conjecture for all graphs with girth $g \geq 11$ and for all values of $\delta \geq 2$, thereby settling the conjecture.

ROOM UNH416 WED 11:30 AM

CARTESIAN PRODUCT GRAPHS AND k-TUPLE TOTAL DOMINATION

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(Joint work with Adel P. Kazemi, Behnaz Pahlavsay)

A k-tuple total dominating set of a graph G is a set S of vertices in which every vertex in G is adjacent to at least k vertices in S; the minimum size of a kTDS is denoted $\gamma_{\times k,t}(G)$. In this talk, we discuss bounds on $\gamma_{\times k,t}(G \square H)$ for Cartesian product graphs $G \square H$ and give a formula for $\gamma_{\times 2,t}(K_n \square K_m)$.

ROOM UNH421 WED 10:00 AM

ASSOCIATION SCHEMES OBTAINED FROM TWIN PRIME POWERS

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(Joint work with Hadi Kharaghani, Sara Sasani)

It is known that the parallel classes of an affine resolvable design give rise to a symmetric design. In this construction, one uses the auxiliary $(0,1)$-matrices obtained from the parallel classes and a Latin square. In this talk we use twin prime powers, say q and $q+2$, in order to obtain an affine resolvable design from $\mathbb{F}_q$ and Latin squares from $\mathbb{F}_{q+2}$, which yield a set of symmetric designs. We show that these symmetric designs derive a commutative association scheme, and determine its eigenmatrices. This talk is based on joint work with Hadi Kharaghani and Sara Sasani.

ROOM UNH419 MON 11:00 AM

ANTIADJACENCY SPECTRUM OF REGULAR AND LINE (DI-)GRAPHS

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Let G be a simple graph with n vertices and m edges. Antiadjacency matrix of G is an $n \times n$ matrix B such that $B = J - A$, where A is an adjacency matrix of G and J is an $n \times n$ matrix with all elements are equal to 1. There are many results for adjacency spectrum topic already. However, the antiadjacency matrix topic is new and can give us more information on the properties of graphs. In this talk, we discuss the antiadjacency spectrum of a regular undirected graph and directed graph. Moreover, we also show the relationship between adjacency spectrum and antiadjacency spectrum..

2010 Mathematics Subject Classification: *05C50*

Keywords: *adjacency matrix, antiadjacency matrix, spectrum, linegraph.*

ROOM UNH419 MON 3:30 PM

SETS ON A PLANE

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Given a finite projective plane Π, we are interested in finding a large set of points along with an equally large set of lines not containing any of those points. Denote by $\bar{\alpha}(\Pi)$ the cardinality of the largest such set (of points). To date, the exact value of $\bar{\alpha}(PG(2,q))$ is known only when $q \leq 16$ or q is a power of 4. We will examine the best-known bounds for this problem, and compare some of the approaches taken for computing the exact values or for obtaining good bounds. Finally, we will generalise this problem to higher-dimensional projective spaces, before discussing the isoperimetric problem as the original motivation for this problem.

ROOM UNH419 WED 10:00 AM

AN EXACT ALGORITHM FOR MIN-MAX HYPERSTRUCTURE EQUIPARTITION WITH A CONNECTED CONSTRAINT

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(Joint work with Juan A. Mesa, Suixiang Gao)

Hyperstructure is a topological concept that shares characteristics with both graphs and hypergraphs. The Min-Max hyperstructure equipartition with a connected constraint problem is to find a partition of a hyperstructure into K equal-sized connected parts that minimizes the maximum load in each part (the number of hyperedges assigned to each part). This problem is proved to be NP hard. Shrink and Cut algorithm is designed to simplify original complex hyperstructure without changing the optimal solution of the Min-Max hyperstructure equipartition with a connected constraint problem. By the use of this algorithm, Min-Max hyper-tree equipartition with a connected constraint can be solved in polynomial time. An exact algorithm: Min-Max hyperstructure partitioning algorithm, based on Shrink and Cut algorithm and algorithm S for finding all the spanning trees, is designed to solve ordinary cases, which shows great on experimental results.

ROOM UNH421 MON 4:30 PM

REFLEXIVE VERTEX IRREGULAR LABELING OF LADDERS

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(Joint work with Joe Ryan)

For a graph G we define k-labeling ρ such that the edges of G are labeled with integers $1, 2, ..., k_e$ and the vertices of G are labeled with even integers $0, 2, ..., 2k_v$, where $k = max\{k_e, 2k_v\}$. The labeling ρ is called an reflexive vertex irregular k-labeling if distinct vertices have distinct weights, where the vertex weight is defined as the sum of the label of that vertex and the labels of its incident edges. The smallest k for which such labeling exist is called the reflexive vertex strength of G. In this paper we give exact values of reflexive vertex strength for Ladders.

ROOM UNH416 THU 9:30 AM

LATIN SQUARES WITH NO TRANSVERSALS

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(Joint work with Nicholas J. Cavenagh)

A latin square is a matrix in which each row and column are a permutation of the same set of symbols. A k-plex in a latin square of order n is a selection of kn entries that includes k representatives from each row and column and k occurrences of each symbol. A 1-plex is also known as a transversal.

It is well known that if n is even then B_n, the addition table for the integers modulo n, possesses no transversals. We show that there are a great many latin squares that are similar to B_n and have no transversal. As a consequence, the number of species of transversal-free latin squares is shown to be at least $n^{n^{3/2}(1/2-o(1))}$ for even $n \to \infty$.

We also prove a 2002 conjecture of the speaker that for all orders $n > 4$ there is a latin square of order n that contains a 3-plex but no transversal.

ROOM UNH421 MON 3:30 PM

Q_d-SUPERMAGIC LABELING OF THE d-DIMENSIONAL GRID GRAPH

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(Joint work with Joe Ryan, Thomas Kalinowski)

A graph labeling is an assignment of integers to the vertices or edges, or both, subject to certain conditions. A simple graph $G = (V, E)$ admits an H-covering if every edge in E belongs to at least one subgraph of G isomorphic to H. A graph G which admits an H-covering is H-magic if there is a total labeling $f : V \cup E \to \{1, \ldots, |V| + |E|\}$ such that for each subgraph $H' = (V', E')$ of G isomorphic to H,

$$f(H') = \sum_{v \in V'} f(v) + \sum_{e \in E'} f(e) = k,$$

where k is a constant. Additionally, G is said to be H-supermagic if the labels of the vertices are the smallest labels, $f(V) = \{1, 2, \ldots, |V|\}$.

In this talk, we show that the d-dimensional grid $Grid(n_1, \ldots, n_d)$ is Q_d-supermagic total labeling where Q_d is the d-dimensional hypercube. Our proof is by induction on d.

Keywords : H-supermagic labeling, magic labeling, total labeling, grid graph, hypercube graph.

ROOM UNH421 TUE 3:30 PM

ANAGRAM-FREE COLOURING GRAPH SUBDIVISIONS

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(Joint work with David R. Wood)

Anagram-free colouring was independently introduced this year by ourselves [arXiv:1607.01117] and Kamčev, Łuczak and Sudakov [arXiv:1606.09062]. An anagram is a word of the form WP where W is a non-empty word and P is a permutation of W. A graph colouring is anagram-free if the sequence of colours on every path in the graph is not an anagram. Anagram-free colouring is inspired by square-free colouring, which is a colouring avoiding paths with subwords of the form WW.

The two preprints contain many results showing that anagram-free colouring behaves quite differently to square-free colouring. Trees give an example of this difference as trees have square-free chromatic number at most 4. In contrast, Kamčev, Łuczak and Sudakov show that binary trees have unbounded anagram-free chromatic number. Their result can be generalised to show that bounded subdivisions of complete binary trees have unbounded anagram-free chromatic number.

In this talk we prove that every graph has an anagram-free 8-colourable subdivision. This establishes a similarity between between square-free colouring and anagram-free colouring since Pezarski and Zmarz proved that every graph has a square-free 3-colourable subdivision. An implication of our result is that anagram-free chromatic number is not tied to pathwidth.

ROOM UNH416 MON 11:30 AM

EDGE-MAXIMAL GRAPHS ON SURFACES

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(Joint work with Colin McDiarmid)

We prove that for every surface Σ of Euler genus g, every edge-maximal embedding of a graph in Σ is at most $O(g)$ edges short of a triangulation of Σ. This provides the first answer to an open problem of Kainen (1974).

ROOM UNH416 THU 3:30 PM

THE PROBABILITY OF NONEXISTENCE OF A SUBGRAPH IN A MODERATELY SPARSE RANDOM GRAPH

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(Joint work with Dudley Stark)

We develop a general procedure that finds recursions for statistics counting isomorphic copies of a graph G_0 in the common random graph models $\mathcal{G}(n,m)$ and $\mathcal{G}(n,p)$. Our results apply when the average degrees of the random graphs are below the threshold at which each edge is included in a copy of G_0. For all strictly balanced subgraphs G_0, our results give much information on the distribution of the number of copies of G_0 that are not in large "clusters" of copies. The probability that a random graph in $\mathcal{G}(n,p)$ has no copies of G_0 is shown to be given asymptotically by the exponential of a power series in n and p, over a fairly wide range of p. A corresponding result is also given for $\mathcal{G}(n,m)$, which gives an asymptotic formula for the number of graphs with n vertices, m edges and no copies of G_0, for the applicable range of m.

ROOM UNH416 WED 3:30 PM

VERTEX-PRIMITIVE s-ARC-TRANSITIVE DIGRAPHS

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(Joint work with Michael Giudici, Cai Heng Li)

An s-arc in a digraph is a sequence $v_0, v_1, \ldots, v_s$ of vertices such that for each admissible i, the pair (v_i, v_{i+1}) is an arc of the digraph. A digraph Γ is said to be s-arc-transitive if the automorphism group $\mathrm{Aut}(\Gamma)$ of Γ acts transitively on the set of s-arcs of Γ, and is said to be vertex-primitive if $\mathrm{Aut}(\Gamma)$ preserves no nontrivial partition of the vertex set. In this talk I will discuss vertex-primitive s-arc-transitive digraphs according to different O'Nan-Scott types of vertex-primitive groups, and solve the existence problem of vertex-primitive 2-arc-transitive digraphs by giving some infinite families.

ROOM UNH419 THU 3:30 PM

ON CONSTRUCTION WEIGHING MATRICES BY NEGACYCLIC MATRICES

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In this paper we construct the weighing matrices by 2-suitable negacyclic matrices and give evidence to support the conjecture "For every $n = 2$ (modulo 4), there exist weighing matrices $W(n, k)$, where $k = 1, \ldots, n$.".

ROOM UNH419 MON 10:30 AM

SMALLEST 4-CHROMATIC GRAPH WITH ODD-GIRTH 7

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(Joint work with Gordon Royle)

In 1995, Ngoc and Tuza construct a family of graphs, known as the generalised Mycielski graph, with an arbitrary chromatic number k and odd-girth g. Denote the unique graph in that construction with such property as $M_k(C_g)$. It is known that the Grotzsch graph, $M_4(C_5)$ is the unique smallest 4-chromatic triangle-free graph and it is conjectured that $M_4(C_g)$ is the unique 4-chromatic triangle-free graph with odd-girth g. With computer assistance, we prove that for $g = 7$, $M_4(C_7)$ is not the only 4-chromatic graph with odd-girth 7 on 22 vertices. We also obtain partial proof that the smallest 4-chromatic graphs with odd-girth 7 have at least 22 vertices.

ROOM UNH419 WED 11:00 AM

TUTTE INVARIANTS FOR ALTERNATING DIMAPS

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(Joint work with Graham Farr and Kerri Morgan)

An *alternating dimap* is a directed embedded Eulerian graph where the edges incident with each vertex are directed inwards and outwards alternately. Three reduction operations for alternating dimaps were investigated by Farr [1]. A *minor* of an alternating dimap can be obtained by reducing some of its edges using the reduction operations. Unlike classical minor operations, these reduction operations do not commute in general. A *Tutte invariant* for alternating dimaps is a function F defined on every alternating dimap such that F is invariant under isormorphism, and which obeys a linear recurrence relation involving reduction operations. We study the Tutte invariants for alternating dimaps introduced by Farr [1]. As a result of the non-commutativity of the reduction operations, the Tutte invariants are not always well defined. We investigate the properties of alternating dimaps that are required in order to obtain a well defined Tutte invariant.

Bibliography

[1] G. E. Farr. Minors for alternating dimaps, preprint, 2013. arxiv.org/abs/1311.2783v3

ROOM UNH416 WED 4:00 PM

CLASSIFICATION OF ARC-TRANSITIVE ALMOST MULTICOVERS OF COMPLETE GRAPHS

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A graph is G-arc-transitive if it admits G as a group of automorphisms acting transitively on the set of ordered pairs of adjacent vertices. A project completed recently was to classify G-arc-transitive graphs Γ with G imprimitive on the vertex set of Γ such that the corresponding quotient graph is a complete graph and is almost multi-covered by Γ. In this talk we will discuss this classification together with related results.

Joint work with Massimo Giulietti, Stefano Marcugini and Fernanda Pambianco (2013), and Teng Fang, Xin Gui Fang and Binzhou Xia (2016).

FOOD

BRIAN'S RESTAURANT GUIDE

(Labels 1 – 18 refer to the map on p. 55)

There are many restaurants in the local area along Darby Street, The Foreshore and the CBD. Kathy and I have eaten at some of them but have missed many of them. In any case, based on our experiences and some word-of-mouth, here is a guide and I hope it proves helpful to you.

We have heard many people praising 1 **Napoli Centrale** at 173 King Street for very good pizza. I have not tried it because I am very fond of the pizza at 2 **FogHorn Brewhouse** at 218 King Street. It is the kind I am fond of: thin crust and minimal toppings. In addition, they brew their own beer here and it is worth a visit for that reason alone.

Having lived in Vancouver for thirty plus years, we became rather fussy about Chinese, Japanese and Thai food. We have found two Japanese restaurants we can recommend. One is 3 **Nagisa** on the foreshore at N2/1 Honeysuckle Drive. It is not far from the Crown Plaza Hotel heading west.

The other one is 4 **Asa Don** at 179 King Street. It is a cozy place with a small menu and perhaps a bit of a local secret.

Right next door to Asa Don (181 King Street) is 5 **Habesha Ethiopian** which is another somewhat local secret. Well worth a visit.

There are three Thai restaurants along Darby Street and each of them has a fan club. Our favorite is 6 **Chat Thai** at 88 Darby Street. It is upstairs and if you go there, try to get a seat on the balcony.

There was a plethora of Italian restaurants at one time, but they have thinned out considerably over the last twenty years. Two that we recommend are 7 **Delucas Pizza** at 159 Darby Street and 8 **Rosina's Pizza** at 39 Hunter Street. Ironically, pizza appears in the names of both of these restaurants, but it is other dishes they make that attract me. I had the best butterfly prawns I've ever had at Rosina's. You probably want to make reservations for either of these places.

9 **Goldbergs Coffee House** at 137 Darby Street is probably the most iconic eating place in Newcastle. Anyone who has spent some time in Newcastle should be able to say, "Oh, yes, I've eaten at Goldbergs." Another nice feature of this establishment is that they serve dinners later than most places.

A very nice new restaurant is 10 **Moor Newcastle East** at 33 Hunter Street. It is oriented towards Spanish and North African food. We highly recommend this place.

Anyone not from Australia should have a go at Australian pub food. Much of it is heavy and not necessarily that exciting (they all have chicken schnitzel). However, it is fun to find one that is a cut above the majority. The 11 **Hotel Delany** at 134 Darby Street is better than average and we've recently heard good things about the 12 **Commonwealth Hotel** at 35 Union Street.

A definite cut above and a bit farther away is the 13 **Junction Hotel** at 204 Corlette Street. To get to it you walk along Union Street until you reach Junction. We've eaten there several times and always found the menu much more interesting than the average pub menu.

The 14 **Honeysuckle Hotel** at Lee Wharf right on the water is a pleasant place to have a drink and they have standard pub food. It is about the same distance west of Nagisa that Nagisa is from the Crown Plaza.

15 **Scatchley's** is an excellent seafood restaurant and also is right on the water. It is east of the Crown Plaza (200 Wharf Road). My only complaint about this place is how noisy it is when it is crowded, and the latter is usually the case at popular eating times.

16 **Pide Fez** at 126 Darby Street is a popular (deservedly so) place to get Turkish Pide. It is well prepared and the place is open late.

There are several popular coffee shops along the Hunter Mall and along Darby Street. It is pretty hard to find a bad coffee. 17 **Saluna** at 137 King Street has a loyal following. It has a small menu.

18 **Ground Floor Cafe** at 103 Hunter is open for breakfast and lunch. It is a place I recommend.

DRINKS

(Labels 1 – 6 refer to the map on p. 55)

1 **The Hop Factory**
102 Darby St, Cooks Hill NSW 2300
thehopfactory.com.au · ☎ (02) 4929 4854
Open Wed-Thu 11am–11pm, Fri 11am–12am, Sat-Sun 9am–12am, closed Mon-Tue

2 **Grain Store Craft Beer Cafe**
64-66 Scott St, Newcastle East NSW 2300
grainstorenewcastle.com.au · ☎ (02) 4023 2707
Open Tue-Thu 11am–10:30pm, Fri-Sat 11am–11:30pm, Sun 11am–9:30pm, closed Mon

3 **5 Sawyers**
115 Darby St, Cooks Hill NSW 2300
5sawyers.com.au · ☎ (02) 4927 0070
Open Wed-Fri 4pm–12am, Sat 3pm–1am, Sun 3pm–12am, closed Mon-Tue

4 **The Basement**
2/2 Market St, Newcastle NSW 2300
basementonmarketst.com.au · ☎ (02) 4906 1386
Open Mon-Sat 3pm–12am, Sun 3–10pm

5 **The Lucky Hotel**
237 Hunter St, Newcastle NSW 2300
theluckyhotel.com.au · ☎ (02) 4925 8888
Open Mon-Sun 11am until late

6 **The Edwards**
148 Parry St, Newcastle West NSW 2302
theedwards.com.au · ☎ (02) 4965 3845
Open Tue-Sat 7am–12am, Sun 7am–10pm, closed Mon

Map

Conference

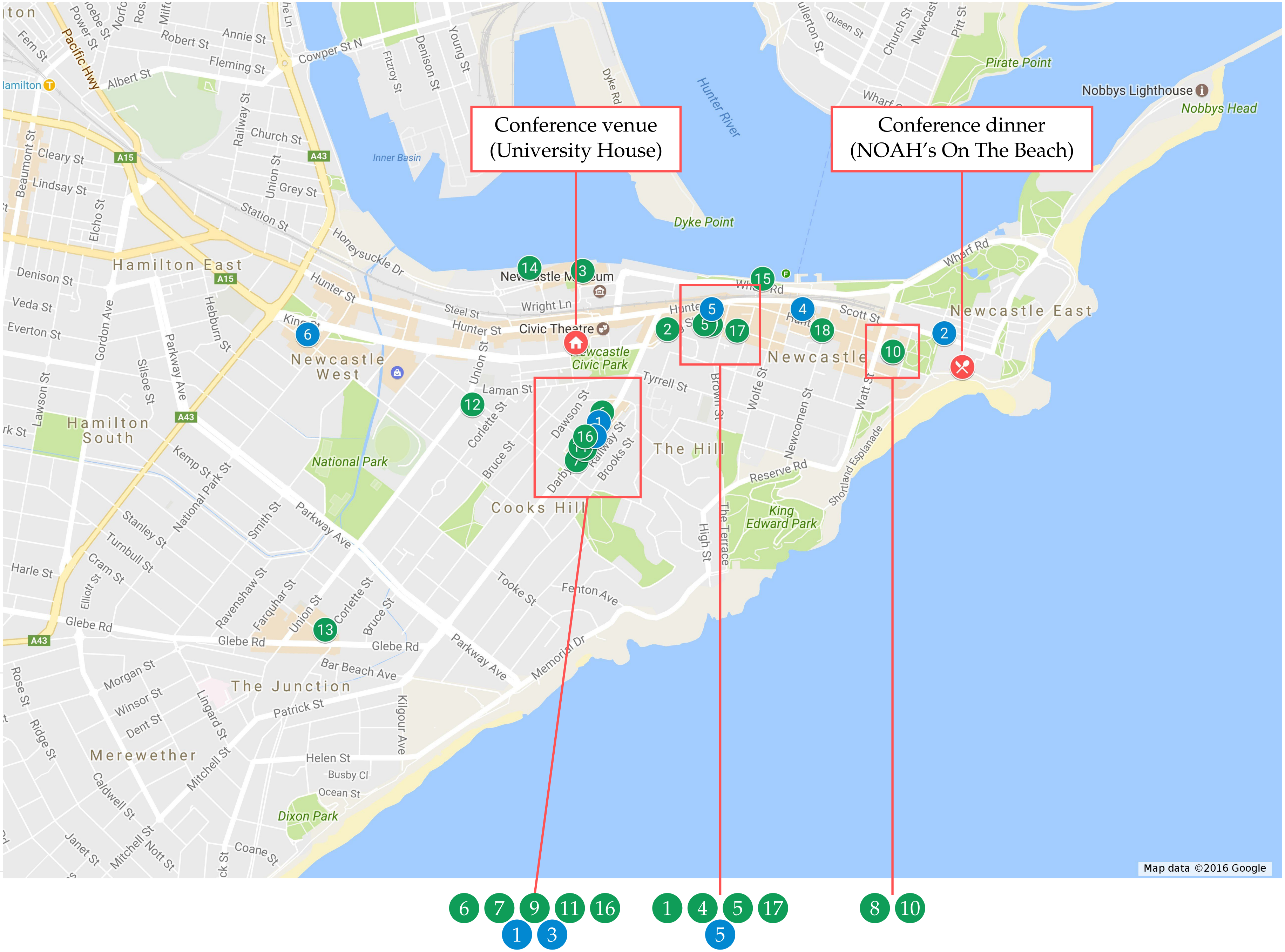
- Conference venue (University House)
- Conference dinner (NOAH'S On The Beach)

Food

1. Napoli Centrale
2. FogHorn Brewhouse
3. Nagisa
4. Asa-don
5. Habesha
6. Chat Chai Thai Cuisine
7. Delucas Pizza
8. Rosina's Pizza
9. Goldbergs Coffee House
10. Moor Newcastle East
11. Hotel Delany
12. Commonwealth Hotel
13. Junction Hotel
14. Honeysuckle Hotel
15. Scratchleys on the Wharf
16. Pide Fez
17. Saluna
18. Ground Floor Cafe

Drinks

1. The Hop Factory
2. Grain Store Craft Beer Cafe
3. 5 Sawyers
4. The Basement
5. The Lucky Hotel
6. The Edwards



CMSA STUDENT PRIZE

The CMSA Student Prize was inaugurated in 2001 at 26ACCMCC and is awarded annually for the best student talk at the ACCMCC or ICC.

PAST PRIZEWINNERS

26ACCMCC: Curtin University, Perth, 9–13 July 2001.
Dillon Mayhew *Victoria University of Wellington*.

27ACCMCC: University of Newcastle, Newcastle, 9–13 December 2002.
Julie Cain *University of Melbourne* and
Peter Jenkins *University of Queensland*.

28ACCMCC: Deakin University, Melbourne, 15–18 December 2003.
Jeanette McLeod *Australian National University*.

29ACCMCC: Copthornes-Manuels, Taupo, 13–18 December 2004.
Shuji Kijima *University of Tokyo, Japan*.

30ACCMCC: University of Queensland, Brisbane, 5–9 December 2005.
Daniel Horsley *University of Queensland* and
James Lefevre *University of Queensland*.

31ACCMCC: Alice Springs, Northern Territory, 8–11 July 2006.
Alison Thomson *University of Melbourne*.

32ACCMCC: University of Otago, Dunedin, 3–7 December 2007.
Ben Smith *University of Queensland*.

4ICC: University of Auckland, Auckland, 15–19 December 2008.
Kerri Morgan *Monash University*.

33ACCMCC: University of Newcastle, Newcastle, 7–11 December 2009.
Beáta Faller *University of Canterbury* and
Joanne Hall *Royal Melbourne Institute of Technology*.

34ACCMCC: Australian National University, Canberra, 6–10 December 2010.
Ben Clark *Victoria University of Wellington*.

35ACCMCC: Monash University, Melbourne, 5–9 December 2011.
Sarada Herke *University of Queensland*.

36ACCMCC: University of New South Wales, Sydney, 10–14 December 2012.
Mohammadreza Jooyandeh *Australian National University*.

37ACCMCC: University of Western Australia, Perth, 9–13 December 2013.
Florian Lehner *Graz University of Technology*.

38ACCMCC: Victoria University of Wellington, Wellington, 1–5 December 2014.
Darcy Best *Monash University*.

39ACCMCC: University of Queensland, Brisbane, 7–11 December 2015.
Mark Ioppolo *University of Western Australia*.

CONFERENCES IN THIS SERIES

Event	Location	Dates
1st ACCM	University of Newcastle	10–12 June 1972
2nd ACCM	University of Melbourne	25–26 August 1973
3rd ACCM	University of Queensland	16–18 May 1974
4th ACCM	University of Adelaide	27–29 August 1975
5th ACCM	Royal Melbourne Institute of Technology	24–26 August 1976
1st ICCMC	Australian Academy of Science	16–27 August 1977
6th ACCM	University of New England	29 Aug – 1 Sep 1978
7th ACCM	University of Newcastle	20–24 August 1979
8th ACCM	Deakin University	25–29 August 1980
9th ACCM	University of Queensland	24–28 August 1981
10th ACCM	University of Adelaide	23–27 August 1982
11th ACCM	University of Canterbury	29 Aug – 2 Sep 1983
12th ACCMC	University of Western Australia	13–17 August 1984
13th ACCMC	University of Sydney	26–30 August 1985
14th ACCMC	Part 1: National University of Singapore	19–23 May 1986
	Part 2: University of Otago	1–5 December 1986
2nd ICCMC	Australian National University	24–28 August 1987
15th ACCMCC	University of Queensland	10–14 July 1989
16th ACCMCC	Massey University	3–7 December 1990
17th ACCMCC	Australian National University	8–12 July 1991
18th ACCMCC	University of WA and Curtin University	6–10 July 1992
19th ACCMCC	University of Adelaide	12–16 July 1993
20th ACCMCC	University of Auckland	5–9 December 1994
21st ACCMCC	Deakin University	10–14 July 1995
22nd ACCMCC	University of Technology Sydney	1–5 July 1996
3rd ICCMCC	University of Melbourne	30 June – 4 July 1997
23rd ACCMCC	University of Queensland	6–10 July 1998
24th ACCMCC	Northern Territory University	5–9 July 1999
25th ACCMCC	University of Canterbury	4–8 December 2000
26th ACCMCC	Curtin University	9–13 July 2001
27th ACCMCC	University of Newcastle	9–13 December 2002
28th ACCMCC	Deakin University	15–18 December 2003
29th ACCMCC	Taupo, NZ; joint with NZIMA	13–18 December 2004
30th ACCMCC	University of Queensland	5–9 December 2005
31st ACCMCC	Alice Springs, followed by	8–12 July 2006
	"Dry & Discrete" at Uluru and Kings Canyon	12–16 Jul and 16-19 Jul
32nd ACCMCC	University of Otago	3–7 December 2007
4th ICC	University of Auckland	15–19 December 2008
33rd ACCMCC	University of Newcastle	7–11 December 2009
34th ACCMCC	Australian National University	6–10 December 2010
35th ACCMCC	Monash University	5–9 December 2011
36th ACCMCC	University of New South Wales	10–14 December 2012
37th ACCMCC	University of Western Australia	9–13 December 2013
38th ACCMCC	Victoria University of Wellington	1–5 December 2014
39th ACCMCC	University of Queensland	7–11 December 2015
40th ACCMCC	University of Newcastle	12–16 December 2016
5th ICC	Monash University	4–9 December 2017

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