1st Joint Meeting of the American Mathematical Society and the New Zealand Mathematical Society

Victoria University of Wellington
Wellington, New Zealand

December 12–15, 2007

American Mathematical Society

New Zealand Mathematical Society

Te Whare Wānanga o te Ūpoko o te Ika a Māui
Victoria University of Wellington

Contents

Timetables

Plenary Addresses

Maclaurin Lecture Theatre 103

Wednesday 12 December

8.45–9.45	Michael Freedman *Physically Motivated Questions in Topology: Manifold Pairings*
13.45–14.45	Gaven Martin *Curvature and Dynamics*

Thursday 13 December

8.45–9.45	Rod Downey *Practical FPT and Foundations of Kernelization*
13.45–14.45	Assaf Naor *The Story of the Sparsest Cut Problem*

Friday 14 December

8.45–9.45	Bruce Kleiner *Bilipschitz Embedding in Banach Spaces*
13.45–14.45	Marston Conder *Chirality*

Saturday 15 December

8.45–9.45	Theodore Slaman *Effective Randomness and Continuous Measures*
13.45–14.45	Matt Visser *Emergent Spacetimes, Rainbow Geometries, and Pseudo-Finsler Geometries*

Special Sessions
Computability Theory

Wednesday 12 December PM		MCLT 102
14.50–15.15	Carl Jockusch Jr *Chains and Antichains in (Weakly) Stable Posets*	
15.15–15.40	Jan Reimann *Effective Capacitability and Dimension of Measures*	
16.00–16.25	Antonio Montalban *On the Back-and-Forth Relation on Boolean Algebras*	
16.25–16.50	Denis Hirschfeldt *Atomic Models and Genericity*	
16.50–17.15	Barbara Csima *Linear Orders with Distinguished Function Symbol*	
Thursday 13 December AM		MCLT 102
9.50–10.15	Cristian Calude *Representation of Computably Enumerable ε–Random Reals*	
10.15–10.40	Johanna Franklin *Truth Table Reducibility and Schnorr Triviality*	
11.00–11.25	Ng Keng-Meng *Strong Jump Traceability and Beyond*	
11.25–11.50	Ludwig Staiger *On Universal Computably Enumerable Prefix Codes*	
11.50–12.15	George Barmpalias *Relative Randomness and Cardinality*	
Friday 14 December AM		MCLT 102
9.50–10.15	Hugh Woodin *Definable Determinacy and Second Order Number Theory*	
10.15–10.40	Chi Tat Chong *A Π^1_1 Uniformization Principle for Reals*	
11.00–11.25	Andre Nies *Borel Presentable Structures*	
11.25–11.50	Qi Feng *Solovay Pairs and supercompacteness*	
11.50–12.15	Noam Greenberg *Working above Totally ω-c.e. Degrees using Strong Reducibilities*	
Saturday 15 December AM		MCLT 103
9.50–10.15	Guohua Wu *On the Complexity of the Successivity Relation in Computable Linear Orderings*	
10.15–10.40	Frank Stephan *Sets of Nonrandom Numbers*	
11.00–11.25	Björn Kjos-Hanssen *Infinite Subsets of Random Sets of Integers*	
11.25–11.50	Bakhadyr Khoussainov *Kolmogorov Complexity, Computable Categoricity and Frasse Limits*	
11.50–12.15	Paul Brodhead *Continuity of Capping in $\mathcal{E}_{\mathrm{bT}}$*	

Wednesday 12 December PM COLT 122

14.50–15.15	Mathias Beiglböck *Ramsey theory from a dynamical viewpoint*
15.15–15.40	Anthony Dooley *The AT Property is not Preserved by Finite Extensions*
16.00–16.25	Anthony Quas *Distances in Positive Density Sets*
16.25–16.50	Alistair Windsor *Tilings and Gallai's Theorem*
16.50–17.15	Reinhard Winkler *For a Topologist, Typical Sequences are Extremely Irregular*

Thursday 13 December Evening CO 118

18.15–18.40	Arno Berger *Uniform Attraction and Growth in Nonautonomous Dynamical Systems*
18.40–19.05	Wenzhi Luo *Equidistribution of closed Geodesics on the Modular Surface*
19.05-19.30	Martin Wechselberger *Canard Induced Mixed-Mode Oscillations*
19.30-19.55	Ilze Ziedins *Nonmonotonicity of Phase Transitions in a Tree Loss Network*

Friday 14 December PM CO 228

14.50–15.15	Boris Baeumer *Brownian Subordinators And Fractional Cauchy Problems*
15.15–15.40	Dmitry Dolgopyat *Galton Board*
16.00–16.25	Ian Melbourne *Decay of Correlations for Lorentz gases*
16.25–16.50	Matthew Nicol *Extreme Value Statistics for non-Uniformly Hyperbolic Systems*

Saturday 15 December AM COLT 122

9.50–10.15	Keith Burns *Typical Partially Hyperbolic Diffeomorphisms with 1-Dimensional Center are Accessible*
10.15–10.40	Gary Froyland *Phase Transitions and Equilibrium States*
11.00–11.25	Rua Murray *Ulam's Method for Invariant Measures with an Indifferent Fixed Point*
11.25–11.50	Luchezar Stoyanov *Spectra of Ruelle Transfer Operators for Contact Flows on Basic Sets*

Dynamics and Control of Systems: Theory and Applications to Biomedicine

Wednesday 12 December AM COLT 122

9.50–10.40	**Keynote:** James Sneyd *Calcium and Ducks*
11.00–11.25	Helmut Maurer *Optimal Multi-Drug Control of the Innate Immune Response with Time Delays*
11.25–11.50	Urszula Ledzewicz *Optimal and Suboptimal Protocols for a Class of Mathematical Models of Tumor Growth under Angiogenic Inhibitors*
11.50–12.15	Scott Graybill *TGF - A Renal Feedback Mechanism*

Thursday 13 December AM COLT 122

9.50–10.15	Phil Wilson *The Lipid Bilayer at the Mesoscale: a Physical Continuum Model*
10.15–10.40	Emily Harvey *Complex Oscillations in Mathematical Models of Calcium Dynamics*
11.00–11.25	Carlo Laing *Bumps and Rings in a Two-Dimensional Neural Field: Splitting and Rotational Instabilities*
11.25–11.50	Dann Mallet *A Hybrid CA-PDE Model of Chlamydia Trachomatis Infection in the Female Genital Tract*
11.50–12.15	Andrzej Swierniak *Evolution of Repeats in Microsatellite DNA and Emergency of Genetic Disorders*

Thursday 13 December Evening COLT 122

18.15–18.40	Michael Plank *Lévy Random Walks in Ecology: Fact or Fiction?*
18.40–19.05	Annette Molinaro *Piecewise Constant Estimation Algorithms for Predicting Clinical Outcomes: Applications in Genomic Data*
19.05-19.30	Michal Swierniak *SVD based Analysis of DNA Microarray Data*

Friday 14 December AM COLT 122

9.50–10.15	Graeme Wake *Modelling of Cancer Treatment*	
10.15–10.40	Wen Duan *Mathematical Modeling of GnRH Neurons in the Rat Brain*	
11.00–11.25	Inga Wang *A Mathematical Model of Airway and Pulmonary Arteriole Smooth Muscle*	
11.25–11.50	Peter Hinow *A Mathematical Model Quantifies Proliferation and Motility Effects of TGF-b on Cancer Cells*	
11.50–12.15	L.G. de Pillis *A Mathematical Model of B Cell Chronic Lymphocytic Leukemia*	
12.15–12.50	Krzysztof Fujarewicz *Optimal Sampling for Identification of Models of Cell Signaling Pathways*	

Friday 14 December PM COLT 122

14.50–15.15	Heinz Schättler *Minimizing the Tumor Size in Mathematical Models for Novel Cancer Treatments*
15.15–15.40	Alona Ben-Tal *Modelling Cheyne-Stokes Respiration and Other Aspects of the Control of Respiration*
16.00–16.25	Ami Radunskaya *A Delayed-Differential Model of the Immune Response: Optimization and Analysis*
16.25–16.50	Matthias Kawski *Chronological Calculus and Nonlinear Feedback Loops*
16.50–17.15	Robert Donnelly *Cellular Automata Model of Radiation Therapy in Cervical Cancer*

Thursday 13 December PM CO 118

14.50–15.15 Laurent O. Jay
Butcher Trees and Curve Search in Nonlinear Optimization

15.15–15.40 John Butcher
G-Symplectic General Linear Methods

16.00–16.25 Yousaf Habib
Symplectic Methods with Transformations

16.25–16.50 Dion O'Neale
Geometric Integration, High Oscillation and Resonance

16.50–17.15 Klas Modin
On Explicit Adaptive Symplectic Integration of Separable Hamiltonian Systems

17.15–17.40 Robert McLachlan
Achieving Brouwer's Law of Round-off Error

Friday 14 December AM CO 118

9.50–10.15 Melvin Leok
Homogeneous Variational Integrators for Lagrangian Dynamics on Two-Spheres

10.15–10.40 Mayya Tokman
Evaluating Performance of Exponential Integrators

11.00–11.25 Allison Heard
Stability of Numerical Solvers for Ordinary Differential Equations

11.25–11.50 Philip Zhang
Dynamics and Numerics of Some Generalised Euler Equations

11.50–12.15 Will Wright
The Efficient Evaluation of Functions Related to the Matrix Exponential

12.15–12.50 Reinout Quispel
Geometric Integration of Ordinary Differential Equations

Saturday 15 December AM COLT 122

11.50–12.15 Gustaf Söderlind
Adaptive Geometric Integration: Structural Aspects of Reversible Step Size Control

Thursday 13 December PM MCLT 103

14.50–15.40	**Keynote:** Ruth Charney *Partially Symmetric Automorphisms of Free Groups*
16.00–16.25	Gerhard Rosenberger *The Tits Alternative for Sherical Generalized Tetrahedron Groups*
16.25–16.50	Benjamin Fine *On Some Finiteness Properties in Infinite Groups*
16.50–17.15	Gunter Steinke *Old and New on the Universal Covering Group of* $SL(2,\mathbb{R})$

Friday 14 December PM MCLT 103

14.50–15.40	**Keynote:** Tomaž Pisanski *A Census of Edge-Transitive Tessellations*
16.00–16.25	Jin Ho Kwak *Enumerating Chiral Maps on Surfaces with a Given Underlying Graph*
16.25–16.50	Antonio Breda d'Azevedo *Bicontactual Rotary Hypermaps*
16.50–17.15	Gareth Jones *Total Chirality of Maps and Hypermaps on Riemann Surfaces*

Saturday 15 December AM CO 216

9.50–10.15	**Keynote:** Russell Blyth *Nonabelian Tensor Squares of free Nilpotent Groups of Finite Rank*
11.00–11.25	Arturo Magidin *Capable Groups of Class Two and Prime Exponent*
11.25–11.50	Michael A. Jackson *The Strong Symmetric Genus and Generalized Symmetric Groups: Results and a Conjecuture*
11.50–12.15	Marston Conder *Short Presentations for the Alternating and Symmetric Groups*

Wednesday 12 December AM CO 119

9.50–10.15 Douglas Bridges
Constructive Reverse Mathematics
10.15–10.40 Hannes Diener
The Dark Side of Constructive Reverse Mathematics
11.00–11.25 Iris Loeb
Indecomposability of the Continuum in Constructive Reverse Mathematics
11.25–11.50 Philip Catton
Elegance and Insight: What is the Link?

Thursday 13 December AM CO 119

9.50–10.15 Bruce Burdick
Mathematical Problems from the Maine Farmer's Almanac
10.15–10.40 Jim Tattersall
Mathematical Contributions to The Educational Times from Australia and New Zealand
11.00–11.25 Lawrence D'Antonio
Leonard Euler and the Dastardly John Robison
11.25–11.50 Hardy Grant
Episodes from the Career of the Riemann Hypothesis
11.50–12.15 Paul R Wolfson
Algebraic Invariant Theory and Characteristic Classes

Friday 14 December PM CO 119

14.50–15.15 Bronwyn Rideout
Probability in Ancient Greek: Moving Beyond the Traditional Narrative
15.15–15.40 Clemency Montelle
Hypsicles of Alexandria and Arithmetical Sequences
16.00–16.25 Kim Plofker
Mathematics and Observation in Indian Astronomical Parameters
16.25–16.50 John Hannah
Limits of Solvability: Unsolvable Problems in Fibonacci's Liber Abbaci

Hopf Algebras and Quantum Groups

Wednesday 12 December PM MCLT 103

14.50–15.40	**Keynote:** David Radford *On the representations of pointed Hopf algebras*
16.00–16.25	Akira Masuoka *On Cocycle Deformations of Pointed Hopf Algebras with Abelian Grouplikes*
16.25–16.50	Yevgenia Kashina *Classifying Semisimple Hopf Algebras of dimension* 2^n
16.50–17.15	Siu-Hung Ng *On the classification of Hopf algebras of dimension pq*

Friday 14 December AM MCLT 103

9.50–10.40	**Keynote:** Fred Van Oystaeyen *On Crystalline Graded Rings*
11.00–11.25	Blas Torrecillas *The Dickson Subcategory Splitting Conjecture for Pseudocompact Algebras*
11.25–11.50	Miodrag C Iovanov *(Co)Representation Theoretic Approach to Fundamental Results in Hopf Algebras*
11.50–12.15	Juan Cuadra *The Hopf-Schur subgroup*

Saturday 15 December AM CO118

9.50–10.40	**Keynote:** Susan Montgomery *Frobenius-Schur Indicators for Hopf Algebras*
11.00–11.25	Stefaan Caenepeel *A Structure Theorem for Relative Hopf Bimodules with Applications to Morita Equivalences*
11.25–11.50	Aaron Armour *The Geometric Classification of Four Dimensional Superalgebras*
11.50–12.15	Yorck Sommerhäuser *Hopf Algebras and Congruence Subgroups*

Infinite Dimensional Groups and Their Actions

Thursday 13 December PM CO 216

14.50–15.15 Sidney A. Morris
The Structure of Connected Pro-Lie Groups
15.15–15.40 Christopher Atkin
Isometries of Infinite-Dimensional Riemannian Manifolds
16.00–16.25 Hendrik Grundling
On Group Algebras for non-Locally Compact Groups
16.25–16.50 Stefano Ferri
Groups Acting on Banach Spaces
16.50–17.15 Christian Rosendal
Generic Representations of Finitely Generated Groups
17.15–17.40 Vladimir Pestov
A Footnote to the Property (FH)

Friday 14 December AM CO 216

9.50–10.15 Lionel Nguyen Van Thé
Oscillation Stability for Topological Groups and Ramsey Theory
10.15–10.40 Yevhen Zelenyuk
On Finite Groups in Stone-Cech Compactifications
11.00–11.25 Anthony Dooley
The AT Property is not Preserved by Finite Extensions
11.25–12.50 Inessa Epstein
Orbit Inequivalent Actions of non-Amenable Groups
12.50–13.15 Todor Tsankov
Full Groups of Equivalence Relations

Integrability of Continuous and Discrete Evolution Systems

Thursday 13 December AM CO 216

9.50–10.15 Reinout Quispel
Discrete Integrable Systems

10.15–10.40 Willy Hereman
Symbolic Computation of Conservation Laws of Nonlinear PDEs in $(n + 1)$-dimensions
11.00–11.25 Mark Hickman
Leading Order Integrability Conditions for Differential-Difference Equations

11.25–11.50 Gerrard Liddell
American Barriers
11.50–12.15 Ernie Kalnins
Integrability and Separation of Variables

Wednesday 12 December AM MCLT 102

9.50–10.40	**Keynote:** Paul Seymour *Forcing a $K_{2,t}$ minor*
11.00–11.25	Gordon Royle *Binary matroids with no $K_{3,3}$ minor*
11.25–12.15	**Keynote:** Isidoro Gitler *Some Links Between Combinatorial Optimization Properties of Clutters and Algebraic Properties of Monomial Ideals*

Thursday 13 December PM MCLT 102

14.50–15.40	**Keynote:** Henry Crapo *Simplicial Maps, and the Generic Rigidity Matroid*
16.00–16.25	Rhiannon Hall *Chain-Type and Splitter-Type Theorems for Cocircuits and Hyperplanes in 3-Connected Matroids*
16.25–16.50	Thomas Britz *Matroids Applied to Coding Theory*
16.50–17.15	Peter Humphries *A Basis Exchange Property for Matroids*

Thursday 13 December Evening MCLT 102

18.15–18.40	Carolyn Chun *Unavoidable Minors of Loosely c-Connected Infinite Graphs*
18.40-19.30	**Keynote:** Maria Chudnovsky *Even Pairs in Berge Graphs*

Friday 14 December PM MCLT 102

14.50–15.40	**Keynote:** Joseph P. Kung *The Tutte Polynomial Turned Upside Down*
16.00–16.25	Charles Little *Minimal non-Bipartite Join Covered Graphs*
16.25–16.50	Gary Gordon *Automorphisms of Matroids Associated with Root Systems*
16.50–17.15	Petr Hlineny *Finding Branch-Decompositions and Rank-Decompositions*

Saturday 15 December PM MCLT 103

14.50–15.40	**Keynote:** Jim Geelen *Binary Matroid Minors*
16.00–16.25	Dillon Mayhew *The Excluded Minors for the Class of Matroids that are Either Binary or Ternary*
16.25–17.15	**Keynote:** Neil Robertson *TBA*

New Trends in Spectral Analysis and PDE

Wednesday 12 December AM CO 118

9.50–10.15 Graeme Wake
Spectral Properties of non-Local Eigenvalue Problems

10.15–10.40 Florina Halasan
Absolutely Continuous Spectrum for the Anderson Model on More General Trees

11.00–11.50 **Keynote:** Colin Fox
Semi-analytic Spectral Methods

11.50–12.15 David Wall
The Mathematics of Imaging in Magnetic Resonance Elastography

Wednesday 12 December PM CO 118

14.50–15.15 Yulia Karpeshina
Quasi-intersections of Isoenergetic Surfaces: Description in Terms of Determinants

15.15–15.40 Gunter Stolz
Bubbles Tend to the Boundary

16.00–16.25 William Desmond Evans
Inequalities of Hardy-Sobolev and Hardy-Gagliardo-Nirenberg Type

Thursday 13 December AM CO 118

9.50–10.15 Boris Pavlov
An ill-Posed Problem in Scattering Theory

10.15–10.40 Annalisa Calini
Cable Formation for Finite-Gap Solutions of the Vortex Filament Flow

11.00–11.50 **Keynote:** Jochen Brüning
The Equivariant Index Theorem for Dirac Operators

11.50–12.15 Anjan Biswas
Quasi-Stationary Solitons for Langmuir Waves in Plasmas

Friday 14 December PM CO 118

14.50–15.15 Stephen McDowall
Optical Tomography in Media with Varying Index of Refraction

15.15–15.40 Boris P Belinskiy
Stochastic Wave Equation Driven by a Fractional Brownian Motion

16.00–16.25 Sergei Avdonin
Control and Inverse Problems for Partial Differential Equations on Graphs

16.25–16.50 Georgi Raikov
Spectral Properties of a Magnetic Quantum Hamiltonian on a Strip

16.50–17.15 Felipe Leitner
On Unitary Conformal Holonomy

Quantum Topology

Wednesday 12 December AM MCLT 103

9.50–10.40 **Keynote:** Andrew Kricker
Covering Spaces and the Kontsevich Integral

11.00–11.25 Noah Snyder
The Ribbon Half-Twist

11.25–11.50 David Gauld
Foliations and non-Metrisable Manifolds

11.50–12.15 Vaughan Jones *(TBA)*

Thursday 13 December AM MCLT 103

9.50–10.40 **Keynote:** Michael Freedman
Continuation of Plenary Talk: Manifold Pairings

11.00–11.25 Christopher Tuffley
Generalised Knot Groups

11.25–11.50 Shona Yu
The Cyclotomic Birman-Murakami-Wenzl Algebras

11.50–12.15 Scott Morrison
Lasagna Composition of Khovanov Link Homologies, and a 4-D Skein Module

Special Functions and Orthogonal Polynomials

Wednesday 12 December AM CO 216

9.50–10.40 **Keynote:** Dennis Stanton
Finite Fields and (q, t)-Binomials

11.00–11.25 Pee Choon Toh
Representations of Certain Binary Quadratic Forms as Lambert Series

11.25–11.50 Shayne Waldron
Tight Frames of Multivariate Orthogonal Polynomials

11.50–12.15 Edmund Y. M. Chiang
On the Nevanlinna Order of Lommel Functions and Subnormal Solutions of Certain Complex Differential Equations

Wednesday 12 December PM CO 216

14.50–15.15 Michael Schlosser
Macdonald Polynomials in the Light of Basic Hypergeometric Series

15.15–15.40 Heung Yeung Lam
Sixteen Eisenstein Series

16.00–16.25 Nicholas Witte
Semi-classical Orthogonal Polynomials and the Painlevé-Garnier Systems

16.25–16.50 Howard S. Cohl
Fourier Expansions of the Fundamental Solution for Powers of the Laplacian in $\mathbb{R}^n$

16.50–17.15 Richard Askey
The First Addition Formula and Some of What Came Later

Thursday 13 December Evening MCLT 103

18.15–19.05 **Keynote:** Walter Van Assche
Multiple Hermite Polynomials and Some Applications
19.05-19.30 Tom ter Elst
Does Diffusion Determine the Drum?
19.30-19.55 Diego Dominici
Asymptotic Analysis of the Bell Polynomials by the Ray Method
19.55-20.15 Song Heng Chan
Congruences for Andrews-Paule's Broken 2-Diamond Partition Function

Friday 14 December PM MCLT 102

14.50–15.40 **Keynote:** Mourad E. H. Ismail
Addition Theorems Via Continued Fractions
16.00–16.25 Andrea Laforgia
The Zeros of the Complementary Error Function
16.25–16.50 Kevin A Broughan
The Vanishing of the Integral of the Hurwitz Zeta Function
16.50–17.15 Bruce C. Berndt
Modified Bessel Functions in Ramanujan's Lost Notebook

Saturday 15 December AM MCLT 102

9.50–10.40 **Keynote:** Ernie Kalnins
Orthogonal polynomials and associated algebras.
11.00–11.25 Wenchang Chu
Abel's Lemma on Summation by Parts and Theta Hypergeometric Series
11.25–11.50 Garry J. Tee
Permutable Polynomials and Rational Functions
11.50–12.15 Michael Hirschhorn
Some Conjectures of Melham Concerning Representations by Figurate Numbers

Saturday 15 December PM MCLT 102

14.50–15.15 N J Wildberger
Spread Polynomials
15.15–15.40 A. Sri Ranga
Asymptotics for Gegenbauer-Sobolev and Hermite-Sobolev Orthogonal Polynomials Associated with non-Coherent Pairs of Measures
16.00–16.25 Ross Barnett
High-Precision Values of the Gamma Function of Real Argument
16.25–16.50 Ole Warnaar
The Mukhin-Varchenko Conjecture

Wednesday 12 December PM CO 119

14.50–15.40	**Keynote:** Derek Holton *Where Have All the Mathematicians Gone?*
16.00–16.25	David Easdown *Teaching Proofs in Mathematics*
16.25–17.15	**Panel** Chair: Patricia Cretchley *Writing Effective University Mathematics Texts and Courseware: What Works, and What's New?*

Thursday 13 December PM CO 119

14.50–15.40	**Keynote:** William McCallum *Secondary Mathematics from an Advanced Standpoint*
16.00–16.25	G. Arthur Mihram *Three Attributes of Tertiary-level Mathematical Education to One's Society and its Advancement of Science*
16.25–16.50	Bill Barton *Revisiting Felix Klein's "Elementary Mathematics from an Advanced Standpoint"*
16.50–17.40	**Round Table Discussion** *What Mathematics Studies are Essential for Secondary Level Mathematics Teachers?*

Friday 14 December AM CO 119

9.50–10.15	Matthias Kawski *Interactive Visualization in Advanced University Mathematics*
10.15–10.40	Tim Passmore *A Flexible, Extensible Online Testing System for Mathematics*
11.00–11.25	Patricia Cretchley *Readiness for First-Year Mathematics Studies: Management, Placement and Prognosis*
11.25–11.50	Mark Nelson *Online Learning Resources for Engineering Students: Do they work?*
11.50–12.15	Alex James *From Lessons to Lectures: NCEA Mathematics and First Year Performance*

Water-Wave Scattering, Focusing on Wave-Ice Interactions

Thursday 13 December PM COLT 122

14.50–15.15	Alison Kohout *An Elastic Plate Model for Wave Scattering in the Marginal Ice Zone*
15.15–15.40	Gareth L. Vaughan *Scattering and Damping of Ice Coupled Waves*
16.00–16.25	Malte A. Peter *Time-Dependent Water Waves Incident on a Vertical Elastic Plate*
16.25–16.50	Luke Bennetts *Wave Scattering by a Periodic Line Array of Axisymmetric Ice Floes*
16.50–17.15	Michael Meylan *Simulation of Near-trapping Time-dependent Water Wave Problem*

General Contributions

Wednesday 12 December AM CO 228

9.50–10.15	Winston L. Sweatman *Full Ionisation in Binary-Binary Encounters at High Velocity*
10.15–10.40	John Harper *Electrophoresis of Gas Bubbles*
11.00–11.25	Ratneesh Suri *A Real Options Approach to Fisheries*
11.25–11.50	Nick Depree *Mathematical Modelling of an Annealing Furnace*
11.50–12.15	Celine Cattoen *Cosmography: Extracting the Hubble Series from the Supernova Data*

Wednesday 12 December PM CO 228

14.50–15.15	Robert McKibbin *Modelling Turbulent Dispersion of Pollen in a Forest Canopy*
15.15–15.40	Neil Watson *Recent Progress on the Heat Equation*
16.00–16.25	ChungChun Yang *On Entire Solutions of Certain Type of Nonlinear Differential Equations*
16.25–16.50	Yuncheng You *Regularity Asymptotics of Vorticity for the 2D Navier-Stokes Equation*
16.50–17.15	Petarpa Boonserm *Buchdahl-like Transformations in General Relativity*

Thursday 13 December AM CO 228

9.50–10.15	Irwin Pressman *Steiner Triples and a Solution of the Kirkman School Girl Problem using Matrices with Multiple Symmetry Properties*
10.15–10.40	Bill Taylor *A Note on Strategies for Win/Loss Symmetric Games*
11.00–11.25	E. F. Cornelius, Jr. *Module-Building with Polynomials and Power Series*
11.25–11.50	Kevin Byard *Qualified Residue Difference Sets from Unions of Cyclotomic Classes*
11.50–12.15	Daniel Lond *Külshammer's Second Problem*

Thursday 13 December PM CO 228

14.50–15.15	Michael Tuite *Vertex Operator Algebras on Genus Two Riemann Surfaces*
15.15–15.40	V.Lakshmana Gomathi Nayagam *Fuzzy Translation Invariant Topological Spaces*

16.00–16.25 Andrew Percy
Cohomology Cross-Cap Products

16.25–16.50 Driss Drissi
On Bounded Sequences and Applications to Invariant Subspace Problem

16.50–17.15 Jacek Krawczyk
A Viability Theory Approach to a Two-Stage Optimal Control Problem

Friday 14 December AM CO 228

9.50–10.15 Peter Donelan
Genericity of Serial Manipulator Singularities

10.15–10.40 Avinesh Prasad
A Lyapunov-based Path Planning and Obstacle Avoidance for a Two-link Manipulator on a Wheeled Platform

11.00–11.25 Krishna Sami Raghuwaiya
Potential Field Functions for Motion Planning and Posture Control of 3-Trailer Systems

11.25–11.50 Bibhya Sharma
A Navigation and Collision Avoidance Scheme for Heterogeneous Robot Collectives

11.50–12.15 Agnes Radl
Transport Processes in Networks with Scattering Ramification Nodes

Saturday 15 December AM CO 119

9.50–10.15 Mareli Korostenski
Regular Martingales in Riesz Spaces

10.15–10.40 Muni V. Reddy
Some Recent Developments on the Structure of Lattice Rules

11.00–11.25 S. K. Sunanda
Generalized Opial type $L(p)$-Inequalities for Fractional Derivatives

11.25–11.50 Stephen Joe
Lattice rules for integration over $\mathbb{R}^s$

11.50–12.15 Alastair McNaughton
Loci of Zeros in Fractional Calculus

Saturday 15 December AM CO 228

9.50–10.15 Sun Young Jang
C^*-Algebras Like the Toeplitz Algebra

10.15–10.40 R.K. Beatson
Preconditioning Radial Basis Function Interpolation Problems Using Mean Value Coordinates

11.00–11.25 Alexey L. Sadovski
On Spacial Statistics Models of the Determination of the Geoid

11.25–11.50 Gloria Cravo
Snapshot-Based Theory: An Interdisciplinary Approach

11.50–12.15 Igor Boglaev
Robust Monotone Iterates

Abstracts

Plenary Addresses

Chirality
Marston Conder
University of Auckland
m.conder@auckland.ac.nz

Chirality, or handedness, is an interesting property in many branches of science and medicine. Roughly speaking, an object is chiral if it is non-isomorphic to its mirror image. For example, the left and right trefoils are chiral knots (with the same Alexander polynomial but different Jones polynomials). Remarkably, when a discrete object is assumed to have a large degree of rotational symmetry, it often happens that it possesses also reflectional symmetry, so that chirality is not the norm. Instances occur in the study of compact Riemann surfaces with large automorphism groups, regular maps on surfaces (generalising the platonic solids), and higher-dimensional polytopes. This talk will look at the notion of chirality in contexts like these, and describe some recent results (including the discovery of the first known finite chiral 5-polytopes with maximum rotational symmetry, and an infinite sequence of gaps in the spectrum of orientably-regular but chiral maps) obtained in joint work with a number of co-authors.

Practical FPT and Foundations of Kernelization
Rod Downey
Victoria University of Wellington
rod.downey@vuw.ac.nz
Coauthors: Hans Bodlaender, Dannay Hermelin (Utrecht), Mike Fellows (Newcastle Australia)

An approach towards practical tractability for combinatorial problems was pioneered by the speaker and Mike Fellows. It involves looking at fixing some parameter and examining the resulting problem. It has emerged that almost all problems for which this approach works in practice use a technique called *kernelization* which involves pre-processing to shrink the problem to one whose size depends only on the parameter. We look at the foundations of this subject, giving pseudo-lower bounds on a number of problems. With Fortnow and Santhanam we prove that a wide class of problems, known to be FPT cannot have practical FPT algorithms based on polynomial kernels unless the polynomial time hierarchy collapses to 3 or fewer levels.

Physically Motivated Questions in Topology: Manifold Pairings
Michael Freedman
Microsoft Research
seanfr@microsoft.com

Since Milnor built the exotic 7-spheres in 1956 by gluing together two copies of $S^3 \times D^4$, gluing has played a key role in manifold topology. In this talk, I will borrow and idea from quantum mechanics and consider gluing superpositions of manifolds. It turns out that there is a dramatic difference according to dimension. The natural pairings induced by gluing have null vectors when the manifold dimension is 4 or higher, in contrast the pairings are positive when the dimension is 3 or lower. This difference has a profound implication for what topological features can be captured within the physics of a d-dimensional quantum mechanical system; it gives another perspective on the fact that the known topological phases of matter are $2+1$ dimensional.

Bilipschitz Embedding in Banach Spaces
Bruce Kleiner
Yale University
bruce.kleiner@yale.edu
Coauthors: Jeff Cheeger

A mapping between metric spaces is L–bilipschitz if it stretches distances by a factor of at most L, and compresses them by a factor no worse than $1/L$. A basic problem in geometric analysis is to determine when one metric space can be bilipschitz embedded in another, and if so, to estimate the optimal bilipschitz constant. In recent years this question has generated great interest in computer science, since many data sets can be represented as metric spaces, and associated algorithms can be simplified, improved, or estimated, provided one knows that the metric space space in question can be bilipschitz embedded (with controlled bilipschitz constant) in a nice space, such as L^2 or L^1.

The lecture will discuss several new existence and non-existence results for bilipschitz embeddings in Banach spaces. One approach to non-existence theorems is based on generalized differentiation theorems in the spirit of Rademacher's theorem on the almost everywhere differentiability of Lipschitz functions on R^n. We first show that earlier differentiation based results of Pansu and Cheeger, which proved non-existence of embeddings into R^k, generalize to many Banach space targets, such as L^p for $1 < p < \infty$. We then focus on the case when the target is L^1, where differentiation theory is known to fail, and the embedding questions are of particular interest in computer science. When the domain is the Heisenberg group with its Carnot–Caratheodory metric, we show that a modified form of differentiation still holds for Lipschitz maps into L^1, by exploiting a new connection with functions of bounded variation, and some very recent advances in geometric measure theory.

Curvature and Dynamics
Gaven Martin
IAS, Massey University
g.j.martin@massey.ac.nz

Most of us have seen a bit of the Fatou/Julia theory of iteration of rational mappings of the Riemann sphere and pictures of associated parameter spaces such as the Mandelbrot set. A natural question is "are there such rational (conformal) dynamical systems on manifolds in higher dimensions?" Classical rigidity theorems (eg the Liouville theorem from 1860) suggests strongly that there are not. Surprisingly there are, but we must give up smooth Riemannian structures to allow singular structures where branching of mappings may occur and quite fascinating examples can be found. The Lichnerowicz problem asks us to classify those (closed) manifolds which admit a rational (conformal away from singular set) endomorphism. For injective mappings this problem was solved in the 70s: only the sphere admits a noncompact family of conformal self maps. For rational mappings the situation is more complicated. Using ideas from Sela's proof of the Hopf property for Gromov hyperbolic groups and old results of Walsh and Smale on open mappings we can prove quite strong rigidity theorems (preventing branching) for open self mappings of negatively curved spaces since we prove the fundamental groups of such spaces are virtually Hopf (self homomorphism with image of finite index is an isomorphism). Recent work also identifies those knot groups which are virtually Hopf and therefore identifies those knot complements which admit a proper open self map which is not homotopic to a homeomorphism.

This is a general talk aimed at a broad audience and represents joint work largely with Martin Bridson (Imperial), Jonathan Hillman (Sydney), Volker Mayer (Lille) and Kirsi Petonen (Helsinki).

The Story of the Sparsest Cut Problem

Assaf Naor
Courant Institute of Mathematical Sciences, NYU
naor@cims.nyu.edu

In the past decade methods from Riemannian geometry and Banach space theory have become a central tool in the design and analysis of approximation algorithms for a wide range of NP hard problems. In the reverse direction, problems and methods from theoretical computer science have recently led to solutions of long standing problems in metric geometry. This talk will illustrate the connection between these fields through the example of the Sparsest Cut problem. This problem asks for a polynomial time algorithm which computes the Cheeger constant of a given finite graph. The Sparsest Cut problem is known to be NP hard, but it is of great interest to devise efficient algorithms which compute the Cheeger constant up to a small multiplicative error. We will show how a simple linear programming formulation of this problem leads to a question on bi-Lipschitz embeddings of finite metric spaces into L_1, which has been solved by Bourgain in 1986. We will then proceed to study a quadratic variant of this approach which leads to the best known approximation algorithm for the Sparsest Cut problem. The investigation of this "semidefinite relaxation" leads to delicate questions in metric geometry and isoperimetry, in which the geometry of the Heisenberg group plays an unexpected role.

Effective Randomness and Continuous Measures

Theodore A Slaman
University of California, Berkeley
slaman@math.berkeley.edu

In joint work with Jan Reimann, we study the question, "For which reals x does there exist a measure μ such that x is random relative to μ?" We show that for every nonrecursive x, there is a measure which makes x random without concentrating on x. We give several conditions on x equivalent to there being continuous measure which makes x random. We show that for all but countably many reals x these conditions apply, so there is a continuous measure which makes x random. There is a meta-mathematical aspect of this investigation. As one requires higher arithmetic levels in the degree of randomness, one must make use of more iterates of the power set of the continuum to show that for all but countably many xs there is a continuous μ which makes x random to that degree.

Emergent Spacetimes, Rainbow Geometries, and Pseudo-Finsler Geometries
Matt Visser
Victoria University of Welington
matt.visser@mcs.vuw.ac.nz

The theoretical physics community is increasingly pushing at the boundaries of classical differential geometry (Riemannian and Lorentzian manifolds), and seeking new mathematical tools to investigate various extensions of Einstein gravity. Among the as yet mathematically imprecise concepts being mooted are the notions of emergent spacetime (where the manifold picture breaks down at short distances), rainbow geometies (where the "metric" somehow depends on energy and momentum), and particular unexplored sub-classes of pseudo-Finsler geometry. I will outline why these ideas are considered interesting, and indicate some of the foundational mathematical issues that remain open.

Computability Theory

Relative randomness and cardinality

George Barmpalias
Victoria University
barmpalias@yahoo.co.uk

We show that for every Δ^0_2 set B, $MLR \subseteq MLR^B$ iff the class $\{A \mid MLR^B \subseteq MLR^A\}$ is countable (where MLR^X denotes the class of Martin-Löf random numbers relative to X and $MLR = MLR^{\emptyset}$). It follows that Δ^0_2 is the largest arithmetical class with this property, and if $\{A \mid MLR^B \subseteq MLR^A\}$ is uncountable it contains a perfect Π^0_1 set P of reals.

Continuity of capping in $\mathcal{E}_{\mathrm{bT}}$

Paul Brodhead
University of Florida
brodhead@math.ufl.edu
Coauthors: Angsheng Li (Chinese Academy of Sciences), Weilin Li (Chinese Academy of Sciences)

For sets $A, B \subseteq \omega$, we say that A is *bounded Turing reducible to* B if A is Turing reducible to B with use bounded by a computable function. We study the continuity properties of the c.e. bT-degrees. We show that for any c.e. bT-degree $\mathbf{b} \neq \mathbf{0}, \mathbf{0}'$, there is a c.e. bT-degree $\mathbf{a} > \mathbf{b}$ such that for any c.e. bT-degree $\mathbf{x}$, $\mathbf{b} \wedge \mathbf{x} = \mathbf{0}$ iff $\mathbf{a} \wedge \mathbf{x} = \mathbf{0}$. This is the first continuity property of the c.e. bT-degrees.

Representation of Computably Enumerable ε–Random Reals

Cristian S Calude
University of Auckland
cristian@cs.auckland.ac.nz
Coauthors: Nicholas J Hay

If $\mathbf{x} = 0.x_1x_2\cdots$ is c.e. random, then clearly $\mathbf{x^0} = 0.x_10x_20\cdots$ is at least 1/2–random. Is $\mathbf{x^0}$ exactly 1/2–random? Can we obtain $\mathbf{x^0}$ in a natural way, i.e. as halting probability of a "weak" type of universal prefix-free machine?

The talk will present some representability results for c.e. ε–random reals which were introduced and studied by Tadaki, Staiger, Calude, Terwijn, Merkle, Nies and Reimann. We will use the techniques developed by Calude, Hertling, Khoussainov, Wang, and Slaman.

Effective Capacity and Randomness of Closed Sets

Douglas Cenzer
University of Florida
cenzer@math.ufl.edu
Coauthors: Paul Brodhead

We investigate the connection between the capacity and randomness of closed sets. For any computable measure μ, the probability $T_\mu(K)$ that an arbitrary closed set Q meets a given closed set K determines a computable capacity and, conversely, every computable capacity is defined in this way from some computable measure. Under certain condition on μ, the capacity $T_\mu(K)$ of a μ-random closed set is zero. Under certain conditions on μ, there exists an effectively closed set P such that $\mu(P) = 0$ but $T_\mu(K) > 0$.

A Π^1_1 uniformization principle for reals

Chi Tat Chong
National University of Singapore
chongct@math.nus.edu.sg
Coauthors: Liang Yu (Nanjing University)

We present a Π^1_1 uniformization principle and illustrate its applications to various problems, including the existence of Π^1_1 maximal chains of Turing degrees, Π^1_1 thin maximal antichains of Turing degrees, as well as Martin's conjecture on degree invariant functions.

Linear Orders with Distinguished Function Symbol

Barbara F Csima
University of Waterloo
csima@math.uwaterloo.ca
Coauthors: Douglas Cenzer, Bakhadyr Khoussainov

We consider certain linear orders with a function on them, and discuss for which types of functions the resulting structure is or is not computably categorical. Particularly, we consider computable copies of the rationals with a fixed-point free automorphism, and also ω with a non-decreasing function.

Solovay pairs and supercompacteness

Qi Feng
National University of Singapore/Chinese Academy of Sciences
qifeng@math.ac.cn

We shall present a new characteristic of supercompact cardinals using Solovay pairs and study related matters.

Truth table reducibility and Schnorr triviality

Johanna Franklin
National University of Singapore
franklin@math.nus.edu.sg
Coauthors: Frank Stephan

In this work, we study the relationship between truth table reducibility and Schnorr triviality. The standard notion of lowness for Schnorr randomness in the Turing degrees does not coincide with Schnorr triviality. Here, we study a new notion, which provides further evidence that Schnorr triviality is most naturally considered in the truth table degrees.

We develop a notion of *tt*-low for Schnorr random and show that it is equivalent to Schnorr triviality as well as several other properties. We are then able to use these properties to show that, among other things, the Schnorr trivial reals form an ideal in the truth table degrees. We also rule out the weak truth table degrees as a natural degree structure for Schnorr triviality, since here, as in the Turing degrees, the Schnorr trivial reals are not closed downward.

This work is joint with Frank Stephan.

Working above totally omega-c.e. degrees using strong reducibilities

Noam Greenberg
Victoria University
greenberg@mcs.vuw.ac.nz
Coauthors: George Barmpalias and Rod Downey

We characterise the c.e. degrees which are not totally omega-c.e. as those that contain c.e. sets which are not wtt-reducible to hypersimple sets; equivalently, to ranked sets. We also give a characterisation of the c.e. array computable degrees in terms of computable Lipschitz reductions to random c.e. reals.

Atomic Models and Genericity

Denis R Hirschfeldt
University of Chicago
drh@math.uchicago.edu
Coauthors: Richard A Shore and Theodore A Slaman

The Atomic Model Theorem states that every complete, consistent, atomic theory in a countable language has a countable atomic model. I will present recent results on the computability theoretic and reverse mathematical strength of this result, and its connections with a certain Π^0_1 genericity principle.

Chains and antichains in (weakly) stable posets

Carl G Jockusch Jr
University of Illinois at Urbana-Champaign
jockusch@math.uiuc.edu
Coauthors: Bart Kastermans (University of Wisconsin), Steffen Lempp (University of Wisconsin), Manuel Lerman (University of Connecticut), Reed Solomon (University of Connecticut)

Hirschfeldt and Shore [1] introduced the notion of stability for partial orderings (or posets). We introduce the notion of *weak stability* for posets, which is arguably more natural than stability. Namely, an infinite poset is *weakly stable* if each of its elements either lies below all but finitely many elements, or above all but finitely many elements, or is incomparable with all but finitely many elements. We study the complexity of infinite chains and antichains in stable and weakly stable infinite computable posets, emphasizing results on the existence of infinite chains and antichains which are computable, low, or Π^0_1. We also obtain a related result in Reverse Mathematics and simplify the proofs of some results on linear orderings in [1].

Reference

[1] Denis R. Hirschfeldt and Richard A. Shore, *Combinatorial principles weaker than Ramsey's Theorem for Pairs*, *J. Symbolic Logic* **72**, 2007, 171–206.

Kolmogorov Complexity, Computable Categoricity, and Frasse Limits

Bakhadyr Khoussainov
University of Auckland/Cornell University
bmk@cs.auckland.ac.nz
Coauthors: Pavel Semukhin and Frank Stephan

We answer the following long standing open question (since the early 80s): does there exist a non-countably categorical ω-saturated structure with exactly one computable isomorphism type?

We motivate the question, give a brief background, and provide our positive solution to the question. We explain the uses of Kolmogorov complexity and Frasse limits in our construction of the desired structure. Kolmogorov complexity is used to build a special type of uniform family of computably enumerable sets. Frasse limits are used to code the family into the structure. We also say why the standard codings known in computable model theory can not be applied in building the desired structure.

Infinite subsets of random sets of integers

Bjrn Kjos-Hanssen
University of Hawaii at Manoa
bjoern@math.hawaii.edu

For all randomness notions between weak 2–randomness and weak 1–randomness, and with respect to any Bernoulli measure, there is an infinite subset of a random set of integers that computes no random set of integers. To obtain this, we design a probability distribution P on the collection of all closed sets of reals, so that P satisfies (1) and (2). Then we apply (3).

(1) Whenever C is random according to P, each member of C computes an infinite subset of a random set of integers.
(2) Each real of sufficiently high effective Hausdorff dimension is a member of some C that is random according to P.
(3) (Greenberg, Miller) There is a real of arbitrarily high effective Hausdorff dimension that computes no random set of integers.

On the Back-and-Forth Relation on Boolean Algebras
Antonio Montalban
University of Chicago
antonio@math.uchicago.edu
Coauthors: Kenneth Harris

The objective of this paper is to provide a good understanding of the structure of the n–back-and-forth-equivalence classes of Boolean algebras, and the n–backand-forth relations between them. As an application, we obtain a characterization of the relatively intrinsically Σ_n^0 relations of Boolean algebras as existential formulas over a finite set of relations.

Strong Jump Traceability and Beyond
Ng, Keng Meng
Victoria University of Wellington
Keng.Meng.Ng@mcs.vuw.ac.nz

A set is low if it is computationally weak when used as an oracle. We study various notions of lowness. In particular we look at strong jump traceability, which is a variant of c.e. traceability. These reals are all superlow in the c.e. case, and by relativizing the notion of strong jump traceablility, we show that there is a subclass of the c.e. K-trivials with no promptly simple members. We look at various other properties of this new class of reals, which are all very weak in terms of their computational power.

Borel presentable structures
Andre Nies
University of Auckland
andrenies@gmail.com
Coauthors: G Hjorth, B Khoussainov, A Montalban

Traditionally, effectivity is studied for countable structures. Borel structures in contrast allow us to develop a theory of effectivity for the equally natural uncountable structures, such as the field of real numbers. After some initial work by Friedman (1979), the forthcoming paper tentatively titled: "From Automatic Structures to Borel Structures" by Khoussainov, Hjorth, Montalban and myself has revived the subject by applying Borel structures to solve a well-known question on Buechi presentable structures; see Section 5 of Nies' paper "Describing Groups", Bull. Symb. Logic**13** (2007) pp305–339. We show that there is a Buechi presentable structure without an injective Borel representation. Further, there exists a Rabin presentable structure that is not Borel.

Effective Capacitability and Dimension of Measures

Jan Reimann
University of California, Berkeley
reimann@math.berkeley.edu

We introduce the notion of effective capacitability and show that every Hausdorff random real is effectively capacitable. This yields a useful characterization of effective dimension. We relate effective capacitability to dimension notions for measures.

On Universal Computably Enumerable Prefix Codes

Ludwig Staiger
Martin-Luther-Universität Halle-Wittenberg, Germany
ludwig.staiger@informatik.uni-halle.de
Coauthors: Cristian S Calude

We study computably enumerable (c.e.) prefix codes which are capable of coding all positive integers in an optimal way up to a fixed constant: these codes will be called universal. We prove various characterisations of these codes including the following one: a c.e. prefix code is universal iff it contains the domain of a universal self-delimiting Turing machine. Finally, we study various properties of these codes from the points of view of computability, maximality, and density.

Sets of nonrandom numbers

Frank Stephan
National University of Singapore
fstephan@comp.nus.edu.sg

Let C and H denote the plain and prefix-free Kolmogorov complexity, respectively. Then the sets NRC of nonrandom numbers with respect to C has neither a maximal nor an r–maximal superset. The set of NRH of nonrandom numbers with respect to H has an r–maximal but no maximal superset. Thus the lattices of recursively enumerable supersets (modulo finite sets) of NRC and NRH are not isomorphic. Further investigations deal with the related set NRW of all numbers x which are the maximum of some r.e. set with an index $e < x$. Friedman originally asked whether NRW is Turing equivalent to K and Davie provided a positive answer for many acceptable numberings. Later Teutsch asked the related question whether one can choose the underlying acceptable numbering such that NRW is either an r.e. or co-r.e. set. A negative answer is provided to this question and the position of NRW in the difference-hierarchy is provided: one can choose the underlying numbering such that NRW is a co-2-r.e. set but NRW is never a 2-r.e. set. Furthermore, if the underlying numbering is a Kolmogorov numbering, then NRW is an ω-r.e. set but not an n-r.e. set for any natural number n.

Definable Determinacy and Second Order Number Theory
Hugh Woodin
UC Berkeley
woodin@math.berkeley.edu

Definable Determinacy is the assertion that all definable sets are determined (no parameters). The base theory is Second Order Number Theory and so Definable Determinacy is an axiom scheme. The basic problem is to compute the consistency strength of this theory. This in turn leads to some interesting questions about the combinatorics associated to Woodin cardinals.

On the complexity of the successivity relation in computable linear orderings
Guohua Wu
Nanyang Technological University
guohua@ntu.edu.sg
Coauthors: Rod Downey, Steffen Lempp

In this paper, we prove that if a computable linear ordering $\mathcal{A}$ has infinitely many successivities, then there is a computable linear ordering $\mathcal{B}$ such that $\mathcal{B}$ is isomorphic to $\mathcal{A}$, and the set of successivities in $\mathcal{B}$, $Succ(\mathcal{B})$, is Turing complete.

Dynamical Systems and Ergodic Theory

Brownian Subordinators And Fractional Cauchy Problems

Boris Baeumer
University of Otago
bbaeumer@maths.otago.ac.nz
Coauthors: M M Meerschaert and E Nane (Michigan State University)

A Brownian time process is a Markov process subordinated to the absolute value of an independent one-dimensional Brownian motion. Its transition densities solve an initial value problem involving the square of the generator of the original Markov process. An apparently unrelated class of processes, emerging as the scaling limits of continuous time random walks, involve subordination to the inverse or hitting time process of a classical stable subordinator. The resulting densities solve fractional Cauchy problems, an extension that involves fractional derivatives in time. We show a close and unexpected connection between these two classes of processes, and consequently, an equivalence between these two families of partial differential equations.

Ramsey theory from a dynamical viewpoint

Mathias Beiglböck
TU Vienna
mathias.beiglboeck@tuwien.ac.at
Coauthors: Vitaly Bergelson, Neil Hindman, Dona Strauss

Theorems in Ramsey theory are formalizations of the principle that highly organized structures are unbreakable. For instance, van der Waerden's Theorem states that one cell of any finite partition of the integers contains arithmetic progressions of arbitrary finite length. Following seminal papers of Furstenberg, methods from ergodic theory and topological dynamics have been applied to give short proofs to such classical results as well as to solve various open problems. We discuss this abstract approach and present an extension of van der Waerden's Theorem which refers simultaneously to the additive and the multiplicative structure of the integers. (Supported by the Austrian Science Foundation FWF, project no. S9612)

Uniform attraction and growth in nonautonomous dynamical systems

Arno Berger
University of Alberta, Canada/University of Canterbury
arno.berger@canterbury.ac.nz

Uniformity plays an important role in nonautonomous dynamics; for parts of this notoriously heterogeneous discipline, most prominently perhaps for the emerging theory of nonautonomous bifurcations, it is in fact quite indispensable. This talk will discuss some of the more subtle, less expected implications of uniformity (in time) pertaining to two topics of considerable current interest in nonautonomous dynamics: the natural concept of uniform attractors/repellors, and the foundations of dynamic partitions or, more generally, finite time dynamics. (Joint work with T. S. Doan and S. Siegmund.)

Typical partially hyperbolic diffeomorphisms with one dimensional center are accessible

Keith Burns
Northwestern University
burns@math.northwestern.edu
Coauthors: Jana and Federico Rodriguez Hertz, Anna Talitskaya, Raul Ures

I will outline how this result fits into Pugh and Shub's program for studying the ergodic theory of partially hyperbolic diffeomorphisms and sketch the main ideas in the proof.

Galton board

Dmitry Dolgopyat
University of Maryland, USA
dmitry@math.umd.edu
Coauthors: Nikolai Chernov

Galton board, is a device invented by Sir Francis Galton to demonstrate the law of error and the normal distribution. The machine consists of a vertical board with interleaved rows of pins. Balls are dropped from the top, and bounce randomly left and right as they hit the pins. Eventually, they are collected into one-ball-wide bins at the bottom. The height of ball columns in the bins approximates a bell curve.

We assume that the collisions of the ball with the pins are perfectly elastic and that there is no friction. We show that the ball almost surely exits the machine from the hole at the top before reaching the bins at the bottom provided that we have sufficiently many rows of pins.

The AT property is not preserved by finite extensions

Anthony Dooley
UNSW, Sydney
a.dooley@unsw.edu.au
Coauthors: Anthony Quas

The property of almost transitivity was introduced by Connes and Woods to characterise flows arising from actions of infinite product type. A question was posed by Giordano, Putnam and Skau as to whether this property was preserved under finite extensions. A simple example was whether the Morse system was AT, as it can be realised as a two-point extension of an infinite product system. In this work, we show that the Morse system is AT, but produce a two-point extension of an AT system which is not AT. This has consequences for operator algebras: there exists an ITPF1 factor with an index two subfactor which is not ITPF1.

Phase transitions and equilibrium states
Gary Froyland
University of New South Wales
mailto:G.Froyland@unsw.edu.au
Coauthors: Dalia Terhesiu (UNSW) and Rua Murray (Canterbury)

It is well known that for several classes of transformations, Ulam's method is an efficient way to estimate the absolutely continuous invariant measure of T. We describe a new extension of Ulam's method that can be used for the numerical approximation of the Ruelle–Perron–Frobenius operator associated with T and the standard potential $\phi_\beta = -\beta \log |T'|$, where $\beta \in \mathbb{R}$. In particular we demonstrate that our extended Ulam's method is a powerful tool for computing the topological pressure $P(T, \phi_\beta)$ and the density of the equilibrium state. We state convergence results, illustrate our approach via examples and demonstrate its effectiveness, even when applied to nonuniformly expanding maps. This work complements recent analytical studies of the statistical properties of nonuniformly expanding maps by offering a simple, fast, and accurate numerical tool for the analysis of Ruelle–Perron–Frobenius operators and their associated thermodynamical objects.

Equidistribution of closed geodesics on the modular surface
Wenzhi Luo
Ohio State University
wluo@math.ohio-state.edu
Coauthors: Zeev Rudnick and Peter Sarnak

It is well-known that the closed geodesics on the modular surface, when collected according to the discriminants, are equidistributed with respect to the hyperbolic measure, by the works of Duke and Iwaniec. We evaluate asymptotically the variance of this distribution on the unit tangent bundle, and show it is equal to the classic variance of the geodesic flow as studied by Ratner, multiplied by an intriguing arithmetic invariant, the central value of certain L-function. Our approach is via Weil representation and the theta correspondence. This is the joint work with P. Sarnak and Z. Rudnick.

Decay of correlations for Lorentz gases
Ian Melbourne
University of Surrey
i.melbourne@surrey.ac.uk

In this talk, I will describe some recent results on decay of correlations for various Lorentz gas models, including infinite horizon Lorentz gases, Bunimovich stadia, and cuspoidal domains.

The cuspoidal example (joint work with Balint, hopefully finished in time) is particularly interesting because we are proving superpolynomial decay for the flow even though the collision map (billiard map) mixes very slowly.

Ulam's method for invariant measures with an indifferent fixed point
Rua Murray
University of Canterbury
r.murray@math.canterbury.ac.nz

Ulam's method is now a well-known technique for gaining numerical access to invariant densities for uniformly expanding maps. However, convergence analyses for the approximations have usually relied on a strong spectral picture for the Frobenius–Perron operator (for example, quasi-compactness in BV for uniformly expanding maps). Even in the case of an interval map which is strictly expanding except at a single point, more delicate analysis is needed. Ideas from Young's tower constructions can be adapted to show that in the case of an indifferent fixed point with tangency of order $x^{1+\alpha}$ ($0 < \alpha < 1$), the Ulam approximately invariant densities converge in L^1 as finer grids are used. An explicit convergence rate (depending on α) will be given.

Extreme value statistics for non-uniformly hyperbolic systems
Matthew Nicol
University of Houston
nicol@math.uh.edu
Coauthors: Mark Holland (University of Exeter), Andrew Torok (University of Houston)

Suppose $f_t : X \to X$ is a non-uniformly hyperbolic map (discrete-time) or flow (continuous time) which may be modelled by a Young tower. Suppose $\phi : X \to R$ is a function on X which is locally Holder except for a finite number of singular points. Define $Z_t(x) = \max_{0 \le s \le t}\{\phi_s(x)\}$. We show that the possible nondegenerate limit distributions for Z_t under linear scaling are the type I, II and III distributions of extreme value statistics. We also determine which particular distribution arises (I, II or III) as a function of the regularity of ϕ and the underlying dynamics.

Distances in positive density sets
Anthony Quas
University of Victoria
aquas@uvic.ca

Given a set of distances D, one can consider the graph $G_{d,D}$ on $\mathbf{R}^d$ where two points are adjacent if they are separated by a distance belonging to D and ask for its chromatic number. The case where $D = \{1\}$ is the Hadwiger-Nelson problem and it is known that $4 \le \chi(G_{2,\{1\}}) \le 7$. If the colour classes are required to be measurable, we obtain the measurable chromatic number $\chi_m(G_{d,D})$. It is known that $5 \le \chi_m(G_{2,\{1\}}) \le 7$.

In the case where D is unbounded, it turns out that $\chi_m(G_{d,D}) = \infty$. We give a conceptual new proof of this and discuss possible extensions to the general (non-measurable) case.

Spectra of Ruelle transfer operators for contact flows on basic sets

Luchezar Stoyanov
University of Western Australia
stoyanov@maths.uwa.edu.au

This talk concerns contact flows on Riemann manifolds satisfying a certain pinching condition over a basic set. Under some additional geometric conditions on the basic set (always satisfied e.g. when the flow is Anosov or when the stable and unstable laminations are one- dimensional), strong spectral estimates are obtained for the Ruelle transfer operators related to arbitrary (Hölder continuous) potentials. These estimates are similar to the ones proved by Dolgopyat in the case of Anosov flows with smooth jointly non-integrable stable and unstable foliations. As is well-known, such estimates lead to some interstring consequences such as the existance of a non-trivial meromorphic extension of the (Ruelle) dynamical zeta function and exponential decay of correlations for the flow over the given basic set.

Canard induced mixed-mode oscillations

Martin Wechselberger
University of Sydney
wm@maths.usyd.edu.au
Coauthors: Nancy Kopell (University of Boston), Horacio Rotstein (NJIT), Warren Weckesser (University of Sydney)

Mixed-mode oscillatory temporal patterns (MMOs) consist of a combination of subthreshold oscillations and spikes. We present a model of medial entorhinal cortex stellate cells (SC model) and show that the mechanism responsible for the observed subthreshold oscillations is based on the canard phenomenon. We explain the canard theory in detail and show which ionic currents are responsible for this phenomenon in the SC model. In particular, we show how variations of key parameters cause bifurcations of MMO patterns.

Tilings and Gallai's Theorem

Alistair Windsor
University of Memphis
awindsor@memphis.edu
Coauthors: Rafael de la Llave (University of Texas at Austin)

We will discuss tilings of the plane, concentrating on aperiodic tilings of the plane of finite local complexity, such as the Kite and Dart tiling of Penrose, or the remarkable Pinwheel tiling due to Conway and Radin. The Penrose tiling can be seen in Storey Hall at the Royal Melbourne Institute of Technology. The Pinwheel tiling can be seen in Melbourne's Federation Square. Using combinatorics, or its equivalent statement in topological dynamics, we prove a result about the appearance of certain configurations.

For a topologist, typical sequences are extremely irregular

Reinhard Winkler
University of Technology Vienna, Austria
reinhard.winkler@tuwien.ac.at
Coauthors: Martin Goldstern, Joerg Schmeling

From the measure-theoretic point of view the typical distribution behavior of sequences is regular in the sense of the law of large numbers (implying uniform distribution) and other main results from probability and ergodic theory. The world looks totally different from the topological point of view where, instead of sets of measure 0, meager sets are considered to be negligible. For instance, most sequences in a compact metric space (i.e. all sequences with the exception of a meager subset) are what we call maldistributed, the extreme opposite of being distributed according to one measure. I present several statements of this flavour including a topological counterpart of Birkhoff's ergodic theorem for transitive dynamical systems. (Supported by the Austrian Science Foundation FWF, project no. S9612)

Nonmonotonicity of phase transitions in a tree loss network

Ilze Ziedins
University of Auckland
i.ziedins@auckland.ac.nz
Coauthors: Brad Luen (Berkeley), Kavita Ramanan (Carnegie Mellon)

We consider a symmetric tree loss network that supports single-link and multi-link connections to nearest neighbours, with finite capacity C on each connecting link. Connections arrive as Poisson processes and have generally distributed holding times with finite mean. At sufficiently high multi-link arrival rates the network exhibits a phase transition, with multiple Gibbs measures existing on the infinite tree. When a simple control is introduced into the network, the phase transition is nonmonotone in the arrival rate of the multi-link connections.

Dynamics and Control of Systems: Theory and Applications to Biomedicine

Modelling Cheyne–Stokes Respiration and other aspects of the control of respiration

Alona Ben-Tal
Massey University
a.ben-tal@massey.ac.nz

Cheyne–Stokes Respiration is a form of periodic breathing where a person experiences cycles of increasing followed by decreasing ventilation, followed by periods of breath-holding. To study this puzzling phenomenon and other aspects of the control of respiration a mathematical model has been developed. The model integrates a reduced representation of the brainstem respiratory neural controller together with peripheral gas exchange and transport. Some features of experimental data are captured by the model and new predictions are made.

Cellular Automata Model of Radiation Therapy in Cervical Cancer

Robert Donnelly
Pomona College, Claremont, CA
robert.donnelly@pomona.edu
Coauthors: K Belsky, H Ueda, A Radunskaya, L dePillis

Spatial interactions and the local chemical environment can play a major role both in the growth of a tumor and its resistance to radiation treatment. We propose a cellular automata (CA) model of radiation therapy in early cervical cancer. This model not only incorporates cellular metabolism and ATP production as functions of glucose, oxygen, and pH levels, but also models diffusion of these nutrients with a modified random walk. In particular, since tissue oxygenation plays a major role in the success of radiation therapy in solid tumors, we have included realistic determination of oxygen levels and the formation of a hypoxic core. Radiation damage is determined using an empirically-supported modified linear-quadratic (LQ) model. Our model can simulate fractionated doses of both external beam radiotherapy and brachytherapy, similar to in vivo treatments described in medical literature. Better understanding the interactions between a tumor and its environment may enhance not only our understanding of tumor growth but also allow us to better predict the effect of radiation therapy on a given tumor. Successful modeling of the effects of radiation therapy on tumor cells and normal cells may prove helpful in optimizing radiation treatment protocols to minimize collateral damage to healthy cells while still effectively treating the cancer.

Mathematical Modeling of GnRH neurons in the Rat Brain

Wen Duan
University of Auckland
wdua004@ec.auckland.ac.nz

Some biological background and the mathematical model I am using will be introduced.

Optimal sampling for identification of models of cell signaling pathways

Krzysztof Fujarewicz
Silesian University of Technology, Poland
Krzysztof.Fujarewicz@polsl.pl

Modeling of cell signaling pathways attracted a lot of interest in recent years. Such models let scientists understand mechanisms governing the cell functioning which plays a crucial role in many areas, for example in new drug development. To obtain a mathematical model that behaves similarly to observed biological process the estimation of model parameters is required. In case of cell signaling pathways, appropriate measurements, for example DNA microarrays or different blotting techniques, are relatively expensive. Hence it is very important to choose right times of measurements in order to obtain low variances of estimates of parameters. This problem is somehow similar to estimation of parameters in pharmacokinetics. The classical approach is to use the Fisher information matrix (FIM), which inverse, under some assumptions, is a lower bound for the covariance matrix of parameters estimates. One possible approach to sampling schedule optimization is to maximize the determinant of FIM. It is usually performed using any non-gradient method. We present formulas for calculation of the gradient of FIM in the space of sampling times and we propose the gradient-based optimization approach.

TGF - A Renal Feedback Mechanism

Scott Graybill
University of Canterbury
S.Graybill@math.canterbury.ac.nz
Coauthors: Alex James, Mike Plank, Tim David (University of Canterbury), Zoltan Endre (Christchurch School of Medicine)

The tubulo-glomerular feedback (TGF) mechanism is one of two widely recognised feedback mechanisms in the kidney. TGF acts to maintain a constant blood flow to the organ despite fluctuations in blood pressure. Sustained oscillations in flow, pressure and salt concentration, that are attributed to the TGF mechanism, are observed in vivo. A physiologically realistic TGF model that captures these dynamics will be presented.

Complex oscillations in mathematical models of calcium dynamics

Emily Harvey
University of Auckland
em.harvey@gmail.com

The dynamics of calcium (Ca^{2+}) is of interest as it is known to play a crucial role in many types of cellular functioning. A common feature of mathematical models of intracellular Ca^{2+} dynamics are that they have some variables that evolve much slower than others. In this talk I will demonstrate the presence of complicated oscillatory patterns known as *mixed-mode oscillations* (MMOs) in a few key models of intracellular Ca^{2+} dynamics. I will then show how these MMOs can arise due to the presence of slower timescales in the models and the existence of special solutions called *canards*.

A Mathematical Model Quantifies Proliferation and Motility Effects of TGF–β on Cancer Cells

Peter Hinow
University of Minnesota
hinow@ima.umn.edu
Coauthors: Shizhen Emily Wang, Nicole Bryce, Glenn F Webb (Vanderbilt University)

Transforming growth factor (TGF) β is a signaling molecule involved in a variety of cellular processes including growth, differentiation, apoptosis and cell motility. While TGF–β slows proliferation of certain cell types it also increases their motility and may decrease cell–cell adhesion. Thus, it has properties of both a tumor suppressor and a tumor promoting factor. We have carried out experiments to quantify cell motility and growth in presence of TGF–β and use a version of the classical Fisher–Kolmogorov equation to interpret the experimental findings. We find that TGF–β increases the tendency of individual cells and cell clusters to move randomly, while simultaneously diminishing overall population growth. Our model, which can also be adopted to simulate other growth-regulating signals, will provide a unique insight into the TGF–β function in both normal and cancer cells, and further understanding on targeted therapeutic strategies that aim at interfering with TGF–β signaling.

Chronological calculus and nonlinear feedback loops

Matthias Kawski
Arizona State University
kawski@asu.edu

Many models in biomedicine involve feedback loops and nonlinearly interacting dynamics. Often it can be advantageous to consider these as systems made up of collections of interacting sub-systems. Such splitting may be based on physical characteristics, or they may be abstract mathematical factorizations.

Commonly, the individual subsystems are comparatively straightforward to analyze, but the nonlinear, generally noncommuting effects of the subsystems on each other present challenges for the analysis of the combined system.

We present tools from the chronological calculus and recent combinatorial simplifications that facilitate the analysis and design and control of such composite systems that involve generally noncommuting nonlinear interactions.

Bumps and rings in a two-dimensional neural field: splitting and rotational instabilities

Carlo Laing
Massey University
c.r.laing@massey.ac.nz
Coauthors: Markus Owen and Steve Coombes (University of Nottingham, UK)

We consider instabilities of localised solutions in planar neural field firing rate models of Wilson–Cowan or Amari type. Importantly we show that angular perturbations can destabilise spatially localised solutions. For a scalar model with Heaviside firing rate function we calculate symmetric one-bump and ring solutions explicitly and use an Evans function approach to predict the point of instability, and the shape of the dominant growing modes. Our predictions are in excellent agreement with direct numerical simulations.

With the addition of spike-frequency adaptation, numerical simulations of the resulting vector model show that it is possible for structures without rotational symmetry, and in particular multi-bumps, to undergo an instability to a rotating wave. We use a general argument, valid for smooth firing rate functions, to establish the conditions necessary to generate such a rotational instability. Numerical continuation of the rotating wave is used to quantify the emergent angular velocity as a bifurcation parameter is varied. Wave stability is found via the numerical evaluation of an associated eigenvalue problem.

Optimal and Suboptimal Protocols for a Class of Mathematical Models of Tumor Growth under Angiogenic Inhibitors

Urszula Ledzewicz
Southern Illinois University Edwardsville
`uledzew@siue.edu`
Coauthors: Heinz Schättler, (Washington University, St. Louis)

Tumor anti-angiogenesis is a novel medical approach to cancer treatment that aims at preventing the development of the blood vessel network a tumor needs for growth. In this talk we shall show how tools from optimal control theory can be used to analyze a class of mathematical models for tumor anti-angiogenesis based on a paper by Hahnfeldt et al., Cancer Research, **59** (1999). In these models the state of the system represents the primary tumor volume and the carrying capacity of the vasculature related to the endothelial cells. The nonlinear dynamics models how control functions representing angiogenic inhibitors effect the growths of these variables. The objective is to minimize the tumor volume with a fixed total amount of inhibitors.

In the talk we shall present a full theoretical solution to the problem in terms of a synthesis of optimal controls and trajectories. Using tools of geometric control theory (e.g., Lie bracket computations), analytic formulas for the theoretically optimal solutions will be given. Optimal controls are concatenations of bang-bang controls (representing therapies of full dose with rest periods) and singular controls (therapies with specific time-varying partial doses). Singular controls, however, are of feedback type and as such do not lead to implementable therapy protocols. Properties of the dynamics and knowledge of the theoretically optimal solution are used to formulate practically realizable suboptimal protocols and evaluate their efficiency. Specifically, for the original model by Hahnfeldt *et al*, it is shown that a constant dose protocol with the dose given by the averaged values of the theoretically optimal control is an excellent suboptimal protocol that achieves tumor volumes that lie within 1% of the theoretically optimal values.

A Hybrid CA-PDE Model of Chlamydia Trachomatis Infection in the Female Genital Tract

Dann Mallet
Queensland University of Technology
dg.mallet@qut.edu.au
Coauthors: Kelly-Jean Heymer, David P Wilson

Chlamydia trachomatis is the most common sexually transmitted pathogen of humans, with the World Health Organisation (WHO) estimating 91.98 million new cases in adults occurring world wide each year. It typically infects the genitals and sometimes the eyes, throat and internal organs.

In this talk I will present the first spatio-temporal model of Chlamydial infection in the genital tract, along with some initial results and directions for future work.

Optimal multi-drug control of the innate immune response with time delays

Helmut Maurer
University of Münster, Germany
maurer@math.uni-muenster.de

Optimal control problems with pure time delays in state or control variables and control-state inequality constraints are considered. We present a Pontryagin-type Maximum Principle and numerical solution techniques for computing state, control and adjoint variables. The algorithm proceeds by first discretizing the retarded control problem and then using a large-scale nonlinear programming solver. In this talk, the numerical methods are applied to the optimal control of the immune response; cf. R. Stengel *et al*, Optimal control of innate immune response, Optimal Control Applications and Methods **23** (2002) pp91-104. In that paper, only undelayed equations are considered, therapeutic agents are treated separately, and the objective function is assumed to be of quadratic type. We discuss optimal multi-drug controls in both the unretarded and retarded case as well as for quadratic and linear type objective functions. In the latter case, all control components are shown to be bang-bang representing therapies that can easily be administered to the patient. Similar results are obained for the optimal control of the chemotherapy of HIV. Parts of the talk are based on joint work with Laurenz Goellmann, Daniela Kern and Lisa Poppe.

Piecewise Constant Estimation Algorithms for Predicting Clinical Outcomes: Applications in Genomic Data

Annette Molinaro
Yale University
annette.molinaro@yale.edu
Coauthors: Karen Lostritto (Yale University)

Clinicians aim toward a more preventative model of attacking cancer by pinpointing and targeting specific early events in disease development. These early events can be measured as genomic, proteomic, epidemiologic, and/or clinical variables. Such measurements are then used to predict clinical outcomes such as primary occurrence, recurrence, metastasis, or mortality. Recursive partitioning seeks to explain the individual contributions of various covariates as well as their interactions for the purposes of predicting outcomes, either continuous or categorical. Potential algorithms such as Classification and Regression Trees (CART) and partDSA aggressively search highly-complex covariate spaces. There are several important considerations when using such algorithms. The first is to not overfit the data. The second consideration is the stability of the resulting predictor. Algorithms such as CART are sensitive to data fluctuations and, thus, given a perturbation will potentially build a different predictor than that built on the original data. A third consideration is variable importance. In this talk, such considerations will be discussed and results comparing both algorithms presented.

A Mathematical Model of B Cell Chronic Lymphocytic Leukemia

L G de Pillis
Harvey Mudd College, California
`depillis@hmc.edu`
Coauthors: S Nanda (Tata Institute, Bangalore); A E Radunskaya (Pomona College, California)

B-cell chronic lymphocytic leukemia (B-CLL) is a disease for which new clinical understanding and treatment strategies continue to emerge. B-CLL is characterized by the existence of large numbers of white blood cells (B cells) in the blood, the bone marrow, the spleen and in the lymph nodes. Until recently it was believed to be a slowly progressing disease of accumulation of abnormal B cells that were immunologically challenged, and not a disease of proliferation of these cells. Over the last decade this view has changed as more is understood about the genetic changes involved in B cell production. Unlike chronic myelogenous leukemia (CML) where the presence of a genetic abnormality in hematopoeitic cells is understood to be the cause of the disease, there is no obvious genetic explanation for B-CLL. It is however understood now that B-CLL cells derive from mature antigen-stimulated cells that are immunologically competent. As a result, questions arise as to how best to treat a patient in light of new information about the disease, and clinical treatment strategies have been evolving. One method for addressing many questions about disease progression and possible treatment approaches is to develop mathematical models that reflect particular disease dynamics. B-CLL is one form of cancer for which very few mathematical models have been developed to date. The goal of the work we will present is to develop a model of B-CLL that is sufficiently complex to reflect key features of disease development, yet sufficiently streamlined to allow for reasonable parameter estimates and to admit computational and mathematical analysis. The biological literature reveals that NK cells, helper T cells and cytotoxic T cells may all play a role in stemming the growth of B-CLL. Therefore, the model we present tracks the progression of diseased B-cells through time together with these three immune cell populations. Such a model can then be used as a test-bed for exploring various treatment options. We will discuss some of these options as well as plans for further model development.

Levy random walks in ecology: fact or fiction?
Michael Plank
University of Canterbury
m.plank@math.canterbury.ac.nz
Coauthors: Alex James

A Levy random walk is one where the lengths of the steps have a distribution that is heavy tailed, i.e. does not have a finite variance. All sorts of ecological data sets have been claimed to support the idea that Levy walks are prevalent in nature, for example in the foraging movements of seals, albatrosses and spider monkeys to name a few. Furthermore, it has been suggested that a power law with an exponent of 2 provides an optimal walk for maximising foraging efficiency. In this talk, the evidence supporting this widely accepted theory will be examined. An alternative, non-Levy model for foraging will also be discussed, based on a stochastic differential equation. This model can provide higher foraging efficiency than a Levy walk, whilst producing distributions consistent with field data that supposedly support the Levy hypothesis. In conclusion, it is important to remember that a Levy walk is not the only random walk, and caution should be used when using data to infer information about an underlying process.

A delayed-differential model of the immune response: optimization and analysis.
Ami Radunskaya
Pomona College, California
aer04747@pomona.edu
Coauthors: Sarah Hook

In this talk we will present techniques for the analysis and optimization of a mathematical model of the immune response to tumor antigen. The model consists of a system of delay differential equations, and is calibrated to experimental data from murine experiments performed specifically for the purpose of the development of the mathematical model. The goal of the model is to suggest dose and scheduling protocols that would maximize the cellular immune response. There is not a definitive answer to what constitutes the "best" response: is it the maximum peak response, the long-term levels, or the functionality of the immune cells? We therefore compare the results from several optimization techniques, with a few different objective functions. This is collaborative work with Dr. Sarah Hook, University of Otago.

Minimizing the Tumor Size in Mathematical Models for Novel Cancer Treatments
Heinz Schättler
Washington University, St Louis
hms@wustl.edu
Coauthors: Urszula Ledzewicz (Southern Illinois University, Edwardsville), and Alberto d'Onofrio (European Institute for Oncology, Milano, Italy)

A simple mathematical model for tumor anti-angiogenesis combined with chemotherapy is considered as an optimal control problem. The model is based on the one by Hahnfeldt *et al*, Cancer Research **59** (1999) and the state of the system represents the primary tumor volume and the carrying capacity of the vasculature related to the endothelial cells. The nonlinear dynamics models how control functions representing angiogenic inhibitors affect the growths of these variables and now also includes a killing term on the primary tumor volume. The problem of how to schedule a priori given amounts of angiogenic inhibitors and cytotoxic agents so as to minimize the primary tumor volume is considered. Due to the multi-control aspect, even with simplified dynamical equations, this becomes a challenging problem mathematically and some initial results about the structure of optimal controls will be presented.

Calcium and Ducks

James Sneyd
University of Auckland
sneyd@math.auckland.ac.nz

Oscillations in the concentration of calcium inside cells (practically every single cell in your body) control a large number of processes, ranging from muscular contraction, to saliva secretion, to gene expression, to cell differentiation. Because the underlying dynamics are so complicated and highly nonlinear, mathematical models are useful for helping us understand these oscillations. I'll present one example of how a mathematical model can help us understand some fundamental things about calcium oscillations, and help us design experiments to test our hypotheses. Conversely, I'll then show how these models can pose new and nontrivial mathematical questions. About ducks.

Evolution of repeats in microsatellite DNA and emergency of genetic disorders

Andrzej Swierniak
Silesian University of Technology
andrzej.swierniak@polsl.pl
Coauthors: M Kimmel, A Polanski

Microsatellites are the shortest non-coding repeats of DNA which are composed of the repetitive sequences of 2 to 5 motifs (see *eg* Ramel (1997)). Formation of tandem repeats composed from such short units occurs most probably as a result of DNA replication errors in which slippage through strand occurs. The slippage of polymerase during replication leads to base pairs mismatching and, if not repaired, gives rise to elongation or shortening of the microsatellite with one or more repeated unit. The stability of the number of repeats in microsatellite sequence depends on the intact mismatch DNA repair. The changes in the number of repeats in microsatellites accompany some human genetic diseases. Disorders such as Huntington's disease, spinocerebellar ataxia type 1, syndrome of fragile X chromosome, myotonic dystrophy and genetic diabetes are related to expansion of repeated units in microsatellites lying in the vicinity of some genes (Green (1993)).

We describe the time evolution of the distribution of the repeat loci in microsatellite DNA by a branching random walk with an absorbing boundary

(Kimmel and Axelrod (2002)) and focus our interest on the stability analysis of the resulting model in the form of infinite-dimensional system of linear differential equations. We follow the line of reasoning used previously in asymptotic analysis of drug resistance in cancer populations caused by gene amplification (Kimmel, Swierniak and Polanski (1998)). The techniques applied include Laplace transforms for the case of initial conditions with finite support and spectral analysis for respectively defined Banach operators in the case of infinite support.

Green H. (1993), Human genetics diseases due to codon reiteration: relationship to evolutionary mechanism. Cell, **74**, 955–956

Kimmel M. and Axelrod D.E. (2002), Branching Processes in Biology, Springer Verlag, New York

Kimmel M., Swierniak A. and Polanski A. (1998), Infinite dimensional model of evolution of drug resistance of cancer cells, J. Math. Syst. Estim. Contr., **8**, 1–16

Ramel C. (1997), Mini- and microsatellites., Env. Health Persp.,**105**, 781–789

SVD based analysis of DNA microarray data

Michal Swierniak
M. Sklodowska-Curie Memorial Cancer Centre, Gliwice
mswierniak@o2.pl
Coauthors: Krzysztof Simek (Silesian University of Technology), Michal Jarzab (Cancer Centre, Gliwice)

The aim of this talk is to show how some techniques based on the Singular Value Decomposition may be used in DNA microarray analysis. Since usually a number of rows in the microarray matrix (number of genes) is much greater than a number of columns (number of samples) SVD seems to be the most proper method for investigation of basic trends in the data. We describe algorithms based on SVD which may be used to select a set of genes with the most important significance of the data and demonstrate how they may be used in unsupervised classification of the patterns and discovery of new classes. Moreover we present results of the oligonucleotide microarray experiments for thyroid carcinomas. We discuss different rules of gene selection and compare the results with the ones previously published. Moreover we discuss some biological issues resulting from the presented analysis.

Modelling of Cancer Treatment

Graeme Wake
Massey University
g.c.wake@massey.ac.nz
Coauthors: Bruce Baguley (University of Auckland), Britta Basse, David Wall (University of Canterbury), Ronald Begg (Massey and Canterbury Universities), Bruce van Brunt(Massey University)

Improved treatment of cancer is one of the most important challenges for medical science. Tailoring treatment for individual patients has long been an objective for oncologists. While many biological techniques and mathematical models have been devised to predict the course of treatment, none have applied

routinely to clinical oncology. Our model, which describes the complexities of the responses of tumour cells over time to both anticancer drugs and radiation, has considerable impact on our ability to advance individualisation of cancer therapy. This process is in advanced stages of implementation. Over the last few years, we have developed sophisticated mathematical equations describing the behaviour of cancer cells as they progress through the cell division cycle. Which stage in the cycle the cells are actually in, can be differentiated by their DNA content and this enables model outcomes to be compared directly to experimental results. These equations describe the response of human tumours to chemotherapy and radiotherapy. Firstly we incorporate programmed cell death (apotosis) into the model. We then consider perturbations of model parameters by treatment and compare model results with data. This research will provide significant new analytical and computational insights into the area of non-local equations, where cause and effect are separated in space and time, as well as underpinning support to oncologists concerned with treatment, drug companies producing drugs and management of clinics. The support of the NZIMA by the award of a Maclaurin Fellowship to assist in the development of this work is gratefully acknowledged.

A mathematical model of airway and pulmonary arteriole smooth muscle.

Inga Wang
University of Auckland
inga@math.auckland.ac.nz
Coauthors: Antonio Z Politi, Nessy Tania, Yan Bai, Michael J Sanderson and James Sneyd

Airway hyper-responsiveness (AHR) is a major characteristic of asthma and is believed to result from the excessive contraction of airway smooth muscle cells (SMCs). However, the identification of the mechanisms responsible for AHR is hindered by our limited understanding of how calcium, myosin light chain kinase (MLCK) and myosin light chain phosphatase (MLCP) interact to regulate airway SMC contraction. In this talk, I will present a modified Hai–Murphy cross-bridge model of SMC contraction that incorporates the calcium regulation of the MLCK and MLCP.

The lipid bilayer at the mesoscale: a physical continuum model

Phil Wilson
University of Canterbury
p.wilson@math.canterbury.ac.nz
Coauthors: Huaxiong Huang (York University, Canada), Shu Takagi (University of Tokyo, Japan)

Cell membranes are the most abundant cellular structure in all living matter. Their core component is a soft, strong, self-assembling sheet called the lipid bilayer. Multiscale simulations of blood flow depend on lipid bilayer properties because such bilayers surround red blood cells and contribute significantly to their modes of deformation. Small patches of the bilayer can be simulated for short times with discrete numerical methods such as Molecular Dynamics.

The interaction of neighbouring red blood cells can be simulated with continuum dynamical methods. However, there is as yet no robust way to transfer microscale information to the macroscale. In this talk we discuss one such potential mesoscale filter. This continuum model is based on minimising the free energy of a mixture of lipid and water molecules. The model extends previous work by (a) formulating a more physical model of the hydrophobic effect, (b) clarifying the meaning of the model parameters through numerical solutions, (c) outlining a method for determining parameter values based on a quantitative comparison of numerical results with physical experimental data.

Geometric Numerical Integration

G–symplectic general linear methods
John Butcher
University of Auckland
butcher@math.auckland.ac.nz

A Runge–Kutta method (A, b, c) with the property that

$$diag(b)A + A^T diag(b) = bb^T$$

is said to be canonical or symplectic. Such methods have an important role in the solution of Hamiltonian problems and for problems possessing a quadratic invariant. Although it is believed that genuine multivalue methods cannot possess an equivalent property, it will be shown that G–symplectic general linear methods can give excellent results.

Symplectic Methods with Transformations
Yousaf Habib
University of Auckland
yhabib@math.auckland.ac.nz

Hamiltonian mechanics is a reformulation of classical mechanics invented by Hamilton (1833). In Hamiltonian mechanics, the equations of motion are based on generalised co-ordinates q_i and generalised momenta p_i. The Hamiltonian H is a function of $\mathbf{p} = (p_1, p_2, , , , , p_n)$ and $\mathbf{q} = (q_1, q_2, , , , , q_n)$ and defines the differential equation system,

$$\frac{dp_i}{dt} = -\frac{\partial H}{\partial q_i}, \qquad \frac{dq_i}{dt} = \frac{\partial H}{\partial p_i}, \qquad i = 1, ..., n.$$

H usually corresponds to the total energy of the underlying mechanical system. Let $\phi_H(t, t_0)$ denote the solution operator of the Hamiltonian system.

$$(\mathbf{p}, \mathbf{q}) = \phi_H(t, t_0)(\mathbf{p}_0, \mathbf{q}_0).$$

It is the property of Hamiltonian systems that ϕ_H is symplectic. This means that if $(\mathbf{p}_0, \mathbf{q}_0)$ on some domain Ω possess certain properties, then $(\mathbf{p}, \mathbf{q})$ retain those properties after the transformation through ϕ_H. Since symplecticness is a characteristic property of Hamiltonian systems in terms of their solutions, it is natural to look for numerical methods that share this property.

Pioneering work in this regard is due to Ruth (1983) and Feng (1985). Later, Sanz-Serna (1988) and Suris (1988) systematically developed symplectic Runge-Kutta methods. Their idea is based on features of algebraic stability introduced, in connection with stiff systems, by Burrage and Butcher (1979) and Crouzeix (1979).

A Runge-Kutta method of order s is symplectic if the coefficients $[a, b, c]$ of the Runge-Kutta method satisfy

$$b_i a_{ij} + b_j a_{ji} - b_i b_j = 0, \qquad i, j = 1, ..., s$$

Thus symplectic methods can be found by imposing the condition stated above in addition to other requirements such as order and stability. The left hand

side of this euqtion represents a matrix involving the coefficients of Runge–Kutta method which we call M.
We can use the matrix M to construct a class of Runge–Kutta methods which are symplectic by construction. The idea is to pre and post multiply the matrix M of symplectic condition by a Vandermonde matrix. This will give us a system of equations involving the coefficients of Runge–Kutta method. These equation are the order conditions for a class of Runge-Kutta methods. We employ interpolation to evaluate the coefficients of a symplectic Runge–Kutta method.

Stability of Numerical Solvers for Ordinary Differential Equations

Allison Heard
University of Auckland
a.heard@auckland.ac.nz
Coauthors: John Butcher

Using the example of the second order BDF method, I will consider the stablity of numerical methods used with variable stepsize, and how this depends not only on the method used but also its formualation. The 'scale and modify' approach, introduced by J Butcher and Z Jackiewicz, can be used to extend the stability region. This technique will be described with reference to the underlying one-step method.

Butcher trees and curve search in nonlinear optimization

Laurent O Jay
University of Iowa
ljay@math.uiowa.edu
Coauthors: Darin G Mohr (University of Iowa)

In this talk we show that the field of nonlinear optimization may benefit from techniques developed primarily for the numerical integration of ordinary differential equations (ODEs). Here we are more specifically concerned with improving line search methods to new curve search methods for problems in unconstrained nonlinear optimization. For line search methods a search direction is computed and then a line search is done on the corresponding half-line. The main new idea is to obtain at each step the parametrization of a desired nonlinear geometric curve with better minimization properties for small values of the steplength and then to apply a curve search. Desired geometric curves can be determined thanks to a careful analysis based on Butcher trees, this is our first connection to the numerical integration of ODEs. We approximate a desired geometric curve using methods analogous to Runge-Kutta methods, this is our second connection to the numerical integration of ODEs. Numerical methods for ODEs applied to the gradient flow of an objective function have been considered in the past by several authors in nonlinear optimization. We show in particular that the gradient flow from a point corresponds to a geometric curve which is generally not the most desirable geometric curve for small values of the steplength.

Homogeneous Variational Integrators for Lagrangian Dynamics on Two-Spheres

Melvin Leok
Purdue University
mleok@math.purdue.edu
Coauthors: Taeyoung Lee and N Harris McClamroch

Homogeneous variational integrators for Lagrangian flows on two-spheres are constructed by lifting the variational principle on S^2 to a constrained variational principle on $SO(3)$, through the use of constrained variations which quotient out the local isotropy subgroup of the action of $SO(3)$ on S^2. This is analogous to the reconstruction process in reduction theory.

This approach yields compact expressions for the continuous and discrete dynamics of mechanisms consisting of particles with inter-particle length constraints. These provide the basis for constructing geometrically exact numerical schemes for representing flexible structures and surfaces arising in modern engineering applications.

This research is partially supported by NSF grant DMS-0714223 and DMS-0714223.

Achieving Brouwer's law of round-off error

Robert McLachlan
Massey University
r.mclachlan@massey.ac.nz
Coauthors: Ernst Hairer

In 1937 the astronomer Dirk Brouwer suggested that round-off errors in the numerical solution of differential equations should be independent random variables with mean zero, so that their cumulative effect would be that of a random walk. However, standard implementations of implicit Runge–Kutta methods do not obey this law, instead showing a much more rapid and systematic error growth. I will explain Ernst Hairer's and my attempts to understand and correct this problem, which may have implications for long-term simulations of the solar system.

On explicit adaptive symplectic integration of separable Hamiltonian systems

Klas Modin
Lund University, Sweden
kmodin@maths.lth.se
Coauthors: Gustaf Söderlind

It is well known that symplecticity is preserved under Sundman transformations if and only if the time scaling function is a first integral of the flow. This observation, in conjunction with Hamiltonian splitting methods, allows the construction of explicit adaptive symplectic methods for a commonly used class of scaling functions.

Due to symplecticity these adaptive integrators have excellent long time energy behavior, which is theoretically explained using standard results on the existence of a modified Hamiltonian function. Contrary to reversible adaptive integration, the constructed methods have good long time behavior also for non-reversible and/or non-integrable systems.

Comparisons between reversible adaptive methods and symplectic adaptive methods are given by several numerical examples.

Geometric integration, high oscillation and resonance.

Dion O'Neale
Massey University
d.r.oneale@massey.ac.nz
Coauthors: Robert McLachlan

We look at the performance of trigonometric integrators applied to highly oscillatory differential equations. It is widely known that some of the trigonometric integrators suffer from low order resonances for particular step sizes. We show here that, in general, trigonometric integrators also suffer from higher order resonances which can lead to loss of nonlinear stability. We illustrate this with the Fermi–Pasta–Ulam problem, a highly oscillatory Hamiltonian system. We also show that in some cases trigonometric integrators preserve invariant or adiabatic quantities but at the wrong values. We use statistical properties such as time averages to further evaluate the performance of the trigonometric methods and compare the performance with that of the mid-point rule.

Geometric Integration of Ordinary Differential Equations

Reinout Quispel
La Trobe University, Australia
reinout.quispel@latrobe.edu.au

Adaptive Geometric Integration: Structural Aspects of Reversible Step Size Control

Gustaf Söderlind
Lund University, Sweden
Gustaf.Soderlind@na.lu.se

Adaptive techniques are of great importance in the numerical solution of differential equations. A smaller number of grid points will suffice if they are properly located. However, in some applications, e.g. in integrable Hamiltonian systems, it is important to preserve invariants of the analytic solution. This imposes structural constraints on step size control algorithms. These constraints are explored in terms of commutative diagrams, and it is shown that if Ψ is the step size map, then $-\Psi$ must be an involution for time reversibility to be preserved in the discrete system. Finally, we will briefly look at Sundman transformations and construct a nonlinear Hamiltonian control system to make the Strmer-Verlet method adaptive, while perserving time symmetry, reversibility and the long-term behaviour normally only associated with constant step sizes.

Evaluating Performance of Exponential Integrators

Mayya Tokman
University of California, Merced
mtokman@ucmerced.edu

A number of exponential integrators have been proposed in the recent years as an alternative to standard schemes for solving large stiff systems of ODEs. A thorough study of the performance of different exponential integrators as well as computational savings they offer for a variety of applications still remains to be carried out. We discuss a class of exponential propagation iterative methods (EPI) and compare them with other exponential integrators. This presentation focuses on construction of these schemes and discussion of their properties as compared to implicit, explicit methods and other exponential integrators. Several exponential integrators as well as implicit and explicit methods will be compared and their performance evaluated using demonstrative numerical examples.

The efficient evaluation of functions related to the matrix exponential

Will Wright
La Trobe University
w.wright@latrobe.edu.au

Recent interest in the class of exponential integrators has led to the need for the efficient evaluation of the matrix exponential and related functions. Exponential integrators are typically employed on discretized PDEs, which often have a very large number of differential equations. Therefore, it is generally unfeasible to compute the matrix exponential or the related functions but only their action on a vector. We will outline our implementation which is based on the Krylov subspace approach.

Dynamics and Numerics of some generalised Euler equations

Philip Zhang
Massey University
X.Y.Zhang@massey.ac.nz
Coauthors: Robert McLachlan

Since V.I. Arnold proposed a geometrical approach to Euler fluid equations in 1966, much attention has been attracted to the generalised Euler equations (or Euler–Poincaré equations), which stand for the geodesic equations on some Lie groups. Misiolek *et al* proved recently that the famous KdV and Camassa–Holm equations are the generalised Euler equations on the Bott–Virasoro group with respect to the L^2 metric and H^0 metric respectively. In this talk, we will investigate the dynamics of the generalised Euler equations on the Bott–Virasoro group with respect to the general H^k metric. Some wellposedness and numeric results will be given.

Group Theory, Actions and Computation

Nonabelian tensor squares of free nilpotent groups of finite rank

Russell Blyth
Saint Louis University
blythrd@slu.edu
Coauthors: Primož Moravec (Univerza v Ljubljani), Robert Fitzgerald Morse (University of Evansville)

Let G be any group. Then the group $G \otimes G$ generated by the symbols $g \otimes h$, where $g, h \in G$, subject to the relations

$$gh \otimes k = ({}^g h \otimes {}^g k)(g \otimes k) \quad \text{and} \quad g \otimes hk = (g \otimes h)({}^h g \otimes {}^h k)$$

for all g, h, and k in G, where ${}^x y = xyx^{-1}$ for $x, y \in G$, is called the *nonabelian tensor square of* G. Let $\nabla(G)$ be the central subgroup of $G \otimes G$ generated by the set $\{g \otimes g \mid g \in G\}$. The factor group $G \otimes G/\nabla(G)$ is called the *nonabelian exterior square* of G, denoted by $G \wedge G$. We discuss results concerning the structures of the nonabelian tensor squares and the nonabelian exterior squares of the free nilpotent groups of finite rank. These results were motivated and guided by computations performed using GAP.

Partially symmetric automorphisms of free groups

Ruth Charney
Brandeis University
charney@brandeis.edu
Coauthors: Kai-Uwe Bux, Adam Piggott, and Karen Vogtmann

We compute the virtual cohomological dimension (vcd) of the group of outer automorphisms of a free group which fix certain generators up to conjugacy. The technique is to find a retraction of Culler–Vogtmann's "outer space" preserved by this group. As a corollary, we compute the vcd of the outer automorphism group of right-angled Artin groups associated to trees.

Short presentations for the alternating and symmetric groups

Marston Conder
University of Auckland
m.conder@auckland.ac.nz
Coauthors: John Bray (Queen Mary, London), Charles Leedham-Green (Queen Mary, London), Eamonn O'Brien (U Auckland)

A standard presentation for the symmetric group S_n is given in terms of transpositions $t_i = (i, i+1)$ for $1 \leq i < n$ and the Coxeter relations satisfied by these. The number of generators is linear in n, and the number of relations is quadratic in n. I will describe some new presentations for S_n that involve a fixed number of generators and relations, and how these can be used to obtain short presentations for both the alternating groups A_n and the symmetric groups S_n, and then similarly for the finite classical linear groups.

On Some Finiteness Properties in Infinite Groups

Benjamin Fine
Fairfield University, Connecticut
fine@mail.fairfield.edu
Coauthors: Gilbert Baumslag, Oleg Bogopolski, Anthony Gaglione, Gerhard Rosenberger, Dennis Spellman

We consider some questions concerning certain finiteness properties in infinite groups which are related to Marshall Hall's Theorem. We call these properties Property S and Property R and both are trivially true in finite groups. We give several elementary proofs using these properties for results on finitely generated subgroups of free groups and in limit groups as well as a new elementary proof of Marshall Hall's basic result. We next consider these properties within surface groups and prove an analog of Marshall Hall's theorem in that context. Finally we show that nilpotent groups and certain finite extensions of nilpotent groups satisfy these properties.

The strong symmetric genus and generalized symmetric groups: results and a conjecuture

Michael A Jackson
Grove City College, USA
majackson@gcc.edu

The strong symmetric genus of a finite group G is the smallest genus of a closed orientable topological surface on which G acts faithfully as a group of orientation preserving automorphisms. Marston Conder found the strong symmetric genus of the alternating and symmetric groups. The idea of the symmetric groups, Σ_n, can be expanded to the generalized symmetric groups, which are defined as $G(n, m)$ is the wreath product of $\mathbb{Z}_m$ by Σ_n, where $n, m \in \mathbb{Z}_+$. This puts the standard symmetric groups as a family of generalized symmetric groups, i.e. $\Sigma_n = G(n, 1)$. Recently, the author has found the strong symmetric genus of the hyperoctahedral groups (which are the generalized symmetric groups of type $G(n, 2)$) and the groups of type $G(n, 3)$. This talk will discuss these results as well as some additional cases of the strong symmetric genus of $G(n, m)$ for $m > 3$. In addition a conjecture concerning the general results will be discussed.

Total chirality of maps and hypermaps on Riemann surfaces

Gareth Jones
University of Southampton
g.a.jones@soton.ac.uk
Coauthors: Antonio Breda

By Belyi's Theorem, the compact Riemann surfaces defined over algebraic number fields are those uniformised by subgroups of triangle groups, or equivalently obtained from hypermaps. The most symmetric of these correspond to normal subgroups of triangle groups, or equivalently to orientably regular hypermaps. Such a hypermap is termed chiral if it is not isomorphic to its mirror image. The most extreme form of this phenomenon is total chirality, where the hypermap and mirror image have no nontrivial common quotients.

Antonio Breda (Aveiro) and I have classified the totally chiral hypermaps of genus up to 1001. The least genus of any totally chiral hypermap is 211, attained by twelve orientably regular hypermaps with automorphism group A_7 and type (3,4,4) (up to triality). The least genus of any totally chiral map is 631, attained by a chiral pair of orientably regular maps of type $\{11, 4\}$, together with their duals; their automorphism group is the Mathieu group M_{11}. This is also the least genus of any totally chiral hypermap with non-simple automorphism group, in this case the perfect triple covering $3.A_7$ of A_7.

Enumerating chiral maps on surfaces with a given underlying graph

Jin Ho Kwak
Pohang University of Science and Technology, Korea
jinkwak@postech.ac.kr
Coauthors: Yan-Quan Feng and Jin-Xin Zhou

Two 2-cell embeddings $\imath : X \to S$ and $\jmath : X \to S$ of a connected graph X into a closed orientable surface S are *congruent* if there are an orientation-preserving surface homeomorphism h on S and a graph automorphism γ of X such that $\imath h = \gamma \jmath$. A 2-cell embedding $\imath : X \to S$ of a graph X into a closed orientable surface S is sometimes described combinatorially by a pair $(X; \rho)$ called a map, where ρ is a product of disjoint cycle permutations each of which is the permutation of the dart set of X initiated at the same vertex following the orientation of S. The *mirror image* of a map $(X; \rho)$ is the map $(X; \rho^{-1})$, and one of the corresponding embeddings is called the *mirror image* of the other. A 2-cell embedding of X is *reflexible* if it is congruent to its mirror image. Mull *et al* [Proc. Amer. Math. Soc. **103** (1988) 321–330] developed an approach for enumerating the congruence classes of 2-cell embeddings of graphs into closed orientable surfaces. In this paper we introduce a method for enumerating the congruence classes of reflexible 2-cell embeddings of graphs into closed orientable surfaces, and apply it to the complete graphs, the bouquets of circles, the dipoles and the wheel graphs to count their congruence classes of reflexible or nonreflexible (called chiral) embeddings.

Capable groups of class two and prime exponent

Arturo Magidin
University of Louisiana, Lafayette
magidin@member.ams.org

A group G is capable if and only if $G \cong H/Z(H)$ for some group H. If G is a group of class two and prime exponent, capability can be characterised in terms of a closure operator on the lattice of subspaces of certain finite dimensional vector space over a field of p elements. I have been working towards a characterisation of the capable groups in this class via this equivalence. In the case of 5-generated groups, GAP was used to search through examples of non-closed subspaces; by considering these examples and why they were not closed, I was able to prove that the only non-capable groups among the 5-generated groups of class at most two and exponent p are the cyclic group and the groups that can be expressed as a direct product of two nonabelian groups G_1 and G_2 amalgamated over a subgroup of order p of the commutator subgroups. I will discuss these and other results, as well as the role GAP is playing in the investigations.

A census of edge-transitive tessellations

Toma Pisanski
University of Ljubljana, Slovenia
Tomaz.Pisanski@fmf.uni-lj.si

B. Grünbaum and G. C. Shephard have classified edge-transitive tessellations according to their edge-symbol $\langle p, q; k, l \rangle$. The growth rate of Bilinski diagrams for each of these tessellations has been determined by S. Graves, T. Pisanski and M.E. Watkins recently. We compute the number of edge-transitive tessellations for a given growth rate and present a census of these tessellations.

The Tits alternative for sherical generalized tetrahedron groups

Gerhard Rosenberger
University of Dortmund
Gerhard.Rosenberger@mathematik.uni-dortmund.de
Coauthors: B Fine, V gr.Rebel and H Hulpke

A generalized tetrahedron group is defined to be a group G admitting the following presentation:

$$< x, y, z \, : \, x^l = y^m = z^n = W_1^p(x, y) = W_2^q(y, z) = W_3^r(x.z) = 1 > .$$

These groups appear in many contexts, not least as fundamental groups of certain hyperbolic orbifolds or as subgroups of generalized triangle groups. If (p, q, r) is not $(2, 2, 2)$ then the Tits alternative holds for G, that is, G contains a non-abelian free subgroup or is solvable-by-finite. If $(p, q, r) = (2, 2, 2)$ we have many partial results, especially we give the the list of the finite generalized tetrahedron groups.

Old and new on the universal covering group of $SL(2, \mathbb{R})$.

Gunter Steinke
University of Canterbury
G.Steinke@math.canterbury.ac.nz
Coauthors: Rainer Loewen

The structure and properties of the universal covering group $\tilde{\Omega}$ of $SL(2, \mathbb{R})$ are well understood. However, since this group permits no faithful linear representation, it remains elusive and only a few geometries are known on which $\tilde{\Omega}$ acts as a group of automorphisms. We survey some known results and present a new geometry which essentially is determined by the one-parameter subgroups of $\tilde{\Omega}$ extended by a factor $\mathbb{R}$.

Bicontactual rotary hypermaps

Antonio Breda d'Azevedo
University of Aveiro
breda@mat.ua.pt
Coauthors: Ilda Rodrigues

We present the classification of the orientably regular hypermaps that are bicontactual, that is, each face has only two adjacent faces. The classification of bicontactual regular maps (orientable and not orientable) was done by Wilson in 1976.

History and Philosophy of Mathematics

Constructive Reverse Mathematics
Douglas Bridges
University of Canterbury
d.bridges@math.canterbury.ac.nz

In constructive reverse mathematics we examine theorems either to determine precisely where they fail to be constructive or else to prove, constructively, their equivalence to one of a number of (plausibly) constructive principles, such as versions of Brouwer's fan theorem. This talk deals with a generic form of proof of equivalence to a fan theorem, taking two particular theorems of analysis as illustrations.

Mathematical Problems from the Maine Farmer's Almanac
Bruce Burdick
Roger Williams University
bburdick@rwu.edu

A recent paper by Albree and Brown discusses the presence of mathematical problems in The Ladies' Diary (1704–1840), an almanac from Britain. We report on an American version of the same phenomenon. In the nineteenth century and into the twentieth, The Maine Farmer's Almanac made an annual feature out of posing various puzzles, including riddles, anagrams, and mathematical problems. Readers would have a year to work on the problems and then see solutions in the following issue. A few readers would mail in their solutions to the editor for publication. Some of the problems were surprisingly sophisticated for a general readership. We will survey some interesting examples and distribute a list of problems from issues we have seen.

Elegance and insight: what is the link?
Philip Catton
University of Canterbury
philip.catton@canterbury.ac.nz

That elegance links to insight is original to mathematical practice and ineluctable from it. Yet this linkage is not well explained by modern epistemologists of mathematics. Two key tenets of modern epistemology are that a proposition is the content of a declarative assertion, and that we demonstrate a proposition by logically deducing it from other such declarative propositions. Yet in mathematics a proposition is often something that it is proposed to do, and a demonstration often simply the rationally most elegant execution of the proposed task. (Such is how Euclid seeks to work throughout his Elements, for example, and as an indication of this, Euclid expresses himself equally often in the imperative as in the declarative voice, for that way of coaching his reader in practical respects is essential to his understanding of propositions, of demonstrations, and of mathematics itself.) Modern epistemologists look past the practical aspect that Euclid remarks as essential to mathematics, partly because they are much affected in how they view ideal or perfected knowledge by the rigorising and formalising programmes of some nineteenth- and early twentieth-century mathematicians. Yet while those programmes have their point, they also have proved demonstrably limited; and moreover, they orient us in diametrically the wrong way to see the practical connection of mathematical theorising, and therewith the original and ineluctable connection between insight and elegance. In this talk I explore again the classical view, according to which the clear logical ordering of thoughts is not so much foundational for mathematics as a distant and in some ways not fully achievable rational goal for it. Reason according to my conception is not chiefly analytically oriented or logical or symbolic in form; it is chiefly synthetically oriented and intuitive and practical in form. The view that I develop explains the link between elegance and insight appropriately, by associating it with conditions for the very possibility of mathematical thought.

Leonard Euler and the dastardly John Robison

Lawrence D'Antonio
Ramapo College of New Jersey
ldant@ramapo.edu

The theory of structures in a very real sense begins with Euler's research on elasticity. Euler gives an analysis of the shape of bent beams and the buckling of columns. With the onset of the Industrial Revolution engineering practice undergoes rapid changes. The theoretical basis for this practice is provided by a line of research starting with Euler and proceeding through Coulomb, Cauchy and Navier. The Scottish engineer John Robison knew Euler from the time that Robison taught in St. Petersburg. Robison was severely critical of Euler's theory of elasticity, calling it a 'dry mathematical disquisition'. In this talk we show that the subsequent experimental evidence of Hodgkinson and Duleau strongly supports Euler's theory.

The dark side of constructive reverse mathematics

Hannes Diener
University of Canterbury
H.Diener@math.canterbury.ac.nz

Basing mathematics on foundations that differ from those used classically can lead to alternate and sometimes strange mathematical universes. One can get some order into these universes by identifying principles that hold in some, but fail in others. In this talk we will discuss a hierarchy of very closely related principles together with their antitheses that impact on the notions of continuity and compactness. Although recent results in constructive reverse mathematics will be presented, the focus of the talk will not be about the logical or analytical details, but how they fit into the grander scheme.

Episodes from the career of the Riemann Hypothesis

Hardy Grant
York University, Toronto
hardygrant@yahoo.com

I shall survey aspects of the early history of this most celebrated and important of conjectures, focussing on the theoretical and technological advances that enabled extensions of the known range of validity. The account will suggest contemporary perceptions of promising strategies for resolution of the "RH" and contemporary expectations of the eventual outcome.

Limits of solvability: unsolvable problems in Fibonacci's Liber Abbaci

John Hannah
University of Canterbury
john.hannah@canterbury.ac.nz

Leonardo of Pisa (also known as Fibonacci) published his Liber Abbaci at the start of the thirteenth century. It begins with one of the earliest European accounts of arithmetic using the decimal system, but it is mostly devoted to the art of problem solving. Leonardo uses a variety of problem solving strategies (including proportional thinking, false position and al-Khwarizmi's algebra), justifying each of his methods by Euclidean geometrical arguments. He also explores variations on well-known problems (men exchanging money, or finding purses, or buying horses, and so on) investigating the boundaries between solvable and unsolvable problems. Sometimes an unsolvable problem becomes solvable if debts are allowed, but this comes at the cost of violating Leonardo's Euclidean principles. His decisions on when to allow such irregular solutions seem to be guided by whether the resulting scenarios sound sensible in terms of everyday experience.

Indecomposability of the Continuum in Constructive Reverse Mathematics

Iris Loeb
University of Canterbury
I.Loeb@math.canterbury.ac.nz

Different philosophical schools hold different views on the continuum. For example, in contrast to the classical continuum, the intuitionistic continuum cannot be split effectively: it is indecomposable. In this talk we will study some of the consequences of these different philosophical views on the continuum within the programme of Constructive Reverse Mathematics.

Hypsicles of Alexandria and Arithmetical Sequences
Clemency Montelle
University of Canterbury
c.montelle@math.canterbury.ac.nz

The determination of rising times for the twelve zodiacal signs at a given terrestrial latitude was a challenge for ancient mathematicians and astronomers and many attempts to model this were proposed in antiquity based on the leading mathematical theories and techniques of the day. An important early approach was put forth by the Alexandrian mathematician Hypsicles (fl. ca. 150 BCE (?)) in a work called the Anaphoricos who based his solution on the assumption that rising times increase and decrease strictly linearly with constant difference. Indeed, in an era when the overwhelming success of Ptolemy's mathematical Syntaxis ensured the redundancy of almost all works that predated it, Hypsicles's work is not only significant because of the fact that it is a rare glimpse into early Greek mathematical astronomy but also because it invokes some elegant arithmetical mathematical lemmas to solve a practical problem in a scene that was dominated by geometrical ways of thinking. Hypsicles's presentation is unmistakably Euclidean in style but with some vital differences. This talk will provide a detailed textual, technical, and contextual study of the mathematical content of his work.

Mathematics and observation in Indian astronomical parameters
Kim Plofker
Union College
Kim_Plofker@alumni.brown.edu

For over two hundred years historians have debated (sometimes with great ferocity) about the methods that medieval Indian mathematical scientists used to derive the parameters for their celestial models. Were the values periodically revised in accordance with obscure but comprehensive observational programs, or were they numerically adjusted in a more ad hoc fashion? This talk examines and attempts to mediate in the latest incarnation of this debate, which pitted the statistical reconstructions of the late Roger Billard against the textual historiography of the late David Pingree.

Probability in Ancient Greek: Moving Beyond the Traditional Narrative
Bronwyn Rideout
University of Canterbury
bcr39@student.canterbury.ac.nz

Evidence for a mathematical conception or calculation of probability in Ancient Greece has yet to be uncovered. However, contemporary historians of mathematics interpret this gap in the record to signify either that the practice of such was a trade secret or there was nothing in Greek society to inspire them to engagement within that field. These interpretations are by and large motivated by the reinvigoration of probability via Huygens and Pascal.

Recovery of the hidden history of Greek probability requires the removal of the traditional Huygenian narrative and a reconsideration of Greek thought on probability in its own context. In their mythology, philosophy and art, the Greeks were more than comfortable with the notions of the probable and beating the odds. What is lacking is a transference of that interest into a mathematical mindset and the strongest obstacle to that could be found in philosophy.

A survey of some of the key figures in Greek philosophy over several topics proven integral to probability, i.e. gambling, chance, mathematics etc., will demonstrate that while the Greeks did obtain an understanding of probability akin to its current conception, their beliefs on everything else proved to be a significant barrier.

Mathematical Contributions to *The Educational Times* from Australia and New Zealand

Jim Tattersall
Providence College
tat@providence.edu
Coauthors: Shawnee McMurran (California State University at San Bernardino)

A number of significant mathematical journals have included a section devoted to mathematical problems intended to challenge and educate their readers. None has had a more extensive list of contributions and world-wide readership than the monthly periodical *The Educational Times*. Between 1848 and 1918, there were more than eighteen thousand contributions to the mathematical department from amateur and professional mathematicians. According to the English mathematician William Kingdon Clifford, *The Educational Times* did more to encourage original mathematical research than any other European periodical in the late nineteenth century. The section devoted to mathematical problems and their solutions was later republished in six-month installments as *Mathematical Questions and Their Solutions from the Educational Times*. We focus on problems and solutions from Australian and New Zealand contributors. We illustrate the types of problems they submitted and solved in comparison to contributors from other parts of the world.

Algebraic invariant theory and characteristic classes

Paul R Wolfson
West Chester University
pwolfson@wcupa.edu

In the middle of the twentieth century, André Weil supplied unity and direction to the rapidly developing theory of characteristic classes of bundles. The Weil homomorphism connected characteristic classes to results from classical algebraic invariant theory. In this talk I shall describe the state of characteristic classes at that time, recall the results from invariant theory, and suggest how the homomorphism opened up new lines of research.

Hopf Algebras and Quantum Groups

The Geometric Classification of Four Dimensional Superalgebras

Aaron Armour
Victoria University of Wellington
armour@xtra.co.nz

The algebraic classification problem for algebras of a given dimension is to determine which algebra structures form irreducible components in Alg_n, with Alg_n being the variety of n-dimensional algebra structures. In this talk we shall briefly review these ideas and state the results in dimension four, before examining the corresponding problem for superalgebras and presenting the current state of the results for the geometric classification problem of superalgebras of dimension four.

A structure theorem for relative Hopf bimodules with applications to Morita equivalences

Stefaan Caenepeel
Vrije Universiteit Brussel
scaenepe@vub.ac.be
Coauthors: S. Crivei (University of Murcia, Spain) A. Marcus (Babes-Bolyai University, Cluj-Napoca, Romania) M. Takeuchi (University of Tsukuba, Japan)

Consider two Hopf–Galois extensions A and B. We present a Structure Theorem for Hopf bimodules: the category of Hopf bimodules is equivalent to the category of modules over the cotensor product of A and B^{op}. As an application, we show that a Morita equivalence between $A^{\mathrm{co}H}$ and $B^{\mathrm{co}H}$ can be lifted to an H−Morita equivalence between A and B if and only if the bimodule structure on one of the connecting modules can be extended to an action of the cotensor product on it. As a second application, we present a Hopf algebra version of an exact sequence due to Beattie and del Rio, connecting the graded Picard group of a strongly graded ring, and the stable part of the Picard group of its part of degree zero.

The Hopf-Schur subgroup

Juan Cuadra
University of Almeria, Spain
jcdiaz@ual.es

A finite dimensional central simple k-algebra A (k a field) is *Schur* if there exists a finite group G and a surjective algebra morphism $\pi : k[G] \to A$. Such an algebra is a simple component of the Wedderburn decomposition of $k[G]$ when $char(k)$ does not divide $|G|$. Those classes in $Br(k)$, the Brauer group of k, represented by a Schur k-algebra form a subgroup, called the *Schur subgroup of k*.

In this talk we will propose a generalization of this subgroup by replacing in the above definition the group algebra by a Hopf algebra. The algebras so obtained are named Hopf-Schur algebras and the subset of $Br(k)$ consisting of classes represented by a Hopf–Schur algebra is a subgroup, the Hopf–Schur subgroup. The aim of this talk is to prove that this new sugroup is much larger than the Schur group. To do this we will show the existence of a family of central simple k-algebras, for certain fields k, ocurring in the Wedderburn decomposition of a semisimple Hopf algebra but not in the Wedderburn decomposition of any semisimple group algebra. The results to be presented in this talk are part of a joint work with E. Aljadeff, S. Gelaki and E. Meir.

(Co)Representation theoretic approach to fundamental results in Hopf algebras

Miodrag C Iovanov
SUNY Buffalo and U Bucharest
yovanov@gmail.com

Co-Frobenius coalgebras were introduced as dualizations of Frobenius algebras. Recently, it was shown in [M.C. Iovanov, *Co-Frobenius Coalgebras*, J. Algebr, **303** (2006) 146–153] that they admit left-right symmetric characterizations analogous to those of Frobenius algebras: a coalgebra C is co-Frobenius if and only if it is isomorphic to its rational dual. We consider the more general quasi-co-Frobenius (QcF) coalgebras; we show that these also addmit symmetric characterizations: a coalgebra is QcF if it is weakly isomorphic to its (left, or equivalently right) rational dual $Rat(C^*)$, in the sense that certain coproduct powers of these objects are isomorphic. These show that QcF coalgebras can be viewed as generalizations of bothe co-Frobenius coalgebras and Frobenius algebras. Surprisingly, these turn out to have many applications to fundamental results of Hopf algebras. The equivalent characterizations of Hopf algebras with left (or right) nonzero integrals as left (or right) co-Frobenius, or QcF, or semiperfect or with nonzero rational dual all follow imediately from these results. Also, the uniqueness of integrals follows at the same time also as an equivalent statement. Moreover, as a by-product of our methods, we observe a short proof for the bijectivity of the antipode of a Hopf algebra with nonzero integral. This gives a purely representation theoretic approach to many of the basic fundamental results in the theory of Hopf algebras.

Classifying Semisimple Hopf Algebras of dimension 2^n.

Yevgenia Kashina
DePaul University
ykashina@condor.depaul.edu

In this talk we will discuss some recent progress in classification of semisimple Hopf algebras of dimension 2^n with large abelian groups of grouplike elements.

On cocycle deformations of pointed Hopf algebras with abelian grouplikes
Akira Masuoka
University of Tsukuba
akira@math.tsukuba.ac.jp

I will discuss cocycle deformations of some Hopf algebras, including the quantized enveloping algebras and the finite-dimensional pointed Hopf algebras due to Andruskiewitsch and Schneider.

Frobenius-Schur indicators for Hopf algebras
Susan Montgomery
University of Southern California
smontgom@math.usc.edu

Frobenius-Schur indicators were originally defined for simple modules over finite groups, but have been extended to Hopf algebras, where they have proved very useful. A Hopf algebra H is called totally orthogonal if all of its simple modules have indicator $+1$ (this implies that each module admits a non-degenerate, symmetric, H-invariant bilinear form). In recent work, Guralnick and I have shown that the Drinfel'd double of a finite real reflection group is totally orthogonal, and Jedwab and I have studied this property for two bismash products associated to the symmetric group.

On the classification of Hopf algebras of dimension pq
Siu-Hung Ng
Iowa State University
rng@iastate.edu

The classification of Hopf algebras of dimension pq, where p and q are distinct primes, is still open in general. It has been widely believed these Hopf algebras are trivial. In this talk, we will talk about some recent development of the problem. In particular, we will discuss a proof for the case when $2 < p < q \leq 4p + 11$.

On Crystalline Graded Rings
Fred Van Oystaeyen
University of Antwerp, Belgium
fred.vanoystaeyen@ua.ac.be

We introduce a class of graded rings generalizing crossed product algebras as well as generalized Weyl algebras. For finite grading groups there are problems concerning the determination of the center and related properties like being a maximal order, aan Azumaya algebra, or an hereditary order. Fixing the part of degree zero to be a commutative Dedekind domain we study these properties in some detail. For infinite grading groups there are interesting examples generalizing the Weyl algebra.

On the representations of pointed Hopf algebras

David E. Radford
University of Illinois at Chicago
radford@uic.edu

Let H be a Hopf algebra over a field k whose coradical is a sub-Hopf algebra. There is a program, called the Andruskiewitsch–Schneider classification program, to determine the structure of H. First pass to the associated graded Hopf algebra gr(H), secondly determine the structure of gr(H), and thirdly "lift" the relations of gr(H) to determine H.

This program has been carried out by these two authors with great success in particular when H is finite-dimensional, whose coradical is the group algebra of a finite commutative group, and k is algebraically closed of characteristic zero. In many cases H is the quotient of a generalized double, the irreducible modules of the tensor factors of which are one-dimensional.

We discuss the finite-dimensional irreducibles of such doubles and describe a generalized "highest weight" theory for them. The focus of this presentation will be a detailed discussion of applications to the representation theory of quotients of generalized doubles. This is the basis of an article based on joint work with Schneider.

Hopf Algebras and Congruence Subgroups

Yorck Sommerhäuser
University of South Alabama
sommerh@jaguar1.usouthal.edu
Coauthors: Yongchang Zhu

We prove that the kernel of the natural action of the modular group on the center of the Drinfel'd double of a semisimple Hopf algebra is a congruence subgroup. To do this, we introduce a class of generalized Frobenius-Schur indicators and endow it with an action of the modular group that is compatible with the original one. The talk is based on joint work with Yongchang Zhu.

The Dickson Subcategory Splitting Conjecture for Pseudocompact Algebras

Blas Torrecillas
University of Almera, Spain
btorreci@ual.es
Coauthors: Miodrag Cristian Iovanov, Constantin Nastasescu

Let A be a pseudocompact (or profinite) algebra, so $A = C^*$ where C is a coalgebra. We show that the if the semiartinian part (the *Dickson* part) of every A-module M splits off in M, then A is semiartinian, giving thus a positive answer in the case of algebras arising as dual of coalgebras (pseudocompact algebras), to a well known conjecture of Faith.

Infinite-Dimensional Groups and their Actions

Isometries of infinite-dimensional Riemannian manifolds
Christopher Atkin
Victoria University of Wellington
atkin@mcs.vuw.ac.nz

The group of self-isometries of a complete infinite-dimensional Riemannian manifold is a Lie group (in principle of infinite dimension).

Costs of equivalence relations and group actions
Anthony Dooley
University of New South Wales
a.dooley@unsw.edu.au
Coauthors: V Golodets

Much work has been done in studying amenable group actions, but until recently it has been difficult to handle non-amenable actions (or equivalence relations). A breakthrough was made with work of Levitt, Kechris and Gaboriau to define a new invariant, the cost. Gaboriau showed how to use this invariant to distinguish between group actions of, for example, the free group on two generators and the free group on three generators.

Golodets and I use the theory of index cocycles of Feldman, Sutheraland and Zimmer, to calculate the cost of equivalence relations which are finite extensions. This enables us to resolve some conjectures of Gaboriau and also to show that many group actions cannot be isomorphic.

I will give an outline of the theory of costs and outline our main results.

Orbit inequivalent actions of non-amenable groups
Inessa Epstein
University of California, Los Angeles
iepstein@math.ucla.edu

Let G be a countable group acting in a Borel way on a standard probability space X. The orbits of this action give rise to an equivalence relation on X. We say two measure-preserving actions of groups G and H on spaces X and Y, respectively, are orbit equivalent if there is a measure-preserving bijection between conull subsets of X and Y identifying the orbits. We discuss a result that every non-amenable group admits continuum many orbit inequivalent-free, measure-preserving, ergodic actions.

Groups acting on Banach spaces

Stefano Ferri
Universidad de los Andes
stferri@uniandes.edu.co
Coauthors: Jorge Galindo Pastor

We shall present techniques to determine when a topological group can act as isometries on a "nice" Banach space (where "nice" could mean Hilbert, reflexive, Asplund. . .) and study in details the case of of groups which act on reflexive spaces.

On group algebras for non-locally compact groups

Hendrik Grundling
University of New South Wales
hendrik@maths.unsw.edu.au
Coauthors: Karl-Hermann Neeb

We generalise group algebras to other algebraic objects with bounded Hilbert space representation theory—the generalised group algebras are called "host" algebras. The main property of a host algebra, is that its representation theory should be isomorphic (in the sense of the Gelfand–Raikov theorem) to a specified subset of representations of the algebraic object. The main motivation behind this, comes from the analysis of infinite dimensional Lie groups and other non-locally compact groups (some of which occur in physics).

In recent work on the topic we analyzed ordinary and multiplier (unitary) representations for non-locally compact Abelian groups, and found that host algebras need not exist, nor be unique if they do exist.

On the positive side, we constructed a host algebra for the multiplier representation theory associated to a fixed 2-cocycle of a non-locally compact Abelian group. I will sketch this construction. This has direct application to the canonical commutation relations of quantum fields.

The Structure of Connected Pro-Lie Groups

Sidney A Morris
University of Ballarat
s.morris@ballarat.edu.au

This talk is an introduction to connected pro-Lie groups and their structure as recently appeared in the book "The Lie Theory of Connected Pro-Lie Groups" by Karl Heinrich Hofmann and Sidney A. Morris and published by the European Mathematical Society.

A footnote to the property (FH)
Vladimir Pestov
University of Ottawa, Canada
vpest283@uottawa.ca

For second countable locally compact groups G (though not for more general classes of even discrete groups), Kazhdan's property (T) is equivalent to the following property known as (FH): every continuous action of G by affine isometries on a Hilbert space has a fixed point. Recently there has been some interest towards versions of this property stated for more general classes of Banach spaces, especially uniformly convex spaces, including L^p spaces (cf. a recent preprint by Bader, Furman, Gelander, and Monod, arXiv:math/0506361).

In particular, Haagerup and Przybyszewska have shown [arXiv:math/0606794] that every second countable locally compact non-compact group admits a continuous affine action by isometries without fixed points on a strictly convex (reflexive) Banach space.

One cannot hope to extend this result to non locally compact Polish groups, because, by force of a theorem by Megrelishvili [Semigroup Forum **63** (2001) 357–370] stating that every WAP function on the Polish group $Homeo_+[0,1]$ is constant, this particular group admits no nontrivial continuous affine actions by isomeries on reflexive Banach spaces. Nevertheless, we observe that every topological group G that is not precompact admits a continuous affine actiion by isometries on a Banach space without fixed points. In fact, this property characterizes precompactness.

The proof uses a novel characterization by Uspenskij [arXiv:math/0004119] of precompact groups as those topological groups G in which every neighbourhood of the identity, U, admits a finite set F with $FUF = G$. Another component of the proof is the following observation of independent interest: every continuous action of a topological group G by isometries on a metric space X extends to an affine isometric action of G on a suitable Banach space containing X as a subspace and affinely spanned by it.

Generic representations of finitely generated groups
Christian Rosendal
University of Illinois at Urbana-Champaign
rosendal@math.uiuc.edu

For finitely generated groups Γ and ultrahomogeneous countable relational structures M we study the space $\mathrm{Rep}(\Gamma, M)$ of all representations of Γ by automorphisms on M equipped with the topology it inherits seen as a closed subset of $\mathrm{Aut}(M)^\Gamma$. When Γ is the free group on n generators this space is just $\mathrm{Aut}(M)^n$, but is in general significantly more complicated. We prove that when Γ is finitely generated abelian and M the random structure of a finite relational language or the random ultrametric space of a countable distance set there is a generic point in $\mathrm{Rep}(\Gamma, M)$, *ie* there is a comeagre set of mutually conjugate representations of Γ on M. This is analogous to results of Hrushovski, Herwig, and Herwig-Lascar for the case $\Gamma = F_n$.

Oscillation stability for topological groups and Ramsey theory.

Lionel Nguyen Van Thé
University of Calgary, Canada
nguyen@math.ucalgary.ca
Coauthors: Jordi Lopez-Abad (Université Paris 7), Norbert Sauer (University of Calgary).

In 2003, Kechris, Pestov and Todorcevic established several connections between dynamics of topological groups and combinatorics. Among the concepts that were then introduced stands the so-called 'oscillation stability for topological groups'. Very few results about this notion are currently known. One of the most important ones was obtained by Hjorth in 2006 and states that no non-trivial Polish group G is such that the $(G, \{e\})$ is oscillation stable. Another important example comes from the reformulation of the solution of the so-called distortion problem for ℓ_2 due to Odell and Schlumprecht in 1994 and states that if G is the surjective isometry group of the unit sphere of the Hilbert space ℓ_2 and St_x is the stabilizer of an element x in the sphere, then (G, St_x) is never oscillation stable. The purpose of the present talk is to show that the situation is quite different if the latter problem is considered when the unit Hilbert sphere is replaced by another remarkable Polish metric space: the Urysohn sphere.

Full Groups of Equivalence Relations

Todor Tsankov
California Institute of Technology
todor@caltech.edu
Coauthors: John Kittrell

We study full groups of countable, measure-preserving equivalence relations. By a classical theorem of Dye, those groups are complete invariants for the equivalence relations (up to a.e. isomorphism). We show that the (non-trivial) full groups are homeomorphic to Hilbert space and that homomorphisms from ergodic ones to arbitrary separable groups are continuous. We also find bounds for the minimal number of topological generators (elements generating a dense subgroup) of full groups allowing us to distinguish full groups of equivalence relations generated by free, ergodic actions of the free groups F_n and F_m if m and n are sufficiently far apart. We also show that an ergodic equivalence relation is generated by an action of a finitely generated group iff its full group is topologically finitely generated.

On finite groups in Stone–Čech compactifications

Yevhen Zelenyuk
University of the Witwatersrand, South Africa
Yevhen.Zelenyuk@wits.ac.za

The Stone–Čech compactification of an infinite discrete semigroup is an important object interesting both for its own sake and for its applications to combinatorial number theory and to topological dynamics. It is known that if the semigroup is cancellative, the Stone–Čech compactification contains large free groups. We shall discuss the question whether it contains any nontrivial finite group.

Integrability of Continuous and Discrete Evolution Systems

Quasi-Hamiltonian Structure, Hojman Construction and Integrable Systems

Partha Guha
S.N. Bose National Centre for Basic Sciences
partha@bose.res.in
Coauthors: Jose Cariñena and Manuel Rañada

Given a smooth vector field Γ and assuming the knowledge of an infinitesimal symmetry X, Hojman [J. Phys. A, **29** (1996) 667–674] proposed a method for finding both a Poisson tensor and a function H such that Γ is the corresponding Hamiltonian system. We show this construction leads to the degenerate quasi-Hamiltonian structures introduced by Crampin and Sarlet [J.Math.Phys., **43** (2002) 2505–2517]. We extend Hojman's construction to Nambu–Poisson case. We give several interesting examples from integrable systems in support of our construction.

Symbolic Computation of Conservation Laws of Nonlinear PDEs in $(n+1)$-dimensions

Willy Hereman
Colorado School of Mines
whereman@mines.edu

A direct method will be presented for the symbolic computation of conservation laws of nonlinear PDEs in $(n+1)$-dimensions. The method computes densities and fluxes based on two key tools: the Euler operator to test exactness and the homotopy operator to invert the total divergence.

The method has been implemented in Mathematica. Using the $(2+1)$–dimensional shallow-water wave equations as an example, a computer package will be demonstrated that symbolically computes conservation laws of nonlinear PDEs. The software is being used to compute conservation laws of fluid flow (based on the Navier and Kadomtsev–Petviashvili equations) and transonic gas flow.

Leading Order Integrability Conditions for Differential–Difference Equations

Mark Hickman
University of Canterbury
M.Hickman@math.canterbury.ac.nz

A necessary condition for the existence of conserved densities, ρ, and fluxes of a differential–difference equation which depend on q shifts, for q sufficiently large, is presented. This condition depends on the eigenvalues of the leading terms in the differential-difference equation. It also gives, explicitly, the leading integrability conditions on the density in terms of second derivatives of ρ.

Integrability and Separation of Variables

Ernie Kalnins
University of Waikato
math0236@waikato.ac.nz
Coauthors: W. Miller, K. Kress

A short talk on recent developments in the theory of integrable systems as this relates to the idea of separation of variables is given. An outline of a research programme relating to the idea of superintegrability is briefly discussed with its recent results and future directions outlined.

American Barriers

Gerrard Liddell
University of Otago
gliddell@maths.otago.ac.nz

The problem of managing the finance of multiple projects with early American exercise options can be solved by weak barrier methods. We will describe the symbolic manipulation of the stochastic equations to generate functions for the numerical solution of some of these problems.

Discrete Integrable Systems

Reinout Quispel
La Trobe University, Australia
reinout.quispel@latrobe.edu.au

Matroids, Graphs, and Complexity

Matroids applied to coding theory

Thomas Britz
University of New South Wales
britz@maths.unsw.edu.au
Coauthors: Keisuke Shiromoto

One of the most attractive features of matroid theory is that it generalises objects and results from other fields, such as linear algebra, graph theory, and matching theory, to name three prominent examples. By applying matroid theory to the generalized objects, it is often possible to achieve good results regarding the original objects.

This talk presents several ways in which matroid theory may be applied to coding theory. The results thereby obtained include a new and unexpected dual relationship between bond and cycle cardinalities in graphs, and an efficient method to calculate higher weight enumerators of linear codes.

Even pairs in Berge graphs

Maria Chudnovsky
Columbia/CMI
mchudnov@columbia.edu
Coauthors: Paul Seymour

An even pair in a graph is a pair of non-adjacent vertices so that every induced path between them has even length. A graph is called *Berge* if no induced subgraph of it is a cycle of odd length at least five or the complement of one. In my talk I will discuss two results, obtained in joint work with Paul Seymour, about even pairs in Berge graphs.

The first result is a a simplification of the proof of the Strong Perfect Graph Theorem (which we proved a few years ago in joint work with Neil Robertson, Paul Seymour and Robin Thomas). We were able to replace the last 55 pages of the proof (which are the least intuitive part of it) with a much shorter and simpler argument. This simplification is based on an approach by Maffray and Trotignon that allowed us to find even pairs in certain classes of Berge graphs.

The second result is a description of all K_4-free Berge graph that do not have even pairs. This is a special case of a conjecture of Thomas, attempting to describe all Berge graphs with no even pair. In particular, our result implies a new combinatorial coloring algorithm for K_4–free Berge graphs.

Unavoidable Minors of Loosely c–Connected Infinite Graphs

Carolyn Chun
Louisiana State University
cchun1@lsu.edu
Coauthors: Guoli Ding

An infinite graph G is called loosely c–connected if there exists a number d depending on the graph such that the deletion of fewer than c vertices from G results in a graph containing one infinite component and a collection of components containing d vertices altogether. This talk builds on Konig's Infinity

Lemma, and describes the complete set of unavoidable minors, topological minors, and parallel minors for loosely c–connected infinite graphs.

Simplicial Maps and the Generic Rigidity Matroid

Henry Crapo
CAMS/EHESS, Paris
crapo@ehess.fr
Coauthors: Emanuela Ughi (Perugia) and Tiong Seng Tay (Singapore)

The generic rigidity matroid of a graph G (in dimension d) has as bases all subgraphs of G that are isostatic, that is, that are minimal sets of edges forming subgraphs that are rigid in general position in d-dimensional space.

Everything there is to be known about 2-isostatic graphs has been known for decades, but 3-isostatic graphs have no known combinatorial characterization.

We endeavor to shed some light on this subject by investigating simplicial maps from graphs to the simplex K4. The existence of a single such map that is shellable (in the sense that vertices mapped to the same vertex of K4 can be gradually separated) suffices to establish that a graph is isostatic. The converse problem involves a detailed analysis of obstacles to shellability.

Binary matroid minors

Jim Geelen
University of Waterloo
jfgeelen@uwaterloo.ca
Coauthors: Bert Gerards and Geoff Whittle

I will discuss recent progress towards extending the graph minors project of Neil Robertson and Paul Seymour to the binary matroids.

Some Links Between Combinatorial Optimization Properties of Clutters and Algebraic Properties of Monomial Ideals

Isidoro Gitler
CINVESTAV-IPN Mexico
igitler@math.cinvestav.mx
Coauthors: Enrique Reyes and Rafael Villarreal

Some combinatorial properties of clutters, such as the max-flow min-cut property or the packing property, will be expressed in terms of algebraic properties of square-free monomial ideals. We present some new families of Mengerian hypergraphs, some algebraic criteria for perfect graphs and a general setup for some combinatorial problems in the relatively new field of combinatorial commutative algebra.

Automorphisms of matroids associated with root systems

Gary Gordon
Lafayette College
gordong@lafayette.edu

Given a collection of vectors in Euclidean space, we consider the associated matroid, represented over the reals. We compute the automorphism group of this matroid for two collections of vectors: the root systems associated to the icosahedron and the F4 lattice. We give geometric interpretations to the matroid automorphisms, comparing the automorphism group of the matroids (combinatorial symmetry) to the Coxeter groups (geometric symmetry).

Chain-type and splitter-type theorems for cocircuits and hyperplanes in 3-connected matroids

Rhiannon Hall
Brunel University
rhiannon.hall@brunel.ac.uk
Coauthors: Dillon Mayhew

There has been much interest for many years in the ability to remove elements from 3-connected matroids and remain (almost) 3-connected. Theorems of this nature are generally known as "chain-type" theorems. Theorems in which you remove elements while remaining (almost) 3-connected and retaining a specific minor, are known as "splitter-type" theorems. I will discuss a chain-type theorem where we wish to contract elements from a specific hyperplane, and I will discuss a splitter-type theorem where we wish to contract elements from a specific cocircuit.

Finding Branch-decompositions and Rank-decompositions

Petr Hlineny
TU Ostrava and Masaryk University Brno, Czech Republic
hlineny@fi.muni.cz
Coauthors: Sang-Il Oum

We present a new algorithm that can output the rank-decomposition of width at most k of a graph if such exists. For that we use an algorithm that, for an input matroid represented over a fixed finite field, outputs its branch-decomposition of width at most k if such exists. This algorithm works also for partitioned matroids. Both these algorithms are fixed-parameter tractable, that is, they run in time $O(n^3)$ for each fixed value of k where n is the number of vertices/elements of the input.

A basis exchange property for matroids

Peter Humphries
University of Canterbury
pjh96@student.canterbury.ac.nz
Coauthors: Jim Geelen

Rota conjectured that the set of elements from n disjoint bases of a rank-n matroid M can be repartitioned into n transversal sets that are also bases of M. We present a stronger result for the class of paving matroids, and explain why the techniques used in the proof fail when trying to prove the conjecture directly.

The Tutte polynomial turned upside down

Joseph P Kung
University of North Texas
kung@unt.edu

This talk is about possible new directions for research on the Tutte polynomial. The talk will begin with a generalization of flows and tensions for graphs to matroids represented over partial fields. We will show how results of Goodall and Matiaseyich can be extended in an elementary way to such matroids. We will also discuss whether it is possible to count flows over the dyadic partial field (which is not finite, but "profinite"). We will end by discussing the question of defining an "upside-down" Tutte polynomial based on a natural recursion for the Eulerian function of a matroid.

Minimal non-bipartite join covered graphs

Charles Little
Massey University
c.little@massey.ac.nz
Coauthors: Marcelo de Carvalho

A weight function on a graph G assigns a weight of 1 or -1 to each edge of G. It is said to be conservative if the sum of the weights around any circuit is non-negative. A pair (G, w) is called a conservative graph if G is a graph with a conservative weight function w. A conservative graph is defined to be join covered if for every edge e there is a circuit through e around which the sum of the weights is 0. Join covered graphs are a natural generalisation of matching covered graphs. We characterise minimal non-bipartite join covered graphs.

The excluded minors for the class of matroids that are either binary or ternary

Dillon Mayhew
Victoria University of Wellington
dillon.mayhew@mcs.vuw.ac.nz
Coauthors: Bogdan Oporowski, James Oxley, Geoff Whittle.

The excluded-minor characterisations for matroids that are representable over $GF(2)$ and $GF(3)$ respectively are classic results in matroid theory. The first of these characterisations is due to Tutte, and the second was proved independently by Reid, Bixby, and Seymour. There is a single excluded minor for the class of matroids representable over $GF(2)$, and four for the class of matroids representable over $GF(3)$.

The union of these two classes of matroids is minor-closed, and it is natural to ask for an excluded-minor characterisation of this family. In this talk we present such a characterisation. There are exactly eight excluded minors for the class of matroids that are representable over $GF(2)$ or $GF(3)$.

The proof relies upon Truemper's structural results for his class of almost-regular matroids.

Binary matroids with no $K_{3,3}$ minor

Gordon Royle
University of Western Australia
gordon@csse.uwa.edu.au
Coauthors: Dillon Mayhew, Geoff Whittle

We have recently completed the classification of the internally 4–connected binary matroids with no $K_{3,3}$ minor. Rather than describe the proof of this result (which has been reported previously), this talk will focus on its consequences by considering a number of questions about this class of matroids that can now be answered with the help of the classification.

These results include classifying the largest simple binary matroids in this class, determining the critical exponent of the matroids in this class and the existence of a polynomial time recognition algorithm for matroids in this class. If time permits, I will speculate on the analogous questions for the class of binary matroids excluding K_5 for which we do not (yet) have a suitable classification theorem to use.

Forcing a $K_{2,t}$ minor

Paul Seymour
Princeton University
pds@math.princeton.edu
Coauthors: Maria Chudnovsky, Bruce Reed

Let $t \geq 2$ be an integer, and G be a simple graph with $n \geq t+2$ vertices, with no $K_{2,t}$ minor. What is the maximum number of edges G can have? It is known from general results of Mader that this function is asymptotically linear in n (for fixed t). At the time of writing we seem to be close to a proof that in fact G can have at most $(t+1)(n-1)/2$ edges, which would be best possible for infinitely many values of n. We report progress on this conjecture and related questions.

New Trends in Spectral Analysis and PDE

Control and inverse problems for partial differential equations on graphs

Sergei Avdonin
University of Alaska Fairbanks
ffsaa@uaf.edu

Differential equations on graphs are used to describe many physical processes such as mechanical vibrations of multi-linked flexible structures usually composed of flexible beams or strings, propagation of electro-magnetic waves in networks of optical fibers, heat flow in multi-link networks, and also electron flow in quantum mechanical circuits. In this talk we discuss some known and new controllability results for partial differential equations on graphs and their relations to boundary inverse problems.

Stochastic wave equation driven by a fractional Brownian motion

Boris P Belinskiy
University of Tennessee at Chattanooga
Boris-Belinskiy@utc.edu
Coauthors: Peter Caithamer (Indiana University Northwest)

We consider a linear stochastic wave equation driven by fractional-in-time noise. We prove the existence and uniqueness of the weak solution. We also study the expected energy associated with wave equation and improve our previous results on that matter. Specifically, we find the iff condition of the convergence of the series representing the expected energy. We discuss the smoothness of the solution. We consider both cases $H > \frac{1}{2}$ and $H < \frac{1}{2}$ for the Hurst parameter.

Quasi-stationary solitons for Langmuir waves in plasmas

Anjan Biswas
Delaware State University
biswas.anjan@gmail.com

The multiple-scale perturbation analysis is used to study the perturbed nonlinear Schrödinger's equation, that describes the Langmuir waves in plasmas. The perturbation terms include the non-local term due to nonlinear Landau damping. The WKB-type ansatz is used to define the phase of the soliton that captures the corrections to the pulse where the standard soliton perturbation theory fails.

The equivariant index theorem for Dirac operators

Jochen Brüning
Department of Mathematics, Humboldt-Universität Berlin
bruening@mathematik.hu-berlin.de
Coauthors: Franz Kamber, Ken Richardson

We consider a Dirac operator, D, on the sections of a hermitian vector bundle over a compact manifold M which is odd with respect to a given supersymmetry and equivariant with respect to the action of a compact Lie group G. Fixing a unitary representation, ρ, of G we derive an index formula for the restriction of D to the sections transforming like ρ. This formula is local on the strata of M naturally defined by the G-action and also involves η-invariants of the links. It generalizes previous work of Atiyah, for tori, and of Kawasaki, for orbifolds; it extends to transversally elliptic first order differential operators with only small changes.

Cable Formation for Finite-Gap Solutions of the Vortex Filament Flow

Annalisa Calini
College of Charleston
calinia@cofc.edu
Coauthors: Thomas Ivey (College of Charleston)

The simplest model of self-induced dynamics of a vortex filament in an ideal fluid leads to an integrable nonlinear evolution equation closely related to the cubic focussing nonlinear Schrödinger equation. Closed finite-gap solutions of the vortex filament flow provide examples of evolving curves whose topological features can be related to their algebro-geometric description. We describe how the theory of isoperiodic deformations (developed by Grinevich and Schmidt, after Krichever) can be used to generate a family of closed finite-gap solutions of increasingly higher genus close to a multiply covered circle. Each step of the deformation process corresponds to constructing a cable on the previous filament, whose knot type is determined from the deformation scheme, and is invariant under the time evolution.

Inequalities of Hardy–Sobolev and Hardy–Gagliardo–Nirenberg type

William Desmond Evans
Cardiff University, Wales
EvansWD@cardiff.ac.uk
Coauthors: A. Balinsky, D. Hundertmark, R. T. Lewis

The lecture will report on recent joint work with A. Balinsky, D. Hundertmark and R. T. Lewis on Sobolev and Gagliardo–Nirenberg inequalities in $\mathbb{R}^n$ which also relate to a modified Hardy-type inequality involving the operator $L := \mathbf{x} \cdot \nabla$. A pseudo-Poincaré inequality with respect to the operator semigroup $\{e^{-tL^*L}\}_{t>0}$ has a central role in the proof, the approach being reminiscent of that of M. Ledoux in establishing an improved Sobolev inequality which highlights a connection between Sobolev embeddings and heat kernel bounds.

Semi-analytic spectral methods

Colin Fox
University of Otago
fox@physics.otago.ac.nz
Coauthors: Hyuck Chung (Auckland University)

Analytic techniques allow explicit solution of wave propagation and scattering in simple geometries, or for composite geometries typically limited to asymptotic regimes of 'large' or 'small' lengths. These solutions provide scaling laws that aid engineering and design, and explicit formulas for the inverse problem. Semi-analytic methods provide these tools in complex composite geometries by augmenting analytic spectral methods with numerical calculations that a computer can perform essentially exactly. We examine these methods in the setting of ocean wave scattering. There, removal of exponentials allows exact evaluation of solutions, while application of Liouville's theorem reduces the Dirichlet-to-Neumann map to an operator between low-dimensional spaces. Scattering in composite structures is then easily characterized. These methods are applied to determining low-frequency sound transmission through lightweight timber-framed construction, which is typical in New Zealand. Those solutions agree closely with measurements, and were recently used in the design of a timber floor with excellent sound insulation properties.

Absolutely Continuous Spectrum for the Anderson Model on More General Trees

Florina Halasan
University of British Columbia
halasan@math.ubc.ca

We study the Anderson Model on trees that have a variation in their coordination number. Using geometric tools, we prove that the Anderson Hamiltonian has absolutely continuous spectrum for small disorder.

Quasi-intersections of Isoenergetic Surfaces: Description in Terms of Determinants.

Yulia Karpeshina
University of Alabama at Birmingham
karpeshina@gmail.com

When the Laplacian is perturbed by a periodic potential, self-intersections of isoenergetic surfaces get transformed into quasi-intersections. We define quasi-intersections in terms of determinants and use Rouche's Theorem to establish results on stability of quasi-intersections.

On unitary conformal holonomy

Felipe Leitner
University of Stuttgart/University of Auckland
leitner@mathematik.uni-stuttgart.de

To any space with conformal structure there is an invariant notion of holonomy which is defined via the canonical Cartan connection. I will discuss in my talk CR-spaces and their Fefferman construction from the view point of conformal holonomy. This is the case of unitary conformal holonomy. The conformal Einstein condition can also be characterised in terms of holonomy. This will allow me to present a construction and characterisation result about transversally symmetric pseudo-Einstein and Fefferman Einstein spaces.

Optical tomography in media with varying index of refraction.

Stephen McDowall
Western Washington University
stephen.mcdowall@wwu.edu

Optical tomography refers to the use of near-infrared light to determine the optical absorption and scattering properties of a medium. In the stationary Euclidean setting the dynamics are modeled by the radiative transport equation, which assumes that in the absence of interaction particles follow straight lines. Here we shall study the problem in the presence of a (simple) Riemannian metric where particles follow the geodesic flow of the metric. This non-Euclidean geometry models a medium which has a continuously varying refractive index. We will present results for all dimensions, in the case of full angular-dependent measurements and in the case where the information available at the boundary is averaged over angle. We show that knowledge of the albedo operator, that which maps incoming flux to outgoing flux at the boundary, uniquely determines the absorption and scattering properties of the medium. In dimensions three and higher we assume prior knowledge of the metric while in dimension two it can be shown that the albedo operator also determines the metric. When the measurements are averaged over angle, we are able to determine the absorption, and spatial dependence of the scattering assuming *a priori* knowledge of its angular dependence.

An ill-posed problem in scattering theory

Boris Pavlov
The University of Auckland
pavlov@math.auckland.ac.nz
Coauthors: J. Bruning

Scattered waves in the scattering problem for Helmholtz resonator are obtained via breeding of the standing waves in the inner domain and plain running waves in the outer domain. Breeding them with a help of an appropriate Dirichlet-to-Neumann map requires solution of an ill-posed problem with compact integral operators on the common boundary of the inner and outer domain. We suggest a regularization method for this ill-posed problem.

Spectral properties of a magnetic quantum Hamiltonian on a strip
Georgi Raikov
Pontificia Universdidad Catolica de Chile
graikov@mat.puc.cl
Coauthors: Philippe Briet, Eric Soccorsi (CPT, Marseilles, France)

I will consider a 2D Schrödinger operator H_0 with constant magnetic field, on a strip of finite width. The spectrum of H_0 is absolutely continuous, and contains a discrete set of thresholds. I will discuss the spectral properties of the perturbed operator $H = H_0 + V$ where V is an electric potential which decays in a suitable sense at infinity. First, as a corollary of an appropriate Mourre estimate, I will show that the singular continuous spectrum of H is empty, and any compact subset of the complement of the threshold set may contain at most a finite set of eigenvalues of H, each of them having a finite multiplicity. Next, I will consider the Krein spectral shift function (SSF) for the operator pair (H, H_0), which is bounded on any compact subset of the complement of the threshold set, and is continuous away from the threshold set and the eigenvalues of H. The main result of the talk concerns the asymptotic behaviour of the SSF at the thresholds, which is described in terms of the SSF for a pair of effective Hamiltonians.
The financial support of the Chilean Science Foundation *Fondecyt* under Grant 1050716 is gratefully acknowledged.

Bubbles tend to the boundary
Gunter Stolz
University of Alabama at Birmingham
stolz@math.uab.edu
Coauthors: Jeff Baker, Michael Loss

How should a given compactly supported potential be placed into a bounded domain so as to minimize or maximize the first Neumann eigenvalue of the Schrödinger operator on this domain? We answer this question for rectangular domains and reflection symmetric potentials. As an application we determine the spectral minimum of the so-called random displacement model of an electron in a deformed lattice.

Spectral properties of non-local eigenvalue problems
Graeme Wake
Massey University
g.c.wake@massey.ac.nz
Coauthors: Ronald Begg (Massey and Canterbury Universities)

In the course of developing generic models of the evolution of cell cohorts, simultaneously undergoing growth and fission, which are structured by size (usually taken as DNA content), we have encountered an unusual class of functional differential equations. The solution of these functional partial differential equations possess the behaviour described as a “steady-size distribution (SSD)”, where the size distribution is constant in shape but not magnitude, as time evolves. The solutions are candidates for probability distributions, scaled by a time-factor, whose Lyapunov exponent satifies a non-local singular Sturm–Liouville eigenvalue problem (NLSSLEVP). The SSD-like behaviour is usually globally-attracting, but this is established only for some special cases. This paper will outline some interesting properties of these and some similar problems. The support of the NZ Institute of Mathematics and its Applications by the award of a Maclaurin Fellowship for the current part of this work is gratefully acknowledged.

The Mathematics of Imaging in Magnetic Resonance Elastography

David Wall
University of Canterbury
david.wall@canterbury.ac.nz
Coauthors: Peter Olsson (Jönköping University)

Early and accurate detection of tumours in the female breast is of clinical importance. Use of a combination of low frequency acoustic waves excitation and magnetic resonance imaging (MRI) of the displacement field within the tissue is thought to result in better image reconstruction of the tumour than from standard scattering measurements. Breast cancer tumours are about ten times stiffer than normal tissue.

This elastography imaging problem is an inverse problem. The nature of an inverse problem is that it is ill-conditioned. We consider properties of the mathematical map which describes how the elastic properties of the tissue being reconstructed vary with the field measured by MRI. This map is a nonlinear mapping and our interest is in proving certain conditioning and regularity results for this operator which occurs naturally in this problem of imaging in elastography. In this treatment we consider the tissue to be linearly elastic, anisotropic and spatially heterogeneous. The emphasize on anisotropy in this problem should provide better contrast of the tumour to the background tissue.

Quantum Topology

Continuation of plenary talk: Manifold pairings.
Michael Freedman
Microsoft Research
michaelf@microsoft.com

I'll go into more mathematical detail on the 'manifold pairings' theorem discussed in the plenary talk.

Foliations and non-metrisable manifolds
David Gauld
University of Auckland
d.gauld@auckland.ac.nz
Coauthors: Mathieu Baillif, Alexander Gabard, Paul Gartside and Sina Greenwood

Declare a topological space to be a manifold provided that it is connected and locally Euclidean. Manifolds can be non-metrisable for the simple reason that they are not Hausdorff or because they are too big. Non-Hausdorff 1-manifolds are important in foliation theory because the leaf space of a foliation of the open disc in the plane is such a manifold. I shall describe a 1-manifold which is rigid in the sense that the only homeomorphism of it is the identity. This manifold gives rise to a foliation of the disc such that any leaf-respecting homeomorphism sends each leaf to itself. Hausdorff manifolds that are too big to be metrisable are also interesting when it comes to foliations. For example there is a surface which carries no co-dimension 1 foliation; there is a 3-manifold with a co-dimension 1 foliation having only one leaf which necessarily is not metrisable. This last situation cannot occur in the metrisable case, nor in the non-metrisable case if the leaves are of dimension 1; in either case there are always continuum many leaves.

Covering spaces and the Kontsevich integral.
Andrew Kricker
Nanyang Technological University
ajkricker@ntu.edu.sg

Despite some remarkable insights in recent years, the question of how the quantum topology of knots and three-manifolds relates to their geometric topology remains, to a large extent, a fairly mysterious thing. Covering spaces are a setting in which this relationship can be productively explored. In this talk I'll describe some strong results about how quantum topology sees cyclic covers of knot complements (joint work with Stavros Garoufalidis), and also some preliminary results regarding another important class of covering spaces—the dihedral covers (joint work with Daniel Moskovitch).

Lasagna composition of Khovanov link homologies, and a 4-d skein module.

Scott Morrison
Microsoft Station Q
scott@tqft.net
Coauthors: Kevin Walker

I'll describe a family of operations on the Khovanov homologies of links in S^3, called 'lasagna composition'. These are higher dimensional analogues of the operations in a planar algebra, or tensor category with duals. (In fact, you can think of this result as describing a braid tensor 2-category.) With these operations, we can define an invariant of a pair $(W^4, L \subset \partial W)$ (a link in the boundary of a 4-manifold), which recovers Khovanov's construction for $(B^4, L \subset S^3)$.

The Ribbon Half-Twist

Noah Snyder
University of California, Berkeley
nsnyder@math.berkeley.edu
Coauthors: Peter Tingley

The theory of ribbon categories has an annoying defect, namely that you can only talk about a full 360-degree ribbon twist, but not a 180-degree half-twist. Building on recent work of Kamnitzer and Tingley, I'll explain how to interpret a half-twist. In particular, there is a beautiful picture which gives a formula for the braiding in terms of the half-twist.

Generalised knot groups

Christopher Tuffley
Massey University
c.tuffley@massey.ac.nz

Wada and Kelly independently introduced a family of knot invariants $G_n(K)$ that generalise the fundamental group of a knot. The group $G_1(K)$ is the fundamental group, and $G_n(K)$ is obtained by adjoining an nth root of the meridian that commutes with the longitude. I'll show that the isomorphism type of $G_n(K)$, $n \geq 2$, is a strictly stronger invariant of K than the isomorphism type of the fundamental group, by showing that the generalised knot groups of the square and granny knots are non-isomorphic for each $n \geq 2$.

The Cyclotomic Birman–Murakami–Wenzl Algebras

Shona Yu
University of Sydney
shonayu@maths.usyd.edu.au
Coauthors: Stewart Wilcox

The Birman–Murakami–Wenzl (BMW) algebras are closely tied with the Artin braid group of type A, the Iwahori-Hecke algebras of type A (the symmetric group), the Brauer algebras and even quantum groups. Its algebraic definition was originally motivated by the Kauffman link invariant and, geometrically, it is isomorphic to the Kauffman tangle algebra. The representations and the cellularity of the BMW algebra have now been extensively studied in the literature.

Motivated by type B knot theory and the Ariki-Koike algebras (aka cyclotomic Hecke algebras of type $G(r, 1, n)$), Häring–Oldenburg defined the cyclotomic BMW algebras. In this talk, we present results regarding the structure of these algebras and give a geometric realization of the cyclotomic BMW algebras (in terms of "cylindrical" tangles). It turns out these algebras are also cellular, thereby allowing us to deduce information about its representations using Graham and Lehrer's general theory of cellular algebras.

Special Functions and Orthogonal Polynomials

The first addition formula and some of what came later

Richard Askey
University of Wisconsin
askey@math.wisc.edu

The addition formulas for sine and cosine come from Ptolemy's theorem. Several proofs of Ptolemy's theorem will be given, including Euler's refinement of it and a 19th century extension will be given.

Multiple Hermite polynomials and some applications

Walter Van Assche
Katholieke Universiteit Leuven, Belgium
walter@wis.kuleuven.be

Hermite polynomials are well known orthogonal polynomials with respect to the Gaussian weight $w(x) = e^{-x^2}$ on the real line. We consider multiple Hermite polynomials $H_{\vec{n}}$ which are polynomials of degree $|\vec{n}| = n_1 + n_2 + \ldots + n_r$, for which

$$\int H_{\vec{n}}(x) x^k e^{-x^2+c_j x}\, dx = 0, \qquad k = 0, 1, 2, \ldots, n_j - 1$$

for $j = 1, \ldots, r$, where $c_1, c_2, \ldots, c_r$ are distinct real numbers. Hence multiple Hermite polynomials satisfy orthogonality conditions with respect to r Gaussian weights $w_j(x) = e^{-x^2+c_j x}$, $1 \leq j \leq r$, with mean $c_j/2$. These polynomials are indexed with a multi-index $\vec{n} = (n_1, \ldots, n_r)$ but they are polynomials of one variable. We will show that these polynomials have nice differentiation properties which allow to lower or raise the multi-index. These give rise to a Rodrigues formula and a differential equation of order $r + 1$. The polynomials also satisfy a system of recurrence relations which connect the polynomial $xH_{\vec{n}}$ to its nearest neighbours in the lattice $\mathbb{N}^r$. A Riemann–Hilbert problem can be found that characterizes the multiple Hermite polynomials and this can be used to find the properties mentioned higher, but also allows asymptotic analysis as the multi-index becomes large.

These multiple Hermite polynomials appear in a natural way when analysing random matrices with an external source and also in the analysis of non-interesecting Brownian motions. Both applications will be explained.

High-Precision Values of the Gamma Function of real argument

Ross Barnett
University of Waikato
arbus@math.waikato.ac.nz
Coauthors: J A Youngman

A method is described to calculate values of $\Gamma(\nu)$, $0 \leq \nu \leq 1$ to arbitrary precision by combining a Bessel function with a ${}_0F_1$ function. Steed's algorithm is used to compute the regular Bessel function $J_\nu(x)$, for a suitable argument x and real ν, to arbitrary accuracy. Hence the gamma function is obtained. Example values are given to 200D. Verification is by the 80D-results of Fransén and Wrigge, by the use of the duplication formula, and by computing the closed-form results of Borwein and Zucker.

A caveat is offered concerning the coding of the Bessel functions in Numerical Recipes and in the GSL library.

Modified Bessel functions in Ramanujan's lost notebook

Bruce C Berndt
University of Illinois at Urbana-Champaign
berndt@math.uiuc.edu

In his lost notebook, Ramanujan records several entries involving modified Bessel functions, although he does not use the standard definitions or notation for them. First, he states Koshliakov's formula, first published by N. S. Koshliakov in 1929. Second, he records Guinand's formula, first published by A. P. Guinand in 1955. Third, he offers a formula established by K. Soni in 1966. Fourth, he states three new formulas involving modified Bessel functions. However, most of the presentation will be devoted to a formula involving a double series of Bessel functions that the author cannot prove, but it is unclear if Ramanujan's claim is correct. If correct, the result is intimately related to the famous Dirichlet divisor problem.

The vanishing of the integral of the Hurwitz zeta function

Kevin A Broughan
University of Waikato
kab@waikato.ac.nz

The Hurwitz zeta function $\zeta(s, a)$ unifies the Riemann zeta function, used in the proof of the prime number theorem, and Dirichlet L-functions, used to show the infinitude of primes in arithmetic progressions, and can be used to derive their functional equations. In this talk I will show that the Riemann integral over the parameter range $a \in (0, 1]$, whenever it exists, vanishes.

Congruences for Andrews–Paule's broken 2–diamond partition function.

Song Heng Chan
Nayang Technological University
chansh@ntu.edu.sg

In the latest of a series of papers on combinatorial investigations using a computer algebra package Omega, G. E. Andrews and P. Paule studied plane partitions of "hexagonal shape" and introduced broken k-diamond partitions as generalizations of the plane partitions. In this talk, we first give a brief introduction of the plane partitions leading up to the broken k-diamond partitions.

Next we sketch proofs of two conjectures of Andrews and Paule on congruences of broken 2-diamond partitions.

On the Nevanlinna Order of Lommel Functions and Subnormal Solutions of Certain Complex Differential Equations

Edmund Y M Chiang
Hong Kong University of Science and Technology
machiang@ust.hk
Coauthors: Kit-Wing Yu

In an earlier joint work with M. Ismail [Canadian J. Math. **58** (2006), 257-287] we investigated a class of homogeneous ordinary differential equations in the complex plane with Morse potential that can admit entire solutions with "small" Nevanlinna order of zeros in $\mathbb{C}$ if and only if it can be solved in terms of Bessel polynomials. We continue our study into a class of non-homogeneous ordinary differential equations in the complex plane and show it can admit "sub-normal solution" if and only if the solution can be written in terms of a composition of degenerated forms of Lommel or Struve functions and exponential function. New indentities and properties of the Lommel and the Struve functions are established.

Abel's Lemma on Summation by Parts and Theta Hypergeometric Series

Wenchang Chu
Lecce University
chu.wenchang@unile.it
Coauthors: Cangzhi Jia

The modified Abel lemma on summation by parts is systematically employed to review most of the identities of theta hypergeometric series.

Fourier Expansions of the Fundamental Solution for Powers of the Laplacian in $\mathbb{R}^n$

Howard S Cohl
University of Auckland
h.cohl@math.auckland.ac.nz
Coauthors: Tom ter Elst

In this talk I will show how one can compute closed form algebraic expressions for the fundamental solution of the polyharmonic equation, i.e. for powers of the Laplacian, in $\mathbb{R}^n$. These algebraic expressions can be used to compute Fourier expansions for the fundamental solutions of these operators by using well-known expansion formulae. I will show how the fundamental solutions for the polyharmonic equation naturally breaks up into two different classes in a finite set of separable hyper-spherical and hyper-cylindrical coordinate systems, i.e. those of even and odd dimensions. In odd dimensions I show how the coefficients for the expansions are given in terms of associated Legendre functions (toroidal harmonics) and in even dimensions I show how the coefficients can be given in terms of an interesting set of polynomials.

Asymptotic analysis of the Bell polynomials by the ray method

Diego Dominici
SUNY, New Paltz
dominicd@newpaltz.edu

We analyze the Bell polynomials $B_n(x)$ asymptotically as as $n \to \infty$. We obtain asymptotic approximations from the differential-difference equation which they satisfy, using a discrete version of the ray method. We give numerical examples showing the accuracy of our formulas.

Does diffusion determine the drum?

Tom ter Elst
University of Auckland
terelst@math.auckland.ac.nz
Coauthors: W. Arendt, M. Biegert (Ulm)

The question of Kac is whether one can hear the shape of a drum. Or more precisely, whether all eigen frequencies of a drum determine the drum. In general the answer to the latter question is negative. The eigen frequencies are equal if and only if there exists a unitary operator which intertwines the corresponding Laplacians. In this talk we discuss what happens if the unitary operator is replaced by an order isomophism, *ie* if it maps positive functions to positive functions. Or equivalently, if the diffusion processes on the two drums are equal.

Some conjectures of Melham concerning representations by figurate numbers

Michael Hirschhorn
University of New South Wales
m.hirschhorn@unsw.edu.au

I will report on progress with proving a large number of conjectures recently published by Ray Melham concerning representations of a number as various combinations of figurate numbers.

Addition Theorems Via Continued Fractions

Mourad H Ismail
University of Central Florida, Orlando
ismail@math.ucf.edu
Coauthors: Jiang Zeng (Université de Lyon)

We show connections between a special type of addition formulas and a theorem of Stieltjes and Rogers. We use different techniques to derive the desirable addition formulas. We apply our approach to derive special addition theorems for Bessel functions and confluent hypergeometric functions. We also derive several additions theorems for basic hypergeometric functions. Applications to the evaluation of Hankel determinants are also given.

Orthogonal polynomials and associated algebras

Ernie Kalnins
University of Waikato
math0236@waikato.ac.nz
Coauthors: Willard Miller, Jonathan Kress

In this talk we cover the the properties of the classical orthogonal polynomials. In particular we emphasize those properties that are in common with the polynomials obtained by separation of variables in elliptic-type coordinates. There is then some discussion of the use of representation theory to derive special function identities. Finally some intriguing use of classical mechanics is given which enables the properties of well known orthogonal polynomials to be put in context.

The zeros of the complementary error function

Andrea Laforgia
Università di Roma 3
laforgia@mat.uniroma3.it
Coauthors: Arpad Elbert

We show that the complementary error function $\mathrm{erfc}(z)$ has no zeros when $\mathrm{Arg}\, z$ belongs to the interval $[3\pi/4, \pi]$

Sixteen Eisenstein Series

Heung Yeung Lam
Massey University
h.y.lam@massey.ac.nz
Coauthors: S Cooper (Massey University)

S. Ramanujan (1887–1920) gave fourteen families of series in his Second Notebook in Chapter 17, Entries 13–17. In each case he gave only the first few examples, giving us the motivation to find and prove a general formula for each family of series. In this talk, I will present a powerful tool (four versatile functions f0, f1, f2, and f3) to collect all of Ramanujan's example together.

Asymptotics for Gegenbauer–Sobolev and Hermite–Sobolev orthogonal polynomials associated with non-coherent pairs of measures

A. Sri Ranga
Universide Estadual Paulista, Campus de S.J. Rio Preto, Brazil
ranga@ibilce.unesp.br
Coauthors: Cleonice F. Bracciali and Eliana X.L. de Andrade

Inner products of the type $\langle p, q\rangle = \langle p, q\rangle\, s_0 + \langle p', q'\rangle\, s_1$, where one of the corresponding measures s_0 or s_1 is the measure associated with the Gegenbauer (Hermite) polynomials, are usually referred to as Gegenbauer–Sobolev (Hermite–Sobolev) inner products. This presentation deals with some asymptotic relations associated with the orthogonal polynomials with respect to a class of Gegenbauer–Sobolev (Hermite– Sobolev) inner products. The inner products are such that the associated pairs of symmetric measures (s_0, s_1) are not within the concept of symmetrically coherent pairs of measures, introduced by Iserles *et al* in 1991.

Macdonald polynomials in the light of basic hypergeometric series

Michael Schlosser
University of Vienna
michael.schlosser@univie.ac.at

We survey some (old and recent) results for Macdonald polynomials from a basic hypergeometric series point of view. This is helpful in the search for new identities involving Macdonald polynomials as they should correspond to known summation theorems for basic hypergeometric series.

Finite fields and (q,t)-binomials

Dennis Stanton
University of Minnesota
stanton@math.umn.edu
Coauthors: Vic Reiner

A (q, t)–binomial coefficient is defined, motivated by the invariant theory of the general linear group over a finite field. When either q (the finite field variable) or t (the Hilbert series variable) approaches 1, the result is the q–binomial coefficient. Several combinatorial interpretations, connections with Schur functions, and positivity results and conjectures will be discussed. Some inklings about generalized hypergeometric series will be proposed.

Permutable Polynomials and Rational Functions

Garry J Tee
University of Auckland
tee@math.auckland.ac.nz

Many infinite sequences of permutable rational functions and some infinite sequences of permutable polynomials are constructed, on the basis of elliptic functions and trigonometric functions. Many identities connect those permutable rational functions.

Representations of certain binary quadratic forms as Lambert series

Pee Choon Toh
National University of Singapore
mattpc@nus.edu.sg

Classical algebraic number theory allows us to write certain Lambert series as q-series associated to classes of binary quadratic forms. We will recall how this is done and then give an “inversion” process to represent some of these binary quadratic forms by Lambert series.

Tight frames of multivariate orthogonal polynomials

Shayne Waldron
University of Auckland
waldron@math.auckland.ac.nz

Frame decompositions are useful because they are technically similar to orthogonal expansions (they simply have more terms) and can be constructed to have desirable properties that may be impossible for an orthogonal basis, *eg* in the case of wavelets certain smoothness and small support properties.

Here we show that frames are of interest for spaces of multivariate orthogonal polynomials where the desirable properties are symmetries of the weight (which an orthogonal basis cannot express). We present a number of (hopefully compelling) examples of such tight frames including multivariate Jacobi polynomials on a simplex and the orthogonal polynomials for a radially symmetric weight.

The Mukhin–Varchenko conjecture

Ole Warnaar
University of Melbourne
O.Warnaar@ms.unimelb.edu.au

In their work on the Knizhnik–Zamolodchikov equations, Mukhin and Varchenko were led to conjecture the existence of a Selberg integral for all simple Lie algebras. In this talk I will present a generalisation of the Selberg integral, thus proving the Mukhin–Varchenko conjecture for Lie algebras of type A.

Spread Polynomials

N J Wildberger
University of New South Wales
n.wildberger@unsw.edu.au

Spread polynomials are a new family of orthogonal polynomials closely related to the Chebyshev polynomials, but with interesting number theoretical properties. They arise in universal geometry, a form of Euclidean geometry that holds over a general field, and the spread polynomials make sense in any field. We will describe remarkable factorization properties of these polynomials, connections with cyclotomy and applications to powers of rotations.

Semi-classical orthogonal polynomials and the Painlevé–Garnier systems

Nicholas Witte
University of Melbourne
nsw@ms.unimelb.edu.au

Semi-classical deformations of the classical orthogonal polynomials are generically monodromy preserving systems of linear ODEs with respect to the deformation variables and define an important class of solutions to the Painlevé and Garnier equations. A scheme proposed by Sakai in 2001 organises the

Painlevé equations, their discrete and q–difference analogs under a master elliptic Painlevé equation. It is possible to deform other orthogonal polynomials in the Askey scheme of hyper-geometric orthogonal polynomials in a semi-classical manner and derive the analogs of the Painlevé equations appearing in the Sakai scheme. The example of the Askey–Wilson system will be treated.

University Mathematics Education

Revisiting Felix Klein's "Elementary Mathematics from an Advanced Standpoint"

Bill Barton
University of Auckland
b.barton@auckland.ac.nz

A century ago, in 1908, Felix Klein's lectures on mathematics for secondary teachers were first published (in German). This comprehensive view of the field challenged both teachers and mathematicians to consider, from a perspective sensitive to both mathematical rigour and pedagogical practice, the relationship between mathematics as a school subject, and mathematics as a scientific discipline. The intervening 100 years have witnessed many changes in mathematics the crises in Foundations, the advent of computing, emergence of new fields, and resolutions of some major mathematical challenges. These, as well as changes in the economic environment, have provoked major change and challenges for school mathematics. While Klein's writing remains a valuable source insight, it seems timely to revisit this terrain by linking the topics and approaches of senior secondary or undergraduate mathematics with the field of mathematics. This is an important challenge for both mathematicians and mathematics educators.

This presentation will put up for discussion the idea of a writing project, possibly a joint project between IMU and ICMI, to revisit this work in a contemporary context.

Readiness for first-year mathematics studies: Management, placement and prognosis

Patricia Cretchley
University of Southern Queensland
cretchle@usq.edu.au

There is a growing need for more careful placement of students in first-year university mathematics studies in Australia, and perhaps elsewhere. Widening access to tertiary education brings us increasing numbers of students for whom school mathematics grades are not indicative of preparedness. And online enrolment distances them from early academic counseling. As a result, many enter under-prepared and soon find themselves in difficulty. University response is variable. Support strategies for those at risk have increased, but uptake is often disappointing. Voluntary self-diagnostic skills-testing on entry is a common stimulus, but has long been viewed as inadequate, alone. Mandatory skills-testing is routinely practiced in some universities, and on the increase. But typical entry-skills tests have proved poor predictors of success in one-semester studies. And academics report limited success with at-risk students, many needing more time than a semester allows. In this talk, I offer findings from recent studies, raise for discussion our moral, academic and ethical responsibilities towards such students, emphasise the need for entry testing to reach higher levels of prognosis of readiness for mathematics studies, and propose strategies for doing so. In particular, I turn the spotlight on dynamic testing ("teach and test") and attitude testing. And I present findings on data on students' self-assessment of their ability to learn mathematics.

Teaching proofs in mathematics

David Easdown
University of Sydney
de@maths.usyd.edu.au

One of the most difficult learning thresholds for students of mathematics is the concept of proof. The difficulty manifests itself in several ways: (1) appreciating why proofs are important; (2) the tension between verification and understanding; (3) proof construction. Students entering university are often very adept at performing sophisticated algorithms and calculations. However they tend to have very little experience with mathematical proofs even though these are central to verifying mathematical facts and building a corpus of reliable knowledge. For many, proof technique is an exceedingly difficult hurdle to overcome and has all of the hallmarks of a threshold concept, in the sense of Meyer and Land (2003, 2005). The ability to understand and construct proofs is transformative, both in perceiving old ideas and making new and exciting mathematical discoveries. The most inspiring mathematical proofs are integrative and almost always expose some hidden counter-intuitive interrelations. And of course they are troublesome: it can take a long time, even years, for students to learn to appreciate proofs and to develop sufficient technique to write their own proofs with confidence. However when the moment comes, the eureka effect can be irreversible and students are well on the way to becoming maths 'addicts'. This talk will introduce some ideas and issues surrounding teaching proofs and introducing proof technique in the classroom.

References:

Meyer, J.H.F. and and Land, R. (2003) Threshold concepts and troublesome knowledge: linkages to ways of thinking and practising within the discipline. In Rust, C. (ed.) Improving Student Learning: Improving Student Learning Theory and Practice Ten Years On. Oxford: Oxford Centre for Staff and Learning Development.

Meyer, J.H.F. and and Land, R. (2005) Threshold concepts and troublesome knowledge (2): epistemological considerations and a conceptual framework for teaching and learning. Higher Education **49** 373–388.

Where have all the mathematicians gone?

Derek Holton
University of Otago
dholton@maths.otago.ac.nz

There is a feeling that the numbers of maths majors being graduated in the world is diminishing. I was asked to chair a Survey Team for the maths education conference ICME 11 to look into this. I will cover in my talk, the ways that we are going about collecting data and what we are finding. It turns out that nothing is clear. For instance a country may find that its numbers are decreasing but individual university maths departments are booming. We look into these cases and try to make some suggestions that might be useful for all maths departments.

Discussion will be more than welcome.

From lessons to lectures: NCEA mathematics and first year performance

Alex James
University of Canterbury
a.james@math.canterbury.ac.nz
Coauthors: Clemency Montelle, Phillipa Williams

In 2005, students entered the University of Canterbury with the new NCEA school qualifications for the first time. We analyse the relationship between NCEA Level 3 Mathematics with Calculus qualifications of incoming students and their results in the core first-year mathematics papers at Canterbury. These findings are used to investigate the suitability of this new qualification as a preparation for tertiary mathematics and to revise and update entrance recommendations for students wishing to succeed in their first-year mathematics study.

Interactive visualization in advanced university mathematics

Matthias Kawski
Arizona State University
kawski@asu.edu

Interactive visualization tools have become routine equipment to facilitate inquiry based learning in secondary and entry-level university mathematics courses. Such tools allow the learner to actively participate in the discovery process, develop ownership, and, we argue, they can help build deep conceptual roots.

Using the Vector Field Analyzer II (VFA II), a powerful free JAVA applet, we demonstrate how such tools and approach can readily be adpated to even proof-oriented advanced undergraduate and graduate classes. Even more critical at this level is the ability to perform experiments with virtual zero start up-costs.

The VFA II was originally designed for visualizing the curl and divergence, the integral theorems of vector calculus, and to integrate vector calculus with the first course on differential equations. We will report on successfully using this tool in complex analysis and graduate level differential equations courses for topics such as Poincare-Bendixson theory, omega-limit sets, variational equations, and the stable manifold theorem.

Secondary Mathematics from an Advanced Standpoint

William McCallum
University of Arizona
wmc@math.arizona.edu

The courses in the mathematics major are often oriented towards graduate school. Prospective high school teachers need courses that are oriented towards the mathematics they will teach. High school algebra, often seen as a mechanical subject, provides rich opportunities for reasoning and interpretation. Simple problems in high school geometry can be connected to advanced research in algebraic geometry. In this talk we will consider ways in which advanced topics in mathematics can provide a deeper understanding of high school mathematics,

and make recommendations for a university curriculum for prospective high school teachers.

Three Attributes of Tertiary-level Mathematical Education to One's Society and its Advancement of Science

G. Arthur Mihram
Princeton, NJ
`dmihram@usc.edu`
Coauthors: Danielle Mihram (University of Southern California)

Tertiary-level mathematical education is as valuable for its context as for its content: It provides future citizens/leaders with mental discipline, and provides future citizens/scientists with training in the mental tool basic to the advancement of science. First, the ancient Greeks recognised that training in mathematics provides leaders with minds more likely to be more disciplined for sorting issues political, for striving for impeccably logical conclusions. Second, science (and scientific politics) is/are to search for the very explanation for (i.e., for the truth about) any particular naturally occurring phenomenon. Our mathematics is itself a language, not a science; yet, it is a, but not the only, language that a scientist might use for his/her explanation/model (e.g., C Darwin or Nobel Laureate K Lorenz). Thirdly, any advancement of human knowledge is a result of an analogy made with some knowledge which we [Mankind] had established earlier: Polya remind us that our mathematics is well-suited to educate students (future leaders/scientists) in the use of analogy-making, as per the challenge to prove a conjecture in geometry class.

Online learning resources for engineering students: Do they work?

Mark Nelson
University of Wollongong
`mnelson@uow.edu.au`
Coauthors: Anne Porter, Elahe Aminifar, Richard Caladine

The basic mathematical abilities of first-year engineering students have been in steady decline over many years. To counter this electronic learning resources have been developed for a first-year service course. These learning resources consist of mathematical problems with worked solutions. The worked solutions are available either in a static format, or as a video in which a solver goes through the problem explaining their reasoning.

We compare the performance of students taking the course in 2007, when these resources were available, to those taking the course in 2004, when resources were not available. In week one of the course students take a basic skills test. Analysis of this test shows that the two cohorts had equivalent base-line skills. A comparison of the performance of the students in 2004 and 2007 shows that the new learning resources improved students outcomes over virtually all assessment tasks.

A Flexible, Extensible Online Testing System for Mathematics

Tim Passmore
University of Southern Queensland
passmore@usq.edu.au
Coauthors: Leigh Brookshaw and Harry Butler

An online testing system developed for entry-skills testing of first-year university students in algebra and calculus is described. The system combines the open-source computer algebra system MAXIMA with PHP scripts and XML configuration files to parse student answers, which are entered using standard mathematical notation and conventions. The answers can involve data structures like lists, variable-precision-floating-point or integer numbers and algebra, which allows more sophisticated testing designs than the multiple-choice, or exact-match, paradigms common in other systems. Experience using the system and ideas for further development are discussed.

Water-Wave Scattering Focusing on Wave–Ice Interactions

Wave scattering by a periodic line array of axisymmetric ice floes

Luke Bennetts
University of Otago
lbennetts@maths.otago.ac.nz
Coauthors: Vernon Squire

The case of a periodic array of identical circular ice floes that are equispaced along an infinite straight line is considered under linear and time-harmonic conditions.

In this model the floes possess the new features of a realistic non-zero draught and the ability to vary in thickness axisymmetrically via both their upper and lower surfaces. Moreover, our model is designed in such a manner that we may easily solve for geometrical configurations consisting of an arbitrary number of these straight lines of circular floes and may dictate either free-surface or ice-covered conditions away from the floes. Such extensions could be used as a model of the MIZ for example, or pancake ice appearing within a lead.

The geometry is divided into channels that contain a single floe. By applying phase change conditions on the sides of the channel we may reduce the problem posed by the infinite line array to that of a single channel only. The channel problem is simplified by invoking an approximation of the vertical dependence of the fluid motion. Green's functions are then used to convert the resulting equations into a integral system over the ice-covered disc, which may be solved numerically.

An Elastic Plate Model for Wave Scattering in the Marginal Ice Zone

Alison Kohout
University of Auckland
akohout@math.auckland.ac.nz
Coauthors: Mike Meylan

We present a model for wave attenuation in the Marginal Ice Zone (MIZ) based on a two-dimensional (one horizontal and one vertical dimension) multiple floating elastic plate solution in the frequency domain, which is solved exactly using a matched eigenfunction expansion. The only physical parameters which enter the model are length, mass and elastic stiffness (of which, the latter two depend primarily on thickness) of the ice floes. The model neglects all non-linear effects as well as floe collisions or ice creep, and is therefore most applicable to floes which are large compared to the thickness and to wave conditions which are not extreme. The solution for a given arrangement of floes is fully coherent and the results are therefore dependent on the exact geometry. We firstly show that this dependence can be removed by averaging over a distribution of floe lengths (we choose the Rayleigh distribution). We then show that after this averaging, the attenuation is a function of floe number and independent of floe length, provided the floe lengths are sufficiently large. The model predicts an exponential decay of energy, exactly as is shown experimentally. This enables us to provide explicit values for the attenuation coefficient, as a function of the

average floe thickness and Wave period. We compare our theoretical prediction of the wave attenuation with measured data and other scattering models. The limited data allows us to conclude that our model is applicable to large floes for short to medium wave periods (6 to 15 seconds). We also derive a floe-breaking model based on our wave attenuation model. This also allows us to conclude that we are under prediction the attenuation at long periods.

Simulation of near-trapping time-dependent water wave problem.

Michael Meylan
University of Auckland
meylan@math.auckland.ac.nz

This paper discusses the problem of near trapping by water waves and their simulation in the time domain. In particular, I focus on the problem scattering by cylinders, which is particularly simple to compute in the frequency domain. The methods consists of the following steps. The solution in the time-domain is written as a generalised eigenfunction expansion. Then the single frequency solution is extended to the complex plane where singularities are found close to the real axis. We then approximate the time domain solution as a sum over the contribution from these singularities.

Time-dependent water waves incident on a vertical elastic plate

Malte A. Peter
University of Auckland
mpeter@math.auckland.ac.nz

A time-dependent water-wave scattering problem in two spatial dimensions is considered in a semi-infinite domain: the water is of finite depth and infinite extent in one horizontal direction. It is bounded by a vertical elastic plate in the other horizontal direction. The plate is fixed at the sea bed and either fixed or pinned somewhere above the free water surface. The problem is solved by Fourier transform making use of solutions of the corresponding time-harmonic problem. Near-resonance and trapping are investigated making use of an abstract operator calculus.

Scattering and damping of ice coupled waves

Gareth L Vaughan
Otago University
glv@maths.otago.ac.nz
Coauthors: Vernon A Squire

Ice-coupled waves propagating beneath solid ice sheets experience attenuation that arises due to both scattering and damping effects, where the latter occurs because of hysteresis in the ice, i.e. its inherent inelasticity, and because of energy loss in the water column. Ice floe collisions, which occur during ridge building events, can also potentially cause waves to be attenuated, particularly where the ice sheet is at its most dynamic due to wind, waves and currents.

Both scattering and damping have been examined in isolation but rarely together. Real waves experience both mechanisms and, accordingly, both must be included if a model is to describe physical reality accurately.

I will describe a model that simulates both scattering and damping in two dimensional ice sheets of variable thickness. The damping is accommodated using a linear Kelvin-Voigt beam equation, the most basic viscoelastic model that reproduces the behaviour of ice when it is subjected to stress-strain tests in a laboratory, and the solution is found by means of Green's functions.

Results from examples of simulations are presented that illustrate the most important marine geophysical outcomes that emerge.

General Contributed Talks

Preconditioning radial basis function interpolation problems using mean value coordinates

R K Beatson
University of Canterbury
r.beatson@math.canterbury.ac.nz
Coauthors: J Levesley

Radial basis function interpolation is now a well established and useful technique for scattered data interpolation. Unfortunately, the usual formulation of the RBF interpolation problem with a globally supported basic function Φ is often very ill conditioned. This ill conditioning can be viewed as a consequence of a bad choice of basis. In the paper we discuss a much better choice of basis. The choice considered is based in part upon the mean value coordinates recently introduced by Floater. Theoretical and numerical results will be presented showing the desirable properties of the preconditioner.

Robust Monotone Iterates

Igor Boglaev
Massey University
I.Boglaev@massey.ac.nz

This talk deals with a discrete monotone iterative method for solving semilinear singularly perturbed problems. The monotone iterative method based on the method of lower and upper solutions is constructed. A rate of convergence of the method is estimated. Uniform convergence properties of the monotone iterative method are investigated. Numerical experiments complement the theoretical results.

Buchdahl-like transformations in general relativity

Petarpa Boonserm
Victoria University of Wellington
Petarpa.Boonserm@mcs.vuw.ac.nz
Coauthors: Matt Visser

We develop “algorithmic” techniques that permit one (in a purely mechanical way) to generate large classes of general relativistic static perfect fluid spheres. Working in Schwarzschild curvature coordinates, we used these algorithmic ideas to prove several “solution-generating theorems” of varying levels of complexity. Furthermore, we now consider the situation in other coordinate systems: In particular, in isotropic coordinates we shall encounter a variant of the so-called “Buchdahl transformation”, while in other coordinate systems we shall find a number of more complex “Buchdahl-like transformations” and “solution-generating theorems” that may be used to investigate and classify the general relativistic static perfect fluid sphere.

Qualified Residue Difference Sets from Unions of Cyclotomic Classes

Kevin Byard
Massey University
k.byard@massey.ac.nz

Qualified residue difference sets (QRDS) are a special class of combinatorial configuration that have potential applications in areas such as image formation, signal processing and aperture synthesis. To date, all known QRDS are generated from a single cyclotomic class, namely the set of nth powers of integers modulo certain types of prime p. This talk presents a new class of QRDS that is generated from the union of two cyclotomic classes. It is demonstrated that for $n = 8$, QRDS exist for all primes of the form $p = x^2 + 8x + 8$ where $x \equiv 1 \pmod 4$. The talk is given from the perspective of an astronomical imaging application.

Cosmography: Extracting the Hubble series from the supernova data

Celine Cattoen
Victoria University of Wellington
celine.cattoen@mcs.vuw.ac.nz
Coauthors: Matt Visser

Cosmography is the part of cosmology that proceeds by making minimal dynamic assumptions, that is, one does not assume the Friedmann equations (Einstein equations) unless and until absolutely necessary. By doing so it is possible to concentrate more directly on the observational situation. The Hubble parameters contained in the Hubble relation between distance and redshift provide information on the behaviour of the universe (expansion, acceleration etc...). We perform a number of inter-related cosmographic fits to supernova datasets and pay particular attention to the extent to which the choice of distance scale and manner of representing the redshift scale affect the cosmological parameters. While the preponderance of evidence certainly suggests an accelerating universe, we would argue that (based on the supernova data) this conclusion is not currently supported beyond reasonable doubt.

Module-Building with Polynomials and Power Series

E F Cornelius, Jr
University of Detroit Mercy
efcornelius@comcast.net

Polynomials and power series in one and several variables, expressed with respect to a particularized basis, are used to construct quotients of countable products of integers and other integral domains. Pascal's matrices are generalized to higher dimensions, and products and product bases are characterized in terms of endomorphisms and row-finite matrices. The talk will be based upon one of the authors unpublished papers and others coauthored by Phill Schultz of the University of Western Australia.

Snapshot-Based Theory: An Interdisciplinary Approach

Gloria Cravo
University of Madeira, Portugal
gcravo@uma.pt
Coauthors: Jorge Cardoso

In our work we take an interdisciplinary approach by applying mathematical techniques, based on graph theory and propositional logic to solve a problem from computer science.

Our main goal is to provide a new theoretical mathematical foundation that can describe and analyze workflows. A workflow is the formal definition of a process used to manage business processes, that consists in one or more tasks to be executed to reach a final goal. The tasks are represented with vertices and the partial ordering of tasks is modeled with arcs, known as transitions. Usually, workflows are defined using a graph structure that has one beginning and one end, and their execution can include human participants and software applications that have the responsability to carry out activities. Workflows require a precise modeling to ensure that they perform according to initial specifications. For example, it is important to verify if a workflow, such as sales order processing, will eventually terminate and be completed.

Workflows have been successfully depoyed to various domains, such as bioinformatics, healthcare, the telecommunications industry, the military, insurance, and school administration. Other areas, such as mobile computing, the Internet, application development, object technology, operating systems, and transaction management have also beneficed from the use of workflow technology.

A vast number of papers are available in the literature, investigating various formal aspects of workflows. However, more research is required especially with respect to modeling and analyzing workflows using graph theory. To cover this lack, we model and analyze the behavior of workflows using tri-logic acyclic directed graphs. Our approach is novel, and is based on a formalism that we call snapshot-based theory. This formalism has the advantage of capturing the different behaviors of each task present in a workflow and allows verifying an important structural property of workflows—their logical termination.

Mathematical Modelling of an Annealing Furnace

Nick Depree
University of Auckland
n.depree@auckland.ac.nz

New Zealand Steel uses a very large radiant electric furnace to anneal steel strip in the continuous production of galvanised sheet steel. Because of its large thermal mass and the need to produce many variations of steel sizes and required properties, the furnace spends up to half its operating time in a transient state. Temperature control of the steel is critical to ensure correct product properties, but is very hard to measure; hence a dynamic thermal model can be used to improve process control. A dynamic model was built using the COMSOL package, but is complex and slow to solve. For use in online process control, a much simpler and faster model was created with MATLAB. Successful dynamic furnace control will provide significant financial and energy savings to NZ Steel due to reduced wastage and rework of incorrectly heat treated product

Genericity of Serial Manipulator Singularities
Peter Donelan
Victoria University of Wellington
peter.donelan@mcs.vuw.ac.nz

Brockett's product-of-exponentials formulation provides a succinct way of expressing the forward kinematics of a serial manipulator, by exploiting the representation of joints by means of subgroups of the Euclidean group. The Baker–Campbell–Hausdorff formula can be applied to such a product to derive a Taylor series-type expansion, the jet extension, which provides information about the singularities of the forward kinematics. A generic manipulator is one for which these jet extensions intersect sets that characterise properties of singularities, such as their rank. The foundations for such an approach to analysing singularities and determining conditions for genericity are developed.

On bounded sequences and applications to invariant subspace problem
Driss Drissi
Kuwait University
drissi@mcs.sci.kuniv.edu.kw

Using the classical Phragmén–Lindelöf principle and a standard techniques from functional analysis, we obtain results on the sequences (x_n) of complex Banach space. Applications to the orbits of operators and invariant subspace problem are presented. This helps to improve former results of Gelfand–Hille and Mbekhta–Zemanek.

Electrophoresis of gas bubbles
J F Harper
Victoria University of Wellington
john.harper@vuw.ac.nz

Electrophoresis occurs when a charged particle in an ionic liquid is set in motion by an externally imposed electric field. A recent authoritative review (Delgado *et al*, J. Colloid Interface Sci. **309** (2007) 194) says that modelling this situation when the particle is an uncontaminated bubble or drop is not a trivial task. I have to agree, because there was an error in my own previous analysis (fortunately not published), and I have found that various theories by others do not agree with either one another or the experimental results.

This talk will describe the present state of play. Baygents and Saville (J. Chem. Soc. Faraday Trans. **87** (1991) 1883) seem to have been closer to a good theory than anyone else, but even they were not yet there.

C^*-algebras like the Toeplitz algebra

Sun Young Jang
University of Ulsan, South Korea
jsym@ulsan.ac.kr

If the C^*-algebras generated by isometric representations of semigroups have the uniqueness property, the structures of those C^*-algebras are to some extent independent of the choice of isometries on a Hilbert space. The Toeplitz algebra, the Cuntz algebra and the C^*-algebra generated by one-parameter semigroups of isometries studied by R. Douglas are obtained as particular examples of the C^*-algebras with the uniqueness property. We show that the unperforated property of partially ordered abelian semigroups has a deep relationship with the uniqueness property of C^*-algebras generated by isometric representation of semigroups. When G is a discrete group and M is a subsemigroup of G, the Wiener–Hopf C^*-algebra $W(G,M)$ is the C^*-algebra generated by the left regular isometric representation of M. We also prove that the Wiener–Hopf C^*-algebras $W(\mathbb{Z},M)$ of a subsemigroup M generating the integer group $\mathbb{Z}$ are isomorphic to the Toeplitz algebra and $W(\mathbb{Z},M)$ does not have the uniqueness property except the case $M =$ the semigroup $\mathbb{N}$ of natural numbers, strangely. On the structural relationship between the Wiener–Hopf C^*-algebra and the reduced group C^*-algebra we show that when a semigroup M is a subsemigroup of countable discrete abelian group G, the quotient algebra of $W(G,M)$ by its commutator algebra is isomorphic to the reduced group C^*-algebra $C^*_{red}(G)$ of G.

Lattice rules for integration over $\mathbb{R}^s$

Stephen Joe
University of Waikato
stephenj@math.waikato.ac.nz
Coauthors: Vasile Sinescu

There has been much work done on lattice rules for the numerical approximation of integrals defined over the s-dimensional unit cube. If the integration region happens to be $\mathbb{R}^s$, it is quite common to apply some transformation to map $\mathbb{R}^s$ to the unit cube in order to make use of these lattice rules.

However, there do exist lattice rules for $\mathbb{R}^s$. A natural question that arises is whether these lattice rules have merit for approximating integrals over $\mathbb{R}^s$.

We review some known results for these lattice rules and present some new preliminary theoretical results based on Fourier transforms and reproducing kernel Hilbert spaces.

Regular Martingales in Riesz Spaces

Mareli Korostenski
University of the Witwatersrand, South Africa
Mareli.Korostenski-Davies@wits.ac.za
Coauthors: Coenraad Labuschagne

We consider regular martingales in the measure-free setting of Dedekind complete Riesz spaces. The space of such regular martingales is shown to be a complete Riesz space. We derive, as a special case, a result of Troitsky on regular martingales in Banach lattices.

A Viability Theory Approach to a Two-Stage Optimal Control Problem

Jacek Krawczyk
Victoria University of Wellington
J.Krawczyk@vuw.ac.nz
Coauthors: Oana-Silvia Serea

A two-stage control problem is one in which a model parameter ("technology") might be changed at some time. An optimal solution to utility maximisation for this class of problems needs to thus contain information on the time at which the change will take place (0, finite or never) as well as the optimal control strategies before and after the change. For the change, or switch, to occur, the "new technology" value function needs to dominate the "old technology" value function, after the switch. We charaterise the value function using the fact that its hypograph is a viability kernel and study when the graphs can intersect. Using this characterisation we analyse a technology switching problem.

Külshammer's second problem

Daniel Lond
University of Canterbury
D.Lond@math.canterbury.ac.nz

Let G be a linear algebraic group over an algebraically closed field k, Γ an arbitrary finite group and $\Gamma_p \subset \Gamma$ a Sylow p-subgroup of Γ, where $p = \mathrm{char}(k)$. It is known that there may be infinitely many equivalence classes of representations of Γ into G. Külshammer asks the following:

> *Given an equivalence class of representations of Γ_p into G, are there only finitely many representations $\rho : \Gamma \to G$, up to equivalence, such that the restriction of ρ to Γ_p belongs to that given class?*

The aim of this elementary talk will be to describe the problem to a general audience and to show how a *cohomology* argument may provide some answers.

Modelling turbulent dispersion of pollen in a forest canopy

Robert McKibbin
Massey University
R.McKibbin@massey.ac.nz

Pollen released from trees within a forest is transported by the wind through the canopy. Some is deposited on the forest floor; the remainder is trapped by the foliage as it is advected and dispersed while falling under gravity. The model presented here takes into account these three processes. It is assumed that the pollen particles, being small, quickly reach their terminal velocity with respect to the mean air flow, and are mechanically dispersed by the turbulence generated by the air flow through the foliage. Of particular interest is how the turbulent dispersion can be quantified. Analysis of field data from tri-axial anemometer measurements within a forest canopy near Kanazawa, Japan is described. The overall aim is to obtain analytic solutions to the resulting advection-dispersion-trapping equations. Some examples are presented to illustrate the effects of various parameters.

Loci of zeros in fractional calculus

Alastair McNaughton
University of Auckland
a.mcnaughton@auckland.ac.nz

When a function is continuously integrated or differentiated using the techniques of fractional calculus, the locus of the zeros is often of interest. I will outline technical aspects of how such loci can be determined, with reference to the natural logarithm function.

Fuzzy Translation Invariant Topological Spaces

V Lakshmana Gomathi Nayagam
National Institute of Technology, Tiruchirappalli, India.
velulakshmanan@nitt.edu
Coauthors: G Venkateshwari (P.S.G.College of Technology, Coimbatore), Geetha Sivaraman (Anna University, Tiruchirappalli)

The notion of fuzzy sets was introduced by L. A. Zadeh and was extended to intuitionistic fuzzy subsets by K.Atanassov. The notions of fuzzy and intuitionistic fuzzy topological spaces were introduced and studied by C. L. Chang, D. Coker, K. Hur *et al.* The notion of induced topology on fuzzy singletons has been introduced and it has been extended to the induced topology on intuitionistic fuzzy singletons by myself. The notion of fuzzy subgroups was introduced by A. Rosenfeld. The notion of intuitionistic fuzzy subgroups was studied by K.Hur and et.al. The notion of translation invariant topology in fuzzy topological spaces was studied by A. K. Katsaras. In this paper, a new notion of fuzzy translation invariantness is introduced and the relation between the existing notion of translation invariantness has been studied. The properties of this fuzzy translation invariant topological spaces have also been studied. It is also aimed to extend this notion to intuitionistic fuzzy set up.

Cohomology cross-cap products

Andrew Percy
Monash University
andrew.percy@sci.monash.edu.au

We define a cross-cap product of integral cohomology and relate these products to the Tor groups of the Kunneth formula. We show that these products are bilinear and skew-commutative.

A Lyapunov-based Path Planning and Obstacle Avoidance for a Two-link Manipulator on a Wheeled Platform

Avinesh Prasad
University of the South Pacific, Fiji
prasad_ai@usp.ac.fj
Coauthors: Bibhya Sharma and Jito Vanualailai

In this paper, we show, for the first time, how the Direct Method of Lyapunov could be used to construct a Lyapunov function that controls the motion of a 2-link mobile manipulator system by guiding it to its goal whilst avoiding obstacles in a priori known workspace. The mobile manipulator, modelled via its kinematic constraints, consists of a coupling of a holonomic manipulator with a nonholonomic mobile base. It is guided to its target by an attraction function that is part of the Lyapunov function. It avoids fixed and artificial obstacles, which are created from the singularities and the kinematic and dynamic constraints in the system, via obstacle avoidance functions that also make up the Lyapunov function. Computer simulations are used to illustrate the effectiveness of the proposed Lyapunov-based method.

Steiner triples and a solution of the Kirkman school girl problem using matrices with multiple symmetry properties

Irwin Pressman
Carleton University, Canada
ipress@math.carleton.ca
Coauthors: Brett Stevens (Carleton University), Eric Mendelsohn (University of Toronto)

The problem of generating Steiner triples is challenging. For instance, it is in NP but not P. There have been attempts to realize these beautiful but magical objects in an algebraic manner, *eg* with quasigroups.

We introduce the idea of using sets of matrices over the complex numbers with multiple symmetry properties as the symbols from which the triples are to be constructed. If we name the 15 schoolgirls in the Kirkman problem: symmetric, centrosymmetric, persymmetric, hermitian, centrohermitian, perhermitian, skew-symmetric, skew-centrosymmetric, skew-persymmetric, skew-hermitian, skew-centrohermitian, skew-perhermitian, zero, real, and imaginary then we find that there is a relation. Given a matrix satisfying any 2 of these patterns, then there is a unique third matrix pattern which must be satisfied. That is, any 2 schoolgirls uniquely determine their third. This gives rise to an idempotent, commutative, non-associative relation. The symmetry types give clues on how to build the design.

We have shown that these 15 patterns give a $2-(15,3,1)$ balanced incomplete block design which is a Steiner triple system but in the original paper we did not note the fact that this gives a solution to the Kirkman problem. The interesting remark is that it is not difficult to define higher symmetry types on matrices of size $2n$. These in turn give rise to larger block designs where there is a relation between the patterns that determines the blocks. The blocks complete themselves. This permits us to create larger designs where there is some additional information about the blocks.

Transport processes in networks with scattering ramification nodes
Agnes Radl
University of Otago
aradl@maths.otago.ac.nz

We investigate the streaming of particles with different velocities in a network. In the vertices of the network the particles are scattered, i.e. they change their velocity, and then they are distributed to the outgoing edges of the vertices by Kirchhoff rules. This will be formulated as an abstract Cauchy problem on a suitable Banach space and then studied using semigroup methods. Particular attention is paid to the time asymptotic behaviour of the system.

Potential Field Functions for Motion Planning and Posture Control of 3-Trailer Systems
Krishna Sami Raghuwaiya
University of the South Pacific, Fiji
raghuwaiya_k@usp.ac.fj
Coauthors: B.N Sharma and J.Vanualailai

This paper presents a set of new artificial potential field functions that improves upon, in general, the motion planning and posture control, with theoretically guaranteed point and posture stabilities, convergence and collision avoidance properties of a standard and a general 3-trailer systems in a priori known environment. We utilize ghost walls and the distance optimization technique (DOT) to attain point and posture stabilities, in the sense of Lyapunov, of our kinodynamical model. The effectiveness of the proposed control laws are demonstrated via simulations of a number of traffic scenarios.

Some recent developments on the structure of lattice rules
Muni V. Reddy
University of the South Pacific, Fiji
reddy_mv@usp.ac.fj
Coauthors: Stephen Joe

The structure of lattice rules has been studied using two different approaches. One of them is based on the representation of lattice rules in $D-Z$ form while the other approach is based on the generator matrix B of the dual of the integration lattice. The former approach has previously been used to find unique forms for projection-regular and prime-power lattice rules. We shall use this approach to find a unique representation for a special class of lattice rules. The latter approach has previously made the assumption that the Hermite normal form of the matrix B is upper triangular. However, for the special case of projection-regular rules in which the principal projections have the maximum possible number of distinct quadrature points, it is possible to specify a unique upper triangular matrix Z. The corresponding matrix $B = D\left(Z^T\right)^{-1}$ is then lower triangular. This leads us to investigate the lower triangular Hermite normal form for projection-regular rules.

On Spacial Statistics Models of the Determination of the Geoid

Alexey L Sadovski
Texas A&M University-Corpus Christi
alexey.sadovski@tamucc.edu

This talk deals with the spatial statistics models applied to free air anomalies of the gravity. The gravity data is obtained by flights along meridians and parallels in the area of the Gulf of Mexico. Applications of Kriging methods and Stokes–Helmut Equation yield equipotential geodetic surface of the mean sea level called Geoid. The important questions of errors in the Geoid determination and errors evaluation is discussed.

A Navigation and Collision Avoidance Scheme for Heterogeneous Robot Collectives

Bibhya Sharma
University of the South Pacific, Fiji
sharma_b@usp.ac.fj

In this paper we propose a set of new continuous time-invariant acceleration controllers that considers the multi-task of control and motion planning of heterogeneous robot collectives within a dynamic but constrained environment. The dynamic obstacles will include members of the collective as well as other moving solids in the workspace. An dual avoidance scheme is introduced for a heterogenous 3-robot collective in fixed or mobile topology and the moving/static obstacles within a potential field framework. This, together with the other kinematic and the dynamics constraints have been treated simultaneously via a Lyapunov-based approach. We demonstrate the efficiency of the nonlinear algorithm with results through simulations of a couple of interesting situations.

Generalized Opial type L(p)-Inequalities for Fractional Derivatives

S K Sunanda
Indian Institute of Technology, Kharagpur
sksunanda@gmail.com
Coauthors: C Nahak, S Nanda

The Opial inequality is of great interest in differential equations. One of its important applications is establishing uniqueness and upper bounds of solution of initial value problems. For classical derivatives, it has been generalized in several directions. We establish a class of generalized Opial type $L(p)$–inequalities for fractional derivatives, using generalized Holder's inequality. The basic idea is to apply index law for fractional derivatives in lieu of Taylor's formula. It enables us to minimize the restrictions on the order of derivatives.

A real options approach to fisheries

Ratneesh Suri
Massey University
R.K.Suri@massey.ac.nz

Traditionally, the optimal harvesting strategy is defined in terms of the fishing effort (which includes gear, boats, manpower etc.) and is based on the Expected Net Present Value (ENPV) rule which asserts that an investment should be taken up if the present value of the cash flows from the investment project is greater than or equal to the costs involved. However, as the uncertainty related to the stochastic variables is gradually resolved, it might be beneficial for the decision-maker to alter the initially-decided operating strategy. This issue has been discussed in great detail by a large number of researchers who have put forward the theory of real options in order to fill this gap. This study determines the optimal harvesting strategy using a real options approach and compares it with the solution btained using the ENPV rule.

Full ionisation in binary–binary encounters at high velocity

Winston L Sweatman
Massey University
w.sweatman@massey.ac.nz

Binary stars can be destroyed through interaction with other binary or single stars. By destruction we mean separation into the component stars. Through analogy with atomic physics this process is called ionisation. In the simplest model, stars are approximated by point masses. Within this model theoretical approaches can be used to asymptotically approximate the ionisation cross-section for extremes of high and low total energy. Here we present some new results for the case of binary–binary encounters at high velocity (high energy).

A note on strategies for win/loss symmetric games.

Bill Taylor
University of Canterbury
W.Taylor@math.canterbury.ac.nz

We look at symmetric zero-sum games for 2 players with a finite number of strategies. For win/loss games there may only be an odd number of pure strategies supporting any optimal mixed strategy.

Vertex Operator Algebras on Genus Two Riemann Surfaces

Michael Tuite
National University of Ireland, Galway
michael.tuite@nuigalway.ie
Coauthors: Geoffrey Mason and Alexander Zuevskiy

Vertex Operator Algebras (VOAs) provide a rigorous approach to chiral conformal field theories (CFTs). The genus one (torus) partition function and n-point functions can be calculated for many VOAs/CFTs in terms of appropriate trace functions. Here we discuss recent progress in the fomulation and calculation of the partition function and n-point functions for VOAs on a Riemann surface of genus two. We describe explicit formulas for the bosonic string or Heisenberg VOA, lattice VOAs and fermionic super VOAs.

Recent progress on the heat equation

Neil Watson
University of Canterbury
n.watson@math.canterbury.ac.nz

A known result for superharmonic functions states that, if K is a compact subset of $\mathbb{R}^n$ with a connected complement, and u is superharmonic on some open superset of K, there then exists a superharmonic function u^* on $\mathbb{R}^n$ such that $u^* = u$ on a neighbourhood of K. I shall present a corresponding result for the heat equation.

On entire solutions of certain type of nonlinear differential equations

ChungChun Yang
Hong Kong University of Science & Technology
mayang@ust.hk

In the talk, how to derive the entire solutions of a certain type of nonlinear differential equations, by applying Nevanlinna's value distribution theory, will be illustrated.

Regularity Asymptotics of Vorticity for the 2D Navier–Stokes Equation

Yuncheng You
University of South Florida
you@math.usf.edu

The asymptotic dynamics of higher-order temporal-spatial derivatives of the two-dimensional vorticity and velocity of an incompressible, viscous fluid flow governed by the vorticity formulation of Navier–Stokes equation on the whole space $\mathbb{R}^2$ are studied. It is proved that all these derivatives of the vorticity and the velocity converge to the corresponding Oseen vortex and Oseen velocity field, respectively, at specific decaying rates. The proof is by establishing the exterior decay estimates combined with the similarity and the compactness via various decomposition and bootstrap approaches and utilizing convolution inequalities.