ABSTRACTS
for the
45th Annual Meeting of the
Australian Mathematical Society

Plenary talks

Plenary talks are held in Manning Clark Lecture Theatre 3

SAT 14:30–15:25 | 17B01, 20C15, 20C20

Witt's formula, logarithms and free Lie algebras

R. M. Bryant
UMIST

We consider a formula of Witt which arises in a number of different contexts. It counts the number of primitive necklaces of length n, the number of monic irreducible polynomials of degree n over a finite field and the dimension of the homogeneous component of degree n in a free Lie algebra. It also arises in connection with the logarithm function defined on power series. We shall consider logarithmic functions associated with free Lie algebras. We move from Witt's dimension formula through Brandt's character formula to a brief survey of some recent work on groups acting on free Lie algebras in nonzero characteristic.

SUN 11:30–12:25 | 97D20

Impaired vision: a case of inadequate mathematical input in school mathematics education

Hung-Hsi Wu
University of California at Berkeley, USA

This is a report on some recent developments in school mathematics education in the United States. The first is the presence of major mathematical flaws in the current curricula and assessment. This is the natural consequence of a prolonged divorce of mathematics from mathematics education in the recent past. A second is the recent experiment in California to initiate a rapproachment between the two disciplines. A third is the lesson one has learned from the Californian experience.

SUN 13:30–14:25

Determinants, K_1 and derived categories

Amnon Neeman
The Australian National University

Since this is a general talk, we will begin by reviewing determinants. We will remind ourselves how determinants are defined for square matrices over non-commutative rings, and how the determinant function can be extended to automorphisms of more and more general things.
Then we will talk about identities of determinants, and how one tries to find all of them. We will discuss an old counterexample of Deligne's, showing that identities of determinants are quite subtle. And then we will discuss some old results by the speaker about the problem.
If I manage to keep up a good pace, this will take only 30 minutes or so, leaving us plenty of time to discuss the recent progress made by several young people, and the many open problems left in the subject.

MON 13:30–14:25

Title to be announced

Jamie Sethian
University of California at Berkeley

MON 14:30–15:25 47A25

Power bounded operators and their similarities

Christian Le Merdy
The Australian National University

If you pick a complex number t, then the sequence $(t^n)_{n\geq 0}$ is bounded if and only if $|t| \leq 1$. In this talk, we will discuss the validity of such a statement for operators. By definition a bounded linear mapping $T\colon H \to H$ on Hilbert space is a contraction if $\|T\| \leq 1$ whereas it is power bounded if the sequence $(\|T^n\|)_{n\geq 0}$ is bounded. Clearly any contraction is power bounded but the converse is wrong. The question here is to determine how close to truth that converse is. This involves the fundamental concept of similarity, which will be explained in detail at the beginning of the talk. Then we will try to review the main results and ideas concerning this issue, from 1947 to now. If time permits, we will discuss the related concept of polynomial boundedness, as well as c_0-semigroups similar to contractive ones.

TUE 11:30–12:25

Hunting Nonlinear Mathematical Butterflies

Nalini Joshi
University of Adelaide

Nonlinear partial and ordinary differential equations that arise in mathematical physics generically have highly transcendental solutions. But some of these solutions have very simple asymptotic series expansions, unstable in solution space like the Lorenz butterfly of chaos theory, in certain limits. The trouble is that these series are typically divergent and it is very difficult to extract any information about the solutions from them. I will review the difficulties and some techniques for solving them.

TUE 13:30–14:25 15A42

Honeycombs and sums of Hermitian matrices

Terence Tao
UCLA/Clay Institute/The Australian National University

In 1912 Weyl posed the following problem: if one knows the eigenvalues of two $n \times n$ Hermitian matrices A and B, what can one say about the eigenvalues of the sum $A + B$? This problem has a surprisingly recursive answer, first conjectured by Alfred Horn in 1962 and solved after a long sequence of papers in 1999. The proof relies on a connection to a “quantum” version of the same problem, and on a simple but mysterious geometric object known as a “honeycomb”.

TUE 14:30–15:25 53C40

Developable submanifolds in real and complex Euclidean spaces

Hung-Hsi Wu
University of California at Berkeley, USA

This is a broad survey of the differential geometry of developable submanifolds, from the first results of Monge and Euler to the present time. The classical literature is about local results in real Euclidean space. The emphasis on global results and considerations of the complex category in this context are of more recent vintage. The lecture will report on some progress that goes beyond the classical situation of rank 1.

WED 11:30–12:25 60H10

Numerical Methods for Stochastic Differential Equations with Applications in Finance

Eckhard Platen
University of Technology, Sydney

The application of numerical methods for stochastic differential equations in finance has intensified over the past decade. The lecture introduces strong discrete time approximations that are suitable for scenario simulation. Higher order strong schemes of Runge-Kutta type will be discussed in the context of pathwise approximation. The use of higher order weak approximations and variance reduction techniques will be explained for their use in Monte Carlo simulation. The importance of numerical stability of weak and strong simulation methods will be emphasized. Examples for the simulation of scenarios and the pricing of derivatives will be included.

WED 12:30–13:25 60H10

Biological Sequence Analysis

Terry Speed
Walter & Eliza Hall Institute of Medical Research
and
University of California, Berkeley

For many purposes biological macromolecules such as nucleic acids and proteins may be regarded as sequences or strings of letters. In the case of DNA the letters are A, C, G and T, while they are A, C, G and U for RNA, and the 20 letter alphabet for the biological amino acids in the case of proteins. Many chemical features of such molecules of structural or functional importance can be described in statistical terms involving these letters. One simple example is highly conserved sequence ATG, which is the near-universal translation initiation sequence in genes, while another quite different example would be the base composition, that is, the % A, % C, % G and % T of a given DNA sequence. Between these two extremes - the consensus sequence and base composition - are a great variety of statistical descriptions (models) which can capture biologically important aspects of macromolecules such as family membership, location of active sites and functional or physical properties such as coding for a gene. With the generation of enormous amounts of DNA sequence from the human and other genome projects, a great deal of effort is being devoted to annotating the sequence, that is, to identifying functionally and structurally important features. Statistical models and methods are playing a large role in such annotation, and in this lecture I will discuss some of this research.

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Demonstration Sessions on Solving Problems with Magma

There are three special demonstrations of MAGMA software during this conference by Dr Paulette Lieby of MAGMA, University of Sydney. Participants are invited to attend any of the presentations and to try the software in room G17 in the John Dedman Mathematical Sciences Building. The times of the MAGMA presentations are shown in the timetable and abstracts for the presentations are included under the Applications of Discrete Mathematics session, on pages 28, 32 and 34.

About MAGMA COMPUTER ● ALGEBRA :

Magma is a large, well-supported software package designed to solve computationally hard problems in algebra, number theory, geometry and combinatorics. It provides a mathematically rigorous environment for computing with algebraic, number-theoretic, combinatoric and geometric objects.
See http://www.maths.usyd.edu.au:8000/u/magma/ for more details.

Special Session on Algebra

Talks in this session are held in room JD101

SAT 16:00-16:25

Monomial linear groups over finite fields

Dane Flannery
National University of Ireland, Galway

Describing finite linear groups of small degree is a traditional problem in linear group theory. For example, the description of irreducible primitive unimodular linear groups, over the field of complex numbers, and in degrees up to 11, occupied authors such as Jordan, Klein, Blichfeldt, Brauer, Feit, and successors. These authors were mainly interested in knowing the isomorphism types of the groups, or even just the isomorphism types of their central quotients. In this talk we are concerned with a harder problem: classifying finite irreducible linear groups up to conjugacy in the relevant general linear group. Attention is restricted to monomial linear groups over finite fields, with particular reference to degree 4.

SAT 16:30-17:25 17B70

Constructing Lie algebras

M. F. Newman
The Australian National University

- A survey on finite-dimensional (graded) Lie algebras,
- ways of constructing them (including a new one devised with Caranti),
- application of the constructions towards a better understanding of narrow algebras (in the sense of Shalev and Zelmanov).

SUN 09:00-09:55 20B

Over-groups of finite quasiprimitive permutation groups

Robert Baddeley, Csaba Schneider
and
Cheryl E. Praeger (*)
University of Western Australia

Several problems in algebraic graph theory can be reduced to consideration of graphs with a subgroup of automorphisms that is quasiprimitive on vertices. This raises the question of the nature of the full automorphism group. Is it quasiprimitive? Is it much larger than the given quasiprimitive group? The talk will report on the results of a 'long-lasting' investigation of over-groups of quasiprimitive permutation groups.

SUN 10:00-10:25 20B25

On Cayley graphs of Metacyclic p-groups

Cai Heng Li
and
Hyo-Seob Sim (*)
Pukyong National University

We investigate the automorphism groups of Cayley graphs of metacyclic p -groups. A characterization is given of the automorphism groups of Cayley graphs of a finite metacyclic p-group. In particular, a complete determination of the automorphism group of a connected Cayley graph with valency less than $2p$ of a finite nonabelian metacyclic p-group is obtained as a consequence.
An application to solve a problem in graph theory is also given: A Cayley graph X of G is called a "graphical regular representation" (GRR) of the group G if $\mathrm{Aut}(X) = G$. A simple necessary condition for X to be a GRR of G is that $\mathrm{Aut}(X)$ and $\mathrm{Aut}(G)$ has trivial intersection. C. Godsil (1983) proposed to characterise GRRs of a group G in terms of the intersection of $\mathrm{Aut}(X)$ and $Aut(G)$. This talk presents a complete solution to this problem for the class of metacyclic groups of prime power order.

SUN 10:30-10:55

Modules over nilpotent groups

John Groves
University of Melbourne

We shall discuss some results concerning modules over finitely generated nilpotent groups. We shall be particularly interested in *impervious* modules; that is, those which contain no non-zero submodules which are induced from subgroups of infinite index. Impervious modules arise from a finitely presented abelian-by-nilpotent group but, more generally, an understanding of these modules is essential to any general understanding of modules over nilpotent groups. Impervious modules appear to be much rarer than may appear at first sight.

MON 09:00-09:55 17B01, 20C20

Free Lie algebras as modules for finite groups

Ralph Stöhr
UMIST

Let V be a vector space over a field K, and let $L(V)$ denote the free Lie algebra on V. Suppose that a group G acts on V by linear transformations. Then this group action extends uniquely to the whole of $L(V)$ with G acting by graded algebra automorphisms. Thus $L(V)$ and its homogeneous components, the so-called Lie powers of V, become KG-modules. The central problem in the theory of Lie representations is the determination of the module structure of $L(V)$ for a given KG-module V. In the classical case, where K is a field of characteristic zero, Brandt's character formula (A. Brandt, 1944) provides a complete solution of this problem, at least in principle. Over the past seven years or so, there has been considerable progress on modular Lie representaions. Some aspects of this will be addressed in Roger Bryant's plenary talk. I shall elaborate on this topic, and discuss some recent developments of this newly emerging theory in greater detail.

MON 10:00-10:25 20D35

The Wielandt structure of metabelian groups

Chris Wetherell
The Australian National University

The Wielandt subgroup of a group is the intersection of the normalizers of its subnormal subgroups. This gives rise to the so-called Wielandt series, whose length is a measure of the complexity of the group's subnormal structure.
Ormerod has shown, for p an odd prime, that a metabelian p-group has nilpotency class at most one more than its Wielandt length. In this talk we discuss a generalisation of this result for non-nilpotent metabelian groups.

MON 10:30-10:55 20F99

Classification of parabolic subgroups in $\mathbf{G(m,p,l)}$.

Krishnasamy Muraleedaran
University of Sydney

Every parabolic subgroup of a Coxeter group is conjugate to a standard parabolic subgroup but this property does not generalize to unitary reflection groups. We define the concept of parabolic subgroup for all irreducible imprimtive unitary reflection groups and classify all the parabolic subgroup according to our definition.

MON 16:00-16:25 20B25, 20J06, 94A62

Shift Action on 2-Cocycles

Kathy Horadam
Royal Melbourne Institute of Technology

Each finite group G acts as a group of automorphisms of $Z = Z^2(G, C)$, the finite abelian group of cocycles $G \times G \to C$, for each finite abelian group C. These automorphisms fix the subgroup of coboundaries B in Z, setwise. This *shift* action is invisible from the usual cohomological point of view, perhaps explaining why the fine structure of Z has apparently not been previously noted.

In this talk, progress in understanding fundamental properties of shift action—fixed points, orbits and stabilisers—is outlined in terms of particular types of cocycle: multiplicative, symmetric, skew-symmetric and coboundary.

Shift action preserves statistical distribution properties of the values a cocycle takes in C. Time permitting, a link to planar functions will be used to introduce the idea of *differentially* δ*-uniform* cocycles, for application to the design of highly nonlinear digital sequences.

MON 16:30-16:55 16N80

Pseudoregular Radical Classes

Nick McConnell
Department of Defence
Defence Science and Technology Organisation

The Jacobson radical is the most widely known example of an equationally defined radical class. We define a pseudoregular radical class to be one defined by a single polynomial of two variables which is right linear in its second variable. We then explore which of these are non-trivial and their relationships to classical radical classes.

MON 17:00-17:25 20B05

Permutation groups and Cartesian decompositions

Csaba Schneider
Department of Mathematics and Statistics
The University of Western Australia
Perth, Western Australia

A set Ω can often be decomposed into smaller sets in many different ways. For instance, we can sometimes write Ω as a disjoint union or as a Cartesian product. A permutation group G acting on Ω can then be studied in relation to the given decomposition of Ω. The theory of primitive and imprimitive permutation groups, where G is studied in terms of the invariant disjoint union decompositions of Ω, is an example of this approach. Here we build a theory of permutation groups that preserve a Cartesian product decomposition. In some interesting cases our theory enables us to describe all G-invariant Cartesian decompositions of Ω. This is joint research with Robert Baddeley and Cheryl Praeger.

TUE 9:00-9:55 16W20

Additive Galois Theory of Modules

Phill Schultz
University of Western Australia

I introduce several Galois connections between submodules of an arbitrary module M and ideals of a ring acting on M. This complements recent work on Galois connections between submodules of M and normal subgroups of a group acting on M.
The main application is to the structure of the lattice of ideals of the endomorphism ring of an abelian p-group.

TUE 10:00-10:25 20G40, 20C15

$\mathbf{K(F_q)}$-invariants in Irreducible Representations of $\mathbf{G(F_q)}$, when $\mathbf{G = GL_n}$

Anthony Henderson
University of Sydney

Using a general result of Lusztig, we give explicit formulas for the dimensions of K^F-invariants in irreducible representations of G^F, when $G = GL_n$, $F : G \longrightarrow G$ is a Frobenius map, and K is an F-stable subgroup of finite index in the fixed-point subgroup of an involution of G commuting with F. The proofs use some combinatorial facts about characters of symmetric groups.

TUE 10:30-10:55 20B15

Solving some old problems regarding finite primitive permutation groups

Cai Heng Li
University of Western Australia

Finite permutation groups containing regular subgroups form a subclass of transitive permutation groups. Characterizing such permutation groups is an old topic in permutation group theory, dating from Burnside (1897). Some classical results of Schur and Wielandt were obtained by using Schur ring method. The classification of finite simple groups provides a powerful tool for the study of these permutation groups. For example, Gorenstein (1981) obtained a classification of finite insoluble primitive permutation groups containing cyclic regular subgroups; Liebeck, Praeger and Saxl (2000) gave a description for finite primitive permutation groups containing general regular subgroups
In this talk, some recent results obtained by the speaker will be presented, including a solution to an old question proposed by Wielandt (on page 69 of his book 'Finite Permutation Groups'), and a complete classification of finite primitive permutation groups containing abelian regular subgroups.

WED 9:30-9:55 20D15

Finite p-groups of Wielandt length three

Elizabeth Ormerod
The Australian National University

When considering finite p-groups of Wielandt length three two situations may arise. It is possible that such a group, modulo its Wielandt subgroup, may have class 2 or 3. For primes $p > 3$, previous work has given a description of all 3-generator p-groups when the group modulo its Wielandt subgroup has class 2, and of 2-generator p-groups when the group modulo its Wielandt subgroup has class 2. The work reported in this talk extends this work by looking at groups with a larger number of generators. It also aims to integrate the two cases.

WED 10:00-10:25 20M18, 20M20

Inverse monoids generated by a group and a self-inverse element

Des FitzGerald
University of Tasmania

Necessary and sufficient conditions are given for a monoid generated by a group and an idempotent to be inverse. A joint project with D. Easdown (Sydney) involves applications to presentations for inverse monoids. I shall mention examples generalizing symmetric, alternating or braid groups.

WED 10:30-10:55 16N80

On the base radical class for associative rings

B. J. Gardner
and
R. G. McDougall (*)
Central Queensland University

The base radical class generated by a class of associative rings X consists of those rings whose nonzero homomorphic images have nonzero accessible subrings in X. In this talk we present results concerning the base radical class determined by the semisimple class of a hereditary radical class and give a number of examples of radical classes described in terms of the base radical class construction.

Special Session on Algebraic Geometry and Number Theory

Talks in this session are held in room JD102

SAT 16:00-16:25

Pseudo-Elliptic Integrals

Alf van der Poorten
Macquarie University

Several centuries ago, Abel noticed that the well-known elementary integral

$$\int \frac{dx}{\sqrt{x^2+2bx+c}} = \log(x+b+\sqrt{x^2+2bx+c})$$

is an augur of more unexpected integrals of the shape

$$\int \frac{f(x)dx}{\sqrt{D(x)}} = \log(p(x)+q(x)\sqrt{D(x)}).$$

Here the D are certain polynomials of degree $\deg D(x) = 2g+2$ and the f are polynomials of degree just $\deg f(x) = g$. Specifically, $f(x) = p'(x)/q(x)$ (so q divides p').

Note that, morally, one expects such integrals to produce inverse elliptic functions and worse, rather than an innocent log of an algebraic function. Abel went on to study, well, abelian integrals, and it is Chebychev who explains—using continued fractions—what is going on with these 'pseudo-elliptic' integrals. Recently, a student of mine, Xuan Chuong Tran, computed all the D over the rationals of degree 4 that have an f as above.

I may explain various contexts in which the present issues arise. They include symbolic integration of algebraic functions; the study of units in function fields; diophantine approximation of algebraic numbers; and, given a polynomial g, the consideration of period length of the continued fraction expansion of sequences $\sqrt{g(n)}$ as n varies in the integers.

SAT 16:30-16:55

Lattices and Exponential Sums: Applications to Cryptography

Igor Shparlinski
Macquarie University

We describe a rather surprising, yet powerful, combination of two famous number theoretic techniques. Namely, bounds of exponential sums and lattice reduction algorithms. This combination has led to a number of cryptographic applications, helping to make rigorous several heuristic approaches and provides a two edge sword to defend and attack. It can be used to prove important security results and also to create powerful attacks. The examples of the first group include results about the bit security of the Diffie-Hellman key exchange system, of the Shamir message passing scheme and of the XTR cryptosystem. The examples of the second group include attacks on the Digital Signature Scheme and its modifications which are provably insecure under certain conditions.

SAT 17:00-17:25

T G Room as codebreaker

John Mack
The University of Sydney

T.G. Room, a member of Baker's 'Tea party' Cambridge group pre WW2 and professor of mathematics at Sydney from 1935 to 1968, contributed to military intelligence activities in codebreaking from 1941 to 1945. But from about January 1940, he seems to have been the instigator of a semi-officially supported amateur cryptography group at Sydney University. This talk will summarise information gathered by Peter Donovan and John Mack on Room's work and raise some intriguing questions.

SUN 9:00-9:25

Heron's formula re-examined

Peter Donovan
University of New South Wales

This note extends work (1949) of Redei and Sz-Nagy in analysing the mathematical content of the so-called Heron's formula for the square of the area of a triangle. A formula in the differential geometry of Euclidean space is obtained.

SUN 9:30-9:55

Formulae associated with representations of a number as a sum of 5, 6 or 7 squares

Mike Hirschhorn
University of New South Wales

Let $r_k(n)$ denote the number of representations of n as the sum of k squares. That is,

$$\sum_{n\geq 0} r_k(n)q^n = \phi(q)^k,$$

where

$$\phi(q) = \sum_{-\infty}^{\infty} q^{n^2}.$$

Since $\phi(q)$ is a product, the generating function of $r_k(n)$ is an infinite product. We have been looking for cases of the phenomenon in which the generating function of $r_k(an+b)$ is an infinite product. This phenomenon occurs frequently when $k = 2,\ 3$ and 4, but less so for larger k. In this talk we shall examine the cases $k = 5,\ 6,\ 7$. As a tempting example,

$$\sum_{n\geq 0} r_7(24n+23)q^n = 49728 \prod_{n\geq 1} \frac{(1-q^{2n})^{10}(1-q^{3n})^3}{(1-q^n)^6}.$$

SUN 10:00-10:25

Arc-analytic Solutions of Monic Polynomials are Lipschitz

Laurentiu Paunescu
University of Sydney

In this talk we will investigate when the arc-analytic solutions, i.e. analytic on any real analytic arc, of monic polynomials $G(x,y) = y^n + \sum_{i=1}^{n} a_i(x)y^{n-i}$, $x \in \mathbb{R}^p$, a_i real analytic functions ($i = 1, \ldots, n$), are as well Lipschitz.

SUN 10:30-10:55 11A41

Goldbach Lotto

Noel Patson
Faculty of Informatics and Communication
Central Queensland University

Using probabilistic methods it is shown that Goldbach was very likely correct in his conjecture concerning every even number greater than 2 being the sum of 2 primes.

MON 9:00-9:25 11L05

Short Kloosterman sums for polynomials over finite fields.

I. Shparlinski, A. Harcharras
and
William D. Banks (*)
University of Missouri—Columbia

We extend to the setting of polynomials over finite fields a technique due to Karatsuba for estimating certain short Kloosterman sums. As an application, we show that for every irreducible polynomial M of degree m, the set of inverses modulo M of products $(F.G)$, where F and G are polynomials of very small degree relative to m, are uniformly distributed in an appropriate sense.

MON 9:30-9:55 14J

On the classification of K3 and other surfaces.

Nicholas Buchdahl
University of Adelaide

In the late 1950's, Weil and Andreotti made a number of conjectures concerning $K3$ surfaces: that the set of such surfaces is connected; that a version of the Torelli theorem holds; that each such surface is Kaehler; and that the period map is surjective. Over the years, the conjectures inspired considerable effort on the part of many mathematicians, and eventually all were proven to be true.
Using some recent work generalizing the classical Nakai-Moishezon criterion, I will discuss how the conjectures can all be proved in very short order. The methods are directly applicable not only to $K3$ surfaces but also to other some other compact complex surfaces, notably to complex 2-tori. From a wider perspective, the methods are in fact applicable to the classification of all compact Kaehler surfaces, shedding some light on the murky question of higher-dimensional classification.

MON 10:00-10:25 14D05

Topological invariants of plane algebraic curves

Paul Norbury
University of Adelaide

An interesting topological invariant of a complex algebraic curve in the plane is its link at infinity, obtained by intersecting the curve with a large three-sphere. This can be computed using the relationship between geometric three-manifolds and resolutions of curve singularities. In contrast, the fundamental group of the complement of a plane curve is an important topological invariant that is not easy to compute. For general curves one must rely on numerical calculations and these only work for small degree. In this talk we will describe a more accessible quotient of the fundamental group of the complement of a plane curve that, in many cases, depends only on the link at infinity of the curve.

MON 16:00-16:25 11R23

The structure of pro-p galois groups

William McCallum
University of Arizona

Let p be a prime number and let G be the galois group of the maximal p-ramified pro-p extension of a number field K. Then G has a presentation as a quotient of a free pro-p group by a finite number of relations. We consider the problem of determining the structure of these relations.

MON 16:30-16:55

Squares from products of consecutive integers

Gerhard J. Woeginger
and
Alf van der Poorten (*)
Macquarie University

Notice that $1 \cdot 2 \cdot 3 \cdot 4 + 1 = 5^2$, $2 \cdot 3 \cdot 4 \cdot 5 + 1 = 11^2$, $3 \cdot 4 \cdot 5 \cdot 6 + 1 = 19^2$, $\ldots$. Indeed, it is well known that the product of any four consecutive integers differs by 1 from a perfect square. However, a little experimentation readily leads one to guess that there is no integer n, other than four, so that the product of any n consecutive integers differs from a perfect square by some integer $c = c(n)$ depending only on n.

There are two issues here. The first is to explain the apparently special status of four. We show that this matter lies little deeper than the well known fact that any quadratic polynomial can be completed by a constant to become the square of a polynomial. Second, we give an elegant proof that there is indeed no n larger than four so that $\ldots$, as said above.

MON 17:00-17:25 14F20

Applications of an equivariant comparison theorem for scheme cohomology

Gus I. Lehrer
School of Mathematics and Statistics
University of Sydney
N.S.W. 2006, Australia

Suppose a finite group acts as a group of automorphisms of a smooth complex algebraic variety which is defined over a number field. We show how, in certain circumstances, an equivariant comparison theorem in l-adic cohomology may be used to convert the computation of the graded character of the induced action on cohomology into questions about numbers of rational points of varieties over finite fields. We illustrate the method with three applications: firstly, for the symmetric group acting on the moduli space of n points on a genus zero curve, secondly, for a unitary reflection group acting on the complement of its reflecting hyperplanes and thirdly for the symmetric group action on the space of configurations of points in any smooth variety which satisfies certain strong purity conditions. This is joint work with Mark Kisin.

WED 9:00-9:25 17B67

Buildings, Littelmann paths and functional analysis

Fred Goodman
and
Jacqui Ramagge (*)
University of Newcastle

We started off searching for a combinatorial proof to justify the appearance of the Weyl dimension formula in two analytic results with implications for the Baum-Connes conjecture. What we found was an alternative geometric interpretation of the Littelmann path model for representations of Kac-Moody algebras in terms of foldings of convex hulls in buildings. I will state the motivating results, provide a brief description of Littelmann paths and outline the correspondence between paths and foldings.

WED 9:30-9:55 14G25

The local-global problem for zero-cycles over number fields

Joost van Hamel
University of Sydney

This talk is about conjectures formulated by Colliot-Thélène (inspired by work of Cassels, Tate, Manin, and himself with Sansuc) concerning zero-cycles on varieties over number fields. I will look at these conjectures from the point of homology, rather than cohomology, and demonstrate how this different point of view actually helps in improving existing results.

WED 10:00-10:55

Upper bounds in the theory of irregularities of point distribution

William Chen
Macquarie University

It is well known that no finite set of points can be too well distributed in a finite region. The theory of irregularities of point distribution studies this phenomenon in a quantitative way. On the one hand, there are lower bounds that indicate the "badness" of all distributions, relative to certain ways of measuring such badness. On the other hand, there are upper bounds that show that these lower bounds are essentially best possible. The idea is to construct point sets which are essentially as well distributed as possible. Upper bound techniques involve ideas in number theory, combinatorics, Fourier analysis and probability theory. We shall give an overview of the various techniques, introduced over the years by Davenport, Roth, Beck and the speaker, and also discuss some recent breakthrough by Skriganov and the speaker on explicit constructions, where ideas from Walsh analysis, duality and coding theory are introduced, and where use of probability theory is strictly forbidden.

Special Session on Applications of Discrete Mathematics

Talks in this session are held in room MCC2

SAT 16:00-16:25 05C85

Greedy heuristics for Euclidean Steiner trees

Julie Cain
Department of Mathematics and Statistics
University of Melbourne

The (d-dimensional) Euclidean Steiner tree problem is to find the tree with minimum Euclidean length spanning a fixed set of points in d-space, allowing the addition of auxilliary (Steiner) points to the set. This is known to be an NP-hard problem, giving rise to the search for and study of effective, polynomial heuristics. Smith and Shor's "greedy tree" is considered and further, related polynomial heuristics are presented. These new heuristics have a highter order of computational complexity, but a better performance ratio on average. It will be shown that these heruistics all produce spanning networks no longer than the minimum spanning tree.

SAT 16:30-16:55 05B15

On the size of the largest critical set in a latin square.

Nicholas J. Cavenagh
Centre for Discrete Mathematics and Computing
University of Queensland

A latin square of order n is an $n \times n$ array of integers such that each row (column) is a permutation of the first row (column). A critical set is a partially filled latin square that may be completed to exactly one latin square, and is minimal in this property. Critical sets in latin squares have potential applications to secret sharing schemes. However, we still know very little about their structure. In this talk we give a new bound on the size of the largest critical set in a latin square in the special case that a critical set is 2-critical.

SAT 17:00-17:25 94B05

Skew Arcs and Codes

Michelle Davidson
Deakin University

An arc is defined in a geometry of points and lines to be a set of points that intersects any line in at most 2 points. It has long been known that there is a correlation between arcs and binary linear codes of minimum distance 4. This approach has provided a wealth of information on quasiperfect distance 4 codes. We adapt the definition of an arc by requiring lines with two points in the arc to be skew. Now a similar correlation can be found between skew arcs and codes of distance 5. We use this to give a simple construction of Wagner's [23,14,5] code.

SUN 9:00-9:25 94A60

Implementation Weaknesses of Ciphers and Cryptographic Protocols

Meng Ting
and
Bernard Colbert(*)
Telstra

We consider two proposals for key management for wireless communications. The first is the security management specified by the Bluetooth Consortium and the second is from a Blue Chess Playing company.
Bluetooth is a wireless connexion protocol that come with key management and a cipher specified. We examine the key management and discuss why is it fundamentally flawed. We also discuss work in progress in breaking the cipher.
The second proposal, Two Party Key Distribution Protocol (2PKDP) is a key management protocol that is currently deployed in a number of systems. We discuss a practical flaw that makes this protocol insecure.

SUN 9:30-9:55 12E20

Polynomial composition and the HFE cryptosystem

Marie Henderson
University of Queensland

The talk will cover the composition behaviour of the classes of linearised polynomials and Dembowski-Ostrome polynomials defined over a finite field. Connections to the Hidden Field Equation (HFE) cryptosystem will be given.

SUN 10:00-10:25 05

Homogeneous Bent Functions and Invariant Theory

Chris Charnes
Computer Science and Software Engineering
University of Melbourne

We use classical invariant theory to construct Boolean bent functions with a prescribed symmetry group. The bent functions have algebraic normal form which is homogeneous and of degree three. The machinery of invariant theory produces new homogeneous bent functions in 8, 10, 12 and 16 variables. The resulting bent functions have connections with 1-designs and graph theory. We establish that a recently found class of 6 variable bent functions has a surprising symmetry group—the simple group of order 168. We describe the action of this group on the bent functions combinatorialy.

SUN 10:30-11:00 JDMS.G17

MAGMA
COMPUTER ALGEBRA

The Galois Correspondence

Claus Fieker and **Paulette Lieby**

In this session we show the correspondence between the subgroups of the Galois group of an algebraic number field and the subfields of that field.
From an irreducible polynomial f over Q we construct its splitting field L and compute the Galois group G of L.
For each subgroup H of G we construct the field F of elements fixed by the automorphisms in H. We show that F is isomorphic to a subfield of L such that $[L : F] = |H|$ and $[F : Q] = |G|/|H|$.
Conversely, we find which subgroup of G fixes the elements of a given subfield F of L.

MON 9:00-9:25 05B30

Proportionally Balanced Designs

Ken Gray, Karen Harris
and
Anne Penfold Street (*)
The University of Queensland and
the Queensland Board of Senior Secondary School Studies

Proportionally balanced designs were introduced in 1995 by K. Gray and G. Matters in response to a need for the allocation of markers for a particular examination to have a certain property. Put simply, markers had to be allocated to pairs of questions in proportions that reflected the relative numbers of markers allocated in total to each question. It now appears that such designs may also be appropriate for experiments in plant breeding, where some varieties appear more frequently than others, not by choice, but because of difficulties in obtaining as many samples of some varieties as of others.
Since a design with constant block size is proportionally balanced if and only if it is balanced, designs with blocks of precisely two different sizes are the obvious ones to look at first. We give several theoretical results, some interesting examples and general constructions for these designs, as well as another application in the design of small tests used in trialling questions.

MON 9:30–9:55 05C38, 05B30

Gregarious 4-cycles: a graph decomposition problem

D. G. Hoffman
and
Elizabeth J. Billington (*)
The University of Queensland

Suppose we have three different groups of chemicals, A, B and C. These are stored in racks that are square in shape, with a container at each corner. So each rack contains four chemicals. (The racks have a solid centre, so that the only possible interactions can be between chemicals which lie on adjacent corners of the square rack.) For safety of storage, we have the following constraints:

1. no two chemicals from the *same* group (A, B or C) may be placed on adjacent corners of a square rack, for fear of unsafe reaction;
2. each pair of chemicals from *different* groups is to be stored adjacent in exactly one square rack, so that a reaction check can be made for each such pair;
3. each square rack is to contain at least one of each chemical group, A, B and C, to ensure, for safety, that each rack contains no more than one repeat of any chemical group.

The solution to this problem amounts to decomposing a certain complete tripartite graph into so-called "gregarious" 4-cycles. This and related problems will be discussed; it is based upon joint work with D. G. Hoffman.

MON 10:00-10:25 05B10

Reversible $(4n^2, 4, 4n^2, n^2)$-RDS with forbidden subgroup $\mathbb{Z}_4$

Wei-Hung Liu
RMIT

I am going to determine some necessary and sufficient conditions for the existence of reversible $(4n^2, 4, 4n^2, n^2)$-RDS whose forbidden subgroup A is $\mathbb{Z}_4$. I will also construct an infinite family of reversible $(4n^2, 4, 4n^2, n^2)$-RDS with forbidden subgroup A is $\mathbb{Z}_4$ by using Galois Rings, which will answer a question of Ma's. That is, for reversible RDS, the forbidden subgroup needs not be an elementary Abelian 2-group.

TUE 9:00-9:25 65D15

An Improved Algorithm for the Cutting Angle Method of Global Optimisation

Lynn Margaret Batten
School of Computing and Mathematics
Deakin University

The cutting angle method for solving the global optimisation problem was posed in 1999 by Andramonov, Glover and Rubinov. Analysis of the computer implementation of the resulting algorithm indicates that running time can be significantly improved with appropriate modifications to the underlying mathematical description. In this paper, we present a combinatorial equivalent of the original problem, and show how this results in running times far better than those of the original algorithm. This is joint work with Gleb Beliakov.

TUE 9:30-9:55 05C45

Hamiltonian Cycles and Markov Chains

Jerzy A. Filar
Centre for Industrial and Applicable Mathematics
University of South Australia

In this presentation we derive new characterizations of the Hamiltonian cycles of a directed graph, and a new LP-relaxation of the Travelling Salesman Problem. Our results are obtained via an embedding of these combinatorial optimization problems in suitably perturbed controlled Markov chains. This embedding lends probabilistic interpretation to many of the quantities of interest, which in turn lead naturally to the introduction of a quadratic entropy-like function. If the feasible region of the above mentioned LP-relaxation is denoted by X, it can be shown that the extreme points of X can be ordered according to the value of an appropriately constructed linear function $L(.)$. The Hamiltonian cycles correspond to precisely those extreme points of X which take on the second smallest possible value of $L(.)$. Furthermore, they are the minimizers of the top left element of the fundamental matrices of the Markov chains corresponding to deterministic policies of the perturbed controlled Markov chains. Algorithmic approaches based on these theoretical results are currently being explored. Some preliminary numerical results will be outlined in this presentation.

TUE 10:00-10:25 05C45

Hamiltonian Cycles and the Asymptotics of Fundamental Marices of Perturbed Markov Chains.

Vladimir V. Ejov
Centre for Industrial and Applicable Mathematics
University of South Australia

We consider the Hamiltonian cycle problem embedded in a singularly perturbed Markov decision process (MDP). It is known that the long-run frequency space of this process can be characterized as a polytope whose extreme points correspond to subgraphs that are also deterministic policies of the MDP.
As the objective function we consider the $(1,1)$-entry of the fundamental matrix of the Markov chain induced by the corresponding policy. This objective function is invariant under permutations of the nodes that preserve the chosen home node. Using a combinatorial approach, we give a precise estimate on the perturbation parameter for the Hamiltonian cycles to be the minimizers of the objective over the space of deterministic policies. In the process, we derive analytical expressions for the possible values of the objective over different types of deterministic policies.

TUE 10:30-11:00 JDMS.G17

MAGMA COMPUTER ALGEBRA

Investigating the Automorphisms of a Graph

Brendan McKay and **Paulette Lieby**

In this session we will construct a graph G as an incidence graph of a generalized quadrangle [1, p. 83]. A generalized quadrangle is a partial linear space where given any line L and a point p not on L there is a unique point p' on L such that p and p' are collinear.

Let D be the underlying incidence structure of G. The points of D are 1-dimensional subspaces of the vector space V of dimension 4 over the field F with order 2. The lines of D are 2-dimensional subspaces of V. For simplicity we will talk of points and lines of G when referring to points and lines of D.

Given any vertex v in G, define b to be its basis in V. If v is a 1-dimensional subspace then b contains one vector, if v is a 2-dimensional subspace then b contains two vectors. If M is a linear transformation from V into V we define $v * M$ to be the subspace of V generated by the vectors $e * M$ where e is an element of the basis b of v.

We choose a linear transformation M from V into V such that the mapping $f : G \to G$ defined by $f(v) = v * M$ is an automorphism of G. We find all such linear transformations M and check that they indeed correspond to the automorphisms of G which send points to points and lines to lines.

The linear transformations M which correspond to automorphisms of G form a group B. If time permits, we will show how to derive a generating set for B from the generators of the automorphism group of G.

[1] C. Godsil and G. Royle. *Algebraic Graph Theory*. Graduate Texts in Mathematics, Springer, 2001.

WED 9:30-9:55 05D99, 06A99

The Flat Antichain Theorem

Paulette Lieby
Department of Mathematics and Statistics
University of Sydney

We will present a few consequences of the flat antichain theorem. An *antichain* is a collection of sets in which no two sets are comparable under set inclusion.

An antichain $\mathcal{A}$ is *flat* if there exists an integer $k \geq 0$ such that every set in $\mathcal{A}$ has cardinality either k or $k+1$. The *size* of $\mathcal{A}$ is $|\mathcal{A}|$ and the *volume* of $\mathcal{A}$ is $\sum_{A \in \mathcal{A}} |A|$.

The flat antichain theorem ([**L**], [**K**]) states that $\mathcal{A}$ is an antichain on $[n]$ if and only if there exists a flat antichain on $[n]$ with the same size and volume as $\mathcal{A}$. Some consequences of the theorem are explored: a new simple necessary and sufficient condition for the existence of an antichain of a given size and volume, and an equivalence relation for antichains on $[n]$ of size s defined by the classes of antichains of a given volume. This equivalence relation enables us to give a new simple proof for a theorem of Clements [**C**] that determines the parameters of an antichain of size s and of minimum volume.

References

- **[C]:** G. F. Clements, *The Minimal Number of Basic Elements in a Multiset Antichain*, Journal of Combinatorial Theory, Series A, 25:153–162, 1978.
- **[K]:** Ákos Kisvölscey, *Flattening Antichains*, Alfréd Rényi Institute of Mathematics, Hungarian Academy of Science, Budapest, `ksvlcsrenyi.hu`, 2001.
- **[L]:** P. Lieby, *Extremal Problems in Finite Sets*, PhD thesis, Faculty of Science, Northern Territory University, Casuarina NT 0909 Australia, February 1999.

WED 10:00-10:25 05C85

Fast generation of planar graphs

Gunnar Brinkmann
and
Brendan D. McKay (*)
Dept of Computer Science
The Australian National University

The computer program plantri is able to explicitly generate many classes of planar graphs, including triangulations (possibly with degree restrictions and connectivity restrictions), polytopes, quadrangulations, and other classes.
The program uses little memory, yet the outputs comprise exactly one member of each isomorphism class. The speed is such that, for example, we made all $107,854,282,197,058$ convex polytopes with 18 vertices just because they were there.
The talk will explain how plantri works.

WED 10:30-11:00 JDMS.G17

MAGMA
COMPUTER ALGEBRA

Using a Template for Finite Abelian Groups

Paulette Lieby

In this session we demonstrate the use of a new Magma type which allows the creation of finite abelian groups over any domain endowed with an identity and a group operation.
The first example creates an abelian group A over the units of a residue class ring and computes the structure of A. We find all the cyclic subgroups of A and we show that indeed the direct sum of these subgroups is A. We repeat the same process by computing all the p-Sylow subgroups of A and taking their direct sum.
The second example creates an abelian group B over the Jacobian J of a hyperelliptic curve of genus 20. Computation of the structure of B will be done from a set of selected generators, thus bypassing the need to compute the order of J. We also show how any element of B, that is of J, can be represented in terms of the computed generators of B, in terms of the user-supplied set of generators, or in terms of any random set of elements of B.

Special Session on Computational Mathematics

Talks in this session are held in room MCC4

MON 09:00–09:55 41A05

An extension of Light and Wayne's basis function interpolaton theory to hat functions

Markus Hegland, Steve Roberts
and
Phil Williams (*)
The Australian National University

The goal of my Masters thesis was to develop a theoretical foundation for the analysis of the scalable smoothing algorithm which I have developed with the assistance of my supervisors. This theoretical work applies in any dimension but the smoother is only practical up to about 8 imensions. In future work we intend to improve the smoother using the theory of adaptive, sparse grids. Currently the smoother minimizes a functional on a regular rectangular grid. The functional consists of the sum of a smoothing seminorm term and a constraining least squares term. The minimal smoother is known as a basis function smoother and consists of a linear combination of basis functions translated by the data points plus a polynomial. The basis function is defined directly in terms of the components of the seminorm.

In fact, the function spaces used for smoothing are the same as those used for the minimal interpolation problem, where the functional only has a seminorm term. My thesis only studies the minimal seminorm interpolant problem.

In the seventies Duchon developed interpolation theory using seminorms constructed from a positive weight function. These weight functions generated thin plate spline basis functions. For these interpolants he was also able to obtain rates of pointwise convergence as the data becomes denser.

In the 90s Will Light and Henry Wayne extended the class of weight functions used to form the seminorm. Unfortunately, our smoothing algorithms involve using tensor product hat basis functions, and these cannot be generated using the weight functions of Light and Wayne. However, we have been able to devise an extension of their class of weight functions to overcome this limitation and so allow the theory of Light and Wayne to be applied. Pointwise convergence results for the hat basis function interpolant have thereby been obtained.

MON 09:30–09:55 41

Sinc Approximation to Steady State Waves

Patrick McLean
University of Tasmania

This seminar involves analytical and approximate methods of solution of a singular integrodifferential equation arising from modelling steady fluid flow over a submerged disturbance. Analytical methods of solution involve reduction to a differential equation; while approximate methods employed are Galerkin methods using sinc functions. The asymptotic behaviour of the exact solution and the error in the approximation are investigated.

MON 10:00–10:25 68P10

Challenges of indexing into large datasets with the aim of similarity search.

Vladimir Pestov and Aleksandar Stojmirovic (*)
School of Mathematical and Computing Sciences
Victoria University of Wellington
PO Box 600, Wellington, New Zealand

We survey the existing indexing schemes into large datasets with the purpose of similarity-based information retrieval and analyse the problem of dimensionality curse in the context of an interplay between the phenomenon of concentration of measure and complexity. In particular, we stress the difference between 'inner' similarity search (when the query points all belong to the indexed dataset) and the 'outer' search (when the space of potential query points is so large as to defy attempts at creating a precomputed index structure). We illustrate the main points using the authors' attempt to index into datasets of protein fragments currently under way.

MON 10:30–10:55 65D30

Numerical Integration in Hundreds of Dimensions

Ian H. Sloan
University of New South Wales

Nowadays numerical integrals with hundreds or even thousands of variables often arise, and are (especially in mathematical finance) evaluated numerically, using some form of quasi-Monte Carlo method. One way of understanding the apparent success of such calculations is to assume that the integrands become easier and easier in successive coordinate directions. Woźniakowski and I quantified this assumption by associating numerical weights $\gamma_1, \gamma_2, \dots$ with successive coordinate directions, with $\gamma_1 \geq \gamma_2 \geq \cdots > 0$, and showed that the worst case error in some classes of functions is independent of d if and only if $\sum \gamma_j < \infty$. The original proofs were not constructive, but recently Kuo and Joe at Waikato and I have found a way to construct explicit high-dimensional rules that achieve the theoretical error bounds if $\sum \gamma_j < \infty$. This talk will introduce some of these ideas.

MON 16:00–16:25 93E14

An application of Sparse Grids to the estimation of probability density functions

Stephen Roberts
School of Mathematical Sciences
The Australian National University

In this talk we will provide an overview of the approximation properties of sparse grids and then show how sparse grids can be used to provide an efficient method for the estimation of high dimensional probability density functions (pdf's). We take a simple approach and obtain an estimate of a pdf using an L^2+Mixed Sobolev semi-norm projection method. This method in combination with the work of Markus Hegland on adaptive sparse grids has the potential to provide a efficient method for estimating pdf's in very high dimensions.

MON 16:30–16:55 49L25

Computing Multiple Arrivals to the Eikonal Equation Using Liouville Transforms

Jamie Sethian
Mathematics Department
University of California, Berkeley

In this talk, we show how to compute multiple arrivals to the Eikonal equation using Liouville transforms. Computing multiple solutions allows us to find secondary arrivals, which often contain more energy than the primary arrivals. The technique is performed by casting the result in terms of a higher dimensional representation whose structure describes the arrivals, and which can be computed using very fast finite difference techniques. We demonstrate the results on a variety of problems. This work is joint with Sergey Fomel.

MON 17:00–17:25 65M06

High Order Difference Scheme for Biharmonic Equation

Irfan Altas
School of Information Studies
Charles Sturt University

In this talk, we consider several finite difference approximations for the three-dimensional biharmonic equation. A symbolic algebra package is utilised to derive a family of finite difference approximations for the biharmonic equation on a 27 point compact stencil. The unknown solution and its first derivatives are carried as unknowns at selected grid points. This formulation allows us to incorporate the Dirichlet boundary conditions automatically and there is no need to define special formulas near the boundaries, as is the case with the standard discretizations of biharmonic equations.
As finite difference approximations for three-dimensional biharmonic equations are not available in the literature, we exhibit the standard second order finite difference approximations that require 25 grid points. We also exhibit two compact formulations of the 3D biharmonic equations; these compact formulas are defined on a 27 point compact cubic grid. The fourth order approximations are used to solve a set of test problems and produce high accuracy numerical solutions.
The system of linear equations is solved using a variety of iterative methods. We employ multigrid, Krylov and classical iterative methods to solve the system of equations.

TUE 09:00–09:25 93E14

Adaptive Sparse Grids

Markus Hegland
The Australian National University

Sparse grids, as studied by Zenger and Griebel in the last 10 years have been a very successful in the solution of partial differential equations, integral equations and classification problems with up to around 10 dimensions. We will discuss a general framework which allows to extend the method to the case of nominal and mixed variables and to very high dimensions and applications to nonparametric regression as used in data mining.

TUE 09:30–09:55 93B36

Max-Plus Approximation Methods in Partially Observed Robust Control

M. R. James
Department of Engineering
The Australian National University

In this talk we discuss the use of max-plus approximation methods in the so-called nonlinear H_∞ control. A key issue is the numerical approximation of a quantity called the "information state" which solves a first order nonlinear Hamilton Jacobi equation. Using the max-plus linearity of the solution operator for the information state, we show how the information state can be represented as a max-plus expansion relative to what we call a monotone approximate basis. The forward time propagation of the information state is expressed as max-plus matrix multiplication. This leads to a natural approximation of the optimal value function and the optimal feedback function. The issue of real-time calculation of the information state is addressed, and a Lie-Trotter type splitting scheme is proposed.

TUE 10:00–10:25 55-04

Foundations for computing topology from finite approximations

Vanessa Robins
Applied Mathematics, RSPhysSE
The Australian National University

There is growing interest in extracting topological information from data in a diverse range of fields ranging from structure-function modelling of protein molecules to deducing dynamics from embedded time series data to image processing. The desired topological properties include the number of connected components and number of "holes"—i.e. the Betti numbers of the homology groups. These give an elementary description of structure, and are independent of geometric measures like volume or surface area. Efficient numerical algorithms for computing Betti numbers are based on constructions in computational geometry such as minimal spanning trees and alpha shapes. This talk will address the fundamental problem of extrapolating the topology of an object from a finite scattered-point approximation to it. Our approach is to coarse-grain the data at a sequence of resolutions and deduce the limiting structure. The theory is based on an inverse system of approximating spaces, as in Cech homology and shape theory. It leads to the concept of persistent Betti numbers which count holes that are genuine topological features, while excluding those introduced by the coarse-graining.

TUE 10:30–10:55 90C90, 65D05, 65D32

Optimization methods for choosing good points on the sphere for polynomial approximation and interpolatory cubature.

R. S. Womersley (*) and I. H. Sloan
University of New South Wales

We look at several optimization problems that arise when choosing points $\mathbf{x}_j, j = 1, \dots, m$ on the unit sphere $S^{r-1} \subset \mathbb{R}^r$ which are good for both polynomial interpolation and interpolatory cubature.
In particular we look at extremal fundamental systems which maximize a determinant, and at extremal spherical designs which maximize a determinant while providing equal weight cubature rules which are exact for polynomials of degree at most n. For $n = 128$ this involves the maximization of the determinant of a $16,641$ by $16,641$ symmetric positive definite matrix which is a nonlinear function of some $32,279$ variables, proving a major computational challenge.

WED 09:30–09:55 68Q32

Computational Logic applied to Machine Learning

J. W. Lloyd
Computer Sciences Laboratory
Research School of Information Sciences and Engineering
The Australian National University

Inductive learning is concerned with inducing general theories from specific facts. The theories should be comprehensible and have predictive power. There are many applications of inductive learning systems, ranging from systems that predict carcinogenicity of chemical molecules, that learn definitions of functions in programming languages, and that assign credit ratings. In this talk, I will discuss the application of higher-order logic to inductive learning, concentrating on the key ideas of representation of individuals and predicate construction. I will also outline some applications of a decision-tree learning system based on these ideas.

WED 10:00–10:25 20G15

Computing in groups of Lie type: generalized row reduction

D. E. Taylor
University of Sydney

In computational algebra systems, such as GAP and Magma, groups are represented in several ways: as permutation groups, as matrix groups or as finitely presented groups. Following the pioneering work of Chevalley and Steinberg there is another way to represent the groups of Lie type, namely by the Steinberg presentation in which the generators are parametrised by the elements of a field. In joint work with Arjeh Cohen and Scott Murray this approach has been implemented in Magma. As part of this work we have produced algorithms to convert between a matrix representation of an element and the corresponding word in the Steinberg generators. For groups of type A_n this is none other than row-reduction and the PLU algorithm. In this talk I will give an overview of this algorithm for all Cartan types.

WED 10:30–10:55 62P35

The use of genetic algorithms in finite element model identification

Swanhild Bernstein
Bauhaus-University Weimar, Mathematical Optimization
Coudraystr. 13B, D-99421 Weimar, Germany

We present a procedure to identify parameters of large structures from given vibration data. The structures are modeled by finite elements and the parameters are identified by an optimization procedure based on genetic algorithms. We use frequency response functions in an output error formulation to state the objective function for our optimization problem. To demonstrate the basic features we consider a simply supported beam and a plate.

Special Session on Financial Mathematics

Talks in this session are held in room MCC4

SAT 16:00–16:25 37N40

On Structure of Correlations in Financial Markets

Victor Korotkich (*) and Galina Korotkich
Central Queensland University

Recent results based on Random Matrix Theory suggest that commonly used methods to find correlations in financial markets are not adequate. This motivates us to develop a new approach to understand the correlations. Computational experiments support the approach and picture the correlations by symmetries in eigenvector distributions of the variance-covariance matrix.

SAT 16:30–16:55 91B70

Approximation techniques for discrete monitored exotic options

Konstantin Borovkov
and
Alex Novikov (*)
University of Technology, Sydney,

We discuss different approaches to pricing discretely monitored lookback and barrier type options. We use the Geometric Levy model for the underlying asset and Esscher transformation for calculating the risk-neutral (martingale) measure. At first we show that the prices of the discretely monitored barrier options can be calculated using recurrent numerical integration in observation dates. Then based on a combinatorial identity for the distribution of the maximum in a random walk along with the Chebyshev polynomials or Gauss-Legendre quadrature approximations for the payoffs we show that both discrete lookback and barrier options can be calculated recursively without numerical integration.

SAT 17:00–17:25 62P05

Contingent Claim Pricing using Probablility Distortion Operators: Methods from Insurance Risk Pricing and their Relationship to financial Theory

Michael Sherris
and
Mahmoud Hamada (*)
University of New South Wales

The paper considers the pricing of contingent claims using an approach developed and used in insurance pricing. The approach is of interest and significance because of the increased integration of insurance and financial markets and also because insurance related risks are trading in financial markets as a result of securitisation and new contracts on futures exchanges. This approach uses probability distortion functions as the dual of the utility functions used in financial theory. The pricing formula is the same as the Black-Scholes formula for contingent claims when the underlying asset price is log-normal. The paper compares the probability distortion function approach with that based on financial theory. The theory underlying the approaches is set out and limitations on the use of the insurance based approach are illustrated. We extend the probability distortion approach to the pricing of contingent claims for more general assumptions than those used for Black-Scholes option pricing.

SUN 09:00–09:25 91B28

Implied Volatility, Realized Volatility, and the Level of Debt Protection

Michael Hanke
School of Mathematics
University of New South Wales

We show that deviations between implied and realized volatility arise naturally in a well-known firm value based (structural) option pricing model. This may explain observed deviations between implied and realized volatility in practice and casts doubt on the widespread practice of using implied volatility as a predictor of future realized volatility.

SUN 09:30–09:55 91B28

Weather Derivatives

Ben Petschel
The University of Queensland

The weather has a large effect on most sectors of the economy. Many businesses, including electricity generators, are managing weather risk through the use of derivative contracts. In this talk we discuss some of the problems encountered in pricing such contracts.

Special Session on Geometry and Topology

Talks in this session are held in room MCC5

SAT 16:00–16:25 53C25

Osserman Conjecture in dimension $\mathbf{n \neq 8, 16}$

Yuri Nikolayevsky
La Trobe University

Let M^n be a Riemannian manifold and R its curvature tensor. For any $p \in M^n$ and unit $X \in T_pM^n$, the Jacobi operator is a symmetric operator on T_pM^n defined by $R_X = R(X, \cdot)X$.

Definition. *A Riemannian manifold M^n is called* pointwise Osserman *if, for every $p \in M^n$, the spectrum of the Jacobi operator is independent of X, and is called* globally Osserman *if it is independent of both X and p.*

Two-point homogeneous spaces (Euclidean spaces, spheres, real and complex and quaternionic projective spaces, Cayley projective plane, and their hyperbolic duals) are globally Osserman, since their isometry groups act transitively on the unit tangent bundle. In 1990, Osserman conjectured the converse:

Osserman Conjecture. *Globally Osserman manifolds are 2-point homogeneous.*

In 1991, Q.-S.Chi proved the Osserman Conjecture assuming the dimension n is odd, or $n \equiv 2 \mod 4$, or $n = 4$. P. Gilkey, A. Swann and L. Vanhecke (1995) showed that in the first two cases, the Conjecture remains true for pointwise Osserman manifolds, while for $n = 4$ there exist pointwise Osserman manifolds which are not two-point homogeneous. Our main result is the following Theorem.

Theorem 1. *Every globally Osserman manifold of dimension $n \neq 8, 16$ is two-point homogeneous.*

For pointwise Osserman manifolds we have:

Theorem 2 *Every pointwise Osserman manifold of dimension $n \neq 2, 4, 8, 16$ is two-point homogeneous.*

For $n = 8, 16$, we can prove the Osserman Conjecture only under additional hypothesis on the spectrum of the Jacobi operator (no eigenvalues of certain multiplicities). The proof uses a two step approach suggested by P. Gilkey, A. Swann and L. Vanhecke, showing:

1. that an Osserman *algebraic* curvature tensor admits a Clifford structure (that is, arises from a unitary representation of some Clifford algebra);
2. that a Riemannian manifold with curvature tensor as in 1 is two-point homogeneous.

SAT 16:30–16:55 14J17, 32B15, 32S05, 32W05

A $\bar{\partial}$-Poincaré Lemma for forms near an isolated complex singularity.

Adam Harris (*) and Yoshihiro Tonegawa
University of Melbourne

Let X be an anlytic subvariety of complex Euclidean space with isolated singularity at the origin, and let η be a smooth form of type (1,1) defined on $X \setminus \{0\}$. Our main result is a criterion for solubility of the equation $\bar{\partial}u = \eta$, which is an application of our earlier work on solvability of the Cauchy-Riemann equation near isolated singularities. The main result also implies an intrinsic criterion for triviality of Hermitian-holomorphic line bundles on $X \setminus \{0\}$.

SAT 17:00–17:25 32Q57

Effective actions of $SU(n)$ on n-dimensional complex manifolds.

Alexander Isaev (*) and Nikolay Kruzhilin
The Australian National University

We give an explicit classification of complex connected manifolds of dimension n that admit an effective action of $SU(n)$ by biholomorphic transformations.

MON 09:00–09:25 57N10

On deformations of hyperbolic structures and normal surface theory

Stephan Tillmann
University of Melbourne

We describe a relationship between ideal points of the deformation variety of (incomplete) hyperbolic structure and normal surfaces associated to an ideal triangulation of a cusped hyperbolic 3-manifold.

MON 09:30–09:55 57R

Topological Rigidity of Haken 4-Manifolds

Bell Foozwell
University of Melbourne

A Haken 4-manifold is an (almost) direct generalization of a Haken 3-manifold. In this talk I will define this class of manifolds, describe some basic results and discuss an approach to proving that homotopy equivalent Haken 4-manifolds are homeomorphic.

MON 10:00–10:25 54D35, 22A20

2-knot groups with abelian HNN bases

Jonathan Hillman
University of Sydney

MON 10:30–10:55 57N10

Geodesic Knots in Cusped Hyperbolic 3-Manifolds

Sally Miller
University of Melbourne

It is known that every finite-volume hyperbolic 3-manifold contains at least one simple closed geodesic, or *geodesic knot*. By studying the limiting behaviour of certain families of these geodesics, we show that every cusped hyperbolic 3-manifold in fact contains infinitely many geodesic knots. This approach also shows that many hyperbolic link complements contain simple closed geodesics of infinitely many different knot types in S^3.

TUE 09:00–09:25 57M27

The Smale conjecture for geometric 3-manifolds

J. H. Rubinstein
Department of Mathematics and Statistics
University of Melbourne

Smale asked whether the group of diffeomorphisms of the 3-sphere to itself is homotopy equivalent to the group $O(4)$ of isometries. This was solved by Hatcher in 1983. Thurston conjectured that 3-manifolds can be decomposed into canonical pieces with geometric structures. For each such geometric 3-manifold, one can study the Smale conjecture. I will survey recent results of Gabai (for hyperbolic 3-manifolds), Agol and I (Seifert fibred spaces) and spherical 3-manifolds.

TUE 09:30–09:55 55P15, 5740

A Generalised Connected Sum

I. Bokor
University of New England

We generalise the notion of a connected sum to certain complexes with the same cellular structure Poincaré duality complexes, namely connected complexes with K cells in dimension $2n$ and one in dimension $4n$. Such complexes include all compact, orientable $(2n-1)$-connected n manifolds, as studied by Milnor.
We show that every such complex can be expressed as the connected sum of a rational Poincaré duality complex and a suspended complex, and discuss the extent to which such a decomposition is unique.

TUE 10:00–10:25 57M50

Universal bounds for hyperbolic Dehn surgery

Craig Hodgson
University of Melbourne

We describe joint work with Steve Kerckhoff using harmonic deformations to estimate the changes in geometry during hyperbolic Dehn filling on cusped hyperbolic 3-manifolds. Applications include a hyperbolic version of the Gromov-Thurston two pi theorem, universal bounds on the number of non-hyperbolic Dehn fillings, and new bounds on the volume of closed hyperbolic 3-manifolds containing a short closed geodesic.

Special Session on Harmonic Analysis

Talks in this session are held in room JDG35

SUN 09:30–09:55 51E24, 60G50

Isotropic random walks on a building

Wolfgang Woess
and
Donald Cartwright (*)
University of Sydney

In a paper published in 1978, Stanley Sawyer studied random walks on homogeneous trees which were"isotropic", meaning that the transition probabilities $p(x, y)$ depend only on the graph distance between the vertices x and y. This definition generalizes naturally to $\tilde{A}_n$ buildings (locally finite and thick); now $p(x, y)$ depends on n "distances". Most of Sawyer's results generalize to this context. The simple random walk on the vertices of such a building is isotropic. Random walks on $SL(n+1, F)$, F a local field, which are bi-$SL(n+1, O)$-invariant lead to isotropic random walks of buildings.

SUN 10:00–10:25 43A62

Amalgam Spaces on the Half-Line

Michael Leinert
and
Walter R Bloom (*)
Murdoch University

Amalgam spaces on the real line were first studied systematically by Finbarr Holland, and formed the basis of a considerable refinement of some of the classical results of Fourier analysis. These are spaces $\left(L^p, \ell^q\right)(\mathbb{R})$ of measurable functions on the real line, given by

$$\left(L^p, \ell^q\right)(\mathbb{R}) = \left\{ f : \|f\|_{p,q} < \infty \right\}$$

where

$$\|f\|_{p,q} = \left(\sum_{n=-\infty}^{\infty} \left(\int_n^{n+1} |f(x)|^p \, dx \right)^{\frac{q}{p}\%} \right)^{\frac{1}{q}}$$

(with the usual conventions when one or both of p, q are infinite). For $p = q$ it should be observed that $\left(L^p, \ell^p\right)(\mathbb{R}) = L^p(\mathbb{R})$ is just the usual Lebesgue space. The study of amalgam spaces dates back to papers of Norbert Wiener in 1926 and 1932, the latter being his celebrated work on Tauberian theorems.
In this talk we introduce some of the main properties of amalgam spaces on the real line, and outline an approach to carrying these over to the half-line with the Bessel-Kingman convolution structure.

SUN 10:30–10:55 43A05

mm-Spaces and group actions

Vladimir Pestov
Victoria University of Wellington

We survey some aspects of concentration of measure in the presence of an acting group, including links to Ramsey theory.

MON 09:00–09:25 17B35

Irreducibility conditions for tensor products of Yangian evaluation modules

A. Molev
University of Sydney

The evaluation homomorphisms from the Yangian $Y(\mathrm{GL}(n))$ to the universal enveloping algebra $U(\mathrm{GL}(n))$ allow one to regard the irreducible finite-dimensional representations $\mathrm{GL}(n)$ as Yangian modules. Necessary and sufficient conditions for irreducibility of tensor products of such evaluation modules are given.

MON 09:30–09:55 45E05

The Square Root Problem of Kato, Survey and Solution

Alan McIntosh
CMA
The Australian National University

About 1960 Tosio Kato of the University of California Berkeley, during his investigation of the evolution of physical systems, was led to pose a key question about the square roots of elliptic partial differential operators. A positive answer to his question implies that the square root is stable under small perturbations, this being useful in solving related hyperbolic equations with time-varying coefficients.

The one-dimensional problem was solved by Coifman, McIntosh and Meyer in 1982, along with the boundedness of the Cauchy integral on Lipschitz curves. It was only in 2000 that the two dimensional version of this problem was answered by Hofmann and McIntosh, to be followed some months later by the full solution of Auscher, Lacey and Tchamitchian, as well as these two.

I will survey this development, and indicate some of the ideas which led to the final solution.

MON 10:00–10:25 22E30

Contractions, Fock spaces and multipliers

A. H. Dooley
University of New South Wales

A contraction of Lie groups is a contiuous deformation from one group to another (in general non-isomorphic). In this talk we shall consider the contraction from K to NM inside the Iwasawa decomposition of a rank one semi-simple Lie group. This generalises the contraction of $SU(2)$ to the Heisenberg group. In recent work with Sanjiv Gupta, I have shown how to prove theorems which allow transfer of L^p estimates in both directions. The key to making them work is to find a new basis for the "Fock space" representation of N.

MON 10:30–10:55 42B30, 42B35, 46A16

On p-convex envelopes and atomic decomposition of Hardy-Lorentz spaces

Sergey Ajiev
The Australian National University

For $p \leq 1$, the p-convex envelope of a quasinormed space X is the smallest (in the sense of imbedding order) p-convex space, in which X is imbedded. Descriptions of p-convex envelopes of Hardy-Lorentz spaces are given. Some known parameters p for Lorentz and Hardy-Lorentz space to be p-convex improved as an application of general result proved. The "tools" are: obtained decomposition of Hardy-Lorentz spaces into atomic complecies, above mentioned general result and properties of p-convex envelope.

WED 09:30–09:55 22E30, 35B40

Regularity for some partial differential operators on Lie groups

Nick Dungey
The Australian National University

We consider some partial differential operators on a Lie group G which generalize the Laplacian on Euclidean space. When G has polynomial volume growth, we describe some known regularity results of a global nature, and some recent extensions. The theory has interesting analogies with the theory of divergence-form elliptic operators on Euclidean space. Some of this work is joint with Derek Robinson and Tom ter Elst.

WED 10:00–10:25 42B20

Weighted $\mathbf{H^p - L^p}$ estimates for imaginary powers of the Laplacian

Hendra Gunawan
Department of Mathematics
Bandung Institute of Technology
Bandung 40132 Indonesia

In this talk I will discuss the boundedness of singular integral operators that are imaginary powers of the Laplacian in $\mathbf{R}^n$ from weighted Hardy spaces $H^p_w(\mathbf{R}^n)$ to weighted Lebesgue spaces $L^p_w(\mathbf{R}^n)$ where $0 < p \leq 1$. In particular, I will present some $H^p_w - L^p_w$ estimates for these operators when $0 < p \leq 1$ and w is in the Muckenhoupt's class A_q for some $q > 1$. This work has recently been accepted for publication in the Bulletin of Australian Mathematical Society.

WED 10:30–10:55

Representations of Kac-Moody algebras and their quantizations

Vyacheslav Futorny
University of Sao Paolo

Theory of Verma type modules for Affine Kac-Moody algebras will be discussed. Such modules correspond to different Borel subalgebras which unlike in the finite-dimensional case are not all congugate. We will also consider certain quantum analogs of Verma type modules for quantized Affine Lie algebras. In fact, these modules are the true deformations of the Verma type modules in the affine case.

Special Session on Integrable Systems

Talks in this session are held in room JD1179

SAT 16:30–16:55 37J35

Integrable mappings of the plane preserving biquadratic invariant curves

John A. G. Roberts
School of Mathematics
The University of New South Wales
Sydney NSW 2052

We provide a general framework to construct integrable mappings of the plane that preserve a one-parameter family of biquadratic invariant curves where the parametrization is very general. These mappings generalise integrable maps previously given in the literature (e.g. the so-called QRT family). We discuss normal forms and elliptic parametrisations for symmetric and asymmetric biquadratics.

SAT 17:00–17:25 39A13

Bilinear Form for the lattice Boussinesq equation

Kenji Kajiwara
and
Ken-ichi Maruno (*)
Kyushu University, Japan

The lattice Boussinesq equation derived by Nijhoff et al is transformed into bilinear form and the solutions (e.g. Casorati determinant solution) are constructed by Hirota's method. The lattice modified Boussinesq equation is also investigated by Hirota's method. These solutions are derived from solution of Hirota-Miwa equation by the pseudo-reduction technique.

SUN 09:00–09:25

Some remarks on Poiseuille flow

J. Bryce McLeod
University of Pittsburgh

SUN 09:30–09:55 35K35

Solved and Unsolved Boundary Value Problems with Classically Integrable PDEs

Philip Broadbridge
Institute for Mathematical Modelling and Computational Systems
University of Wollongong

Directly linearisable PDEs may be solved for a variety of boundary conditions, sometimes providing exact testable solutions for real nonlinear processes. For example, the integrable quasilinear convection-diffusion equations can be solved on the half line for any piecewise-constant flux boundary conditions. The solutions explained some puzzling field data for soil ponding times during irrigation. Some special boundary conditions resembling a passing storm or an opening irrigation system, were also incorporated. The same equation with constant-concentration Dirichlet boundary conditions transforms to an interesting linear problem that I haven't yet solved. After potentiation, we arrive at an integrable fully nonlinear diffusion equation $y_t = D(y_{xx})$, where $D(s) = 1/(b - s)$. This is an example of a critically degenerate equation. If $D(s) = o(s^{-1})$, then initial points (x, y) with infinite curvature will continue to have infinite curvature for some finite time. An exactly solvable model with this property is given. Higher order members of the classically integrable hierarchy include a close relative of the IST-integrable Dym equation, and a surface diffusion equation for an anisotropic material.

SUN 10:00–10:25 35L15

Symmetry Groups, Riemann's Method and The Inverse Problem Of Scattering Theory

Peter Zeitsch
School of Mathematics and Statistics
University of Sydney

Riemann's method is one of the definitive ways of finding the fundamental solution for a linear hyperbolic PDE in two variables. The idea of applying Lie Point Symmetries to finding Riemann functions is well established. The results of such searches have invariably led to equations which are isomorphic to Riemann's original example, the EPD equation. However if one looks beyond point symmetries to the logical extension of Lie-Backlund symmetries then a new equivalence class of Riemann functions obtainable only by a generalised symmetry acting on Chaundy's equation is derived. In conclusion these results are connected to the inverse problem of scattering theory.

SUN 10:30–10:55 35Q55

Multisoliton complexes in a sea of radiation modes

Adrian Ankiewicz, Nail N. Akhmediev
and
Andrey A. Sukhorukov(*)
Nonlinear Physics Group
Research School of Physical Sciences and Engineering
Institute for Advanced Studies
The Australian National University

We derive exact analytical solutions of the integrable set of coupled nonlinear Schrodinger equations describing multi-soliton complexes and their interactions on top of a multi-component background in media with self-focusing or self-defocusing Kerr-like nonlinearities. In particular, we establish a rigorous relationship between the eigenvalues of incoherently-coupled fundamental solitons and the range of admissible intensities. These results are illustrated by numerical examples which demonstrate soliton collisions and field decomposition between localized and radiation modes.

WED 09:00–09:25 33E17, 34M55

Painlevé Equations - Nonlinear Special Functions

Peter A Clarkson
Institute of Mathematics and Statistics
University of Kent
Canterbury, CT2 7NF, UK

The six Painlevé equations (PI-PVI) were first discovered about a hundred years ago by Painlevé and his colleagues in an investigation of nonlinear second-order ordinary differential equations. Recently there has been considerable interest in the Painlevé equations primarily due to the fact that they arise as reductions of the soliton equations which solvable by inverse scattering. Consequently the Painlevé equations can be regarded as completely integrable equations and possess solutions which can be expressed in terms of solutions of linear integral equations, despite being nonlinear equations. Although first discovered from strictly mathematical considerations, the Painlevé equations have arisen in a variety of important physical applications including statistical mechanics, plasma physics, nonlinear waves, quantum gravity, quantum field theory, general relativity, nonlinear optics and fibre optics.

The Painlevé equations may be thought of a nonlinear analogues of the classical special functions. They possess hierarchies of rational solutions and one-parameter families of solutions expressible in terms of the classical special functions, for special values of the parameters. For example, there exist solutions of PII-PVI that are expressible in terms of Airy functions, Bessel functions, parabolic cylinder functions, Whittaker functions and hypergeometric functions respectively. Further the Painlevé equations admit symmetries under affine Weyl groups which are related to the associated Bäcklund transformations.

In this talk I shall describe some of plethora of remarkable properties which the Painlevé equations possess including connection formulae, Bäcklund transformations, associated discrete equations, and hierarchies of exact solutions.

WED 09:30–09:55 34M55

Schlesinger systems their reductions and classical solutions

Dr Marta Mazzocco
Mathematical Institute, Oxford, UK

Our aim is to find a general approach to the theory of classical solutions of the Schlesinger systems based on the Riemann-Hilbert problem and on the geometry of the space of isomonodromy deformations. Our approach consists in determining the monodromy data of the corresponding Fuchsian system that guarantee to have a classical solution of the Schlesinger systems.

WED 10:00–10:25 37K05, 70H20

Equivalence of superintegrable Hamiltonians in two dimensions

Jonathan Kress
School of Mathematics
UNSW

When a Hamiltonian on the Euclidean plane, $H = p_x^2 + p_y^2 + V(x, y)$, or the two-sphere, $H = J_x^2 + J_y^2 + J_z^2 + V(x, y, z)$ (with $x^2 + y^2 + z^2 = 1$), is integrable and admits more than 2 functionally independent constants it is said to be superintegrable. For constants quadratic in the momenta, all such superintegrable Hamiltonians are known. This list can be extended to two-dimensional spaces of non-constant curvature and in the process some new transformations relating the previously known superintegrable Hamiltonians are found.

WED 10:30–10:55 34M55

New Transformations for Painlevé's Third Transcendent

N.S. Witte
Department of Mathematics and Statistics and School of Physics
University of Melbourne
Victoria 3010, Australia

We present new transformations for the third transcendent of Painlevé that are entirely analogous to Gambier's 1909 transformation of the second transcendent, which relates a transcendent with parameter $\alpha = 0$ to those with $\alpha = \pm 1/2$. In the case of the third transcendent these transformations relate transcendents with parameter coordinates located at the corners of the Weyl chamber for the symmetry group of the system, the affine Weyl group of the root system $B_2^{(1)}$, to those at the origin. We demonstrate that the transformations in both cases share many properties, such as having additive identities for the Hamiltonians and multiplicative ones for the τ-functions, and differing from the earlier known Bäcklund transformations in similar ways.

Special Session on Mathematical Physics

Talks in this session are held in room MCC6

SUN 09:30–09:55 53B15,83C60,83E15

Gravitating Algebraic Spinors on Clifford Manifolds

JS Roy Chisholm
University of Kent

A Clifford manifold is defined by a position-dependent frame field and metric, satisfying the usual Clifford algebraic anti-commutation rules. At each point x, orthonormal basis sets of the frame field define the tangent space and the spin group. The Riemannian and spin connections are defined by imposing covariance under coordinate and spin group transformations. Then the frame field is necessarily parallel transported as a spin vector, subject to both connections.
Contraction of parallel transported vector fields with the frame field defines 'spin elements' which are parallel transported with two-sided spin connection. Idempotents, and hence algebraic spinors, are defined in terms of spin elements, and it is shown that the idempotent property is preserved under parallel transport.
The two-sided spin connection gives rise to an extra interaction term of the kind studied earlier, proportional to the algebraic unit. It is suggested that this term might be the source of a cosmological 'constant'. More generally, it is conjectured that the necessary asymmetry of spinor idempotents might be the source of asymmetries observed in nature.

SUN 10:00–10:25 81T13, 81R20, 81V10

The Maxwell-Dirac Equations – Some Non-Perturbative Results

Chris Radford
UNE Armidale
NSW 2351, Australia

This talk will look at the Maxwell-Dirac equations, the equations of classical (or first quantised) electronic matter. We will be concerned with non-perturbative properties which often have real physical meaning—total electric and magnetic charge, decay at infinity. The context of the talk will be the possible construction of a Maxwell-Dirac model of a single isolated electron.

SUN 10:30–10:55 82B23

Solvable quantum spin ladders

Mark Maslen
The Australian National University

The Yang-Baxter equation, as the masterkey to integrability, is at the heart of exactly solvable quantum spin chains. It has recently become apparent that certain solutions of the Yang-Baxter equation can also be interpretted as solvable quantum spin ladders. These ladder-like arrays are experimentally realisable systems of coupled spin chains of great interest in condensed matter physics. Our work has found models which may be solved for general spin, and for a general number of ladder legs. Analysis of magnetic effects is also carried out, and it is found that the ladders exhibit magnetisation plateaus of relevance to the experimental systems.

MINI-SESSION ON COMBUSTION

MON 09:00–09:25 76M45, 80A32

Limitations of one-step chemical model; simple chain-branching premixed flames

Rodney Weber
and
John Dold (*)
UMIST, UK

A simple chemical model, that has served as a successful paradigm in very many theoretical descriptions of combustion phenomena, assumes that an exothermic reaction proceeds in one irreversible step. The rate of the reaction is determined by an activation energy that is used as a large parameter in obtaining asymptotic solutions. However, in the case of flame-balls (stationary spherically symmetric flames in the absence of gravity) it has recently been found that the one-step model requires unphysically large activation energies to describe these experimentally observed structures. The reasons for this will be reviewed and an alternative model presented, involving branching (or autocatalysis) of a reactive intermediate species and an exothermic recombination reaction. This model, which is still relatively simple, leads to a satisfactory asymptotic description of flame-balls and their stability. It can also describe non-stationary, propagating premixed flames.

MINI-SESSION ON COMBUSTION

MON 10:30–10:55 35K55

Numerical methods for the travelling wave solutions in reaction-diffusion equations

Vladimir Gubernov
School of Mathematics and Statistics
University College (UNSW)
ADFA

In this work we consider how shooting and relaxation methods can be used to investigate propagating waves solutions of PDEs. Particular attention is paid to overcoming some of the numerical difficulties. The linear stability of these solutions a re analysed by using the Evans function approach. As an illustration, we shall apply the above methods to an autocatalytic reaction involving two diffusing chemicals in one spatial dimension. Prospects of further work are also discussed.

MINI-SESSION ON COMBUSTION

MON 10:00–10:25 80A25

Cubic autocatalysis with Michaelis-Menten kinetics: semi-analytical solutions for the reaction-diffusion cell

T. R. Marchant
University of Wollongong

The cubic-autocatalytic reaction, with decay of the autocatalyst governed by M-M kinetics, is considered in a one-dimensional reaction-diffusion cell. A two-term Galerkin method is used to approximate the governing reaction-diffusion equations by a set of ordinary differential equations, which can be analysed analytically using the techniques used on CSTR systems.
Steady-state solutions are found using a one and two-term Galerkin method. For the one-term method explicit solutions are found while for the two-term method transcendental equations are obtained. A good comparison is found between the semi-analytical results and numerical solutions of the governing partial differential equations.
Singularity theory is used to determine the regions of parameter space in which each of the four main types of steady-state bifurcation pattern occurs. A local stability analysis is also performed on the ordinary differential equations to determine the region of parameter space in which Hopf bifurcations occur.

MON 16:00–16:25 81T30, 19K99

D-branes, bundle gerbes and K-theory

P. Bouwknegt
Department of Physics and Mathematical Physics
and
Department of Pure Mathematics
University of Adelaide
Adelaide, SA 5005

The low-energy effective field theory of strings in the presence of D-branes contains fields which are most naturally interpreted as connections on a bundle gerbe module. In this talk we will give a conceptual introduction to bundle gerbes and their modules, and explain why the K-theory of bundle gerbe modules classifies D-brane charges. The talk is based on joint work with Alan Carey, Varghese Mathai, Michael Murray and Danny Stevenson.

MON 16:30–16:55 37K10

A continuous limit of triple tau-function's model

Vladimir Mangazeev
The Australian National University

We present an integrable system of the second order nonlinear differential equations for three fields in the three-dimensional space. The system is obtained as the continuous limit of the discrete equations for the triple tau-function's model. We also give a parameterization of solitonic solutions, hamiltonian formulation and describe the corresponding linear problem.

TUE 09:00–09:25 05A15

Vicious walkers between two walls

C. Krattenthaler, X. G. Viennot
and
A. J. Guttmann (*)
University of Melbourne

In earlier work we considered networks of directed, vicious walkers that are otherwise unconstrained, then in the presence of a wall. In this work we consider the effect of a second, parallel wall—so that the walks are confined to a slit.

TUE 09:30–09:55 82B41

Functional form versus singularity structure in some integrable lattice models of polymers and vesicles

Aleks L. Owczarek
University of Melbourne

In the context of lattice models of polymers and vesicles we discuss recent developments in the solution of "hard" statistical mechanical lattice models. In particular we highlight the difference between the "complexity" of the solution, as give n by the "type" of function concerned, and its importance in terms of theoretical physics, usually related to the singularity structure of the function. We demonstrate that this relationship is not always straightforward.

TUE 10:00–10:25 00A79

Combinatorical and algebraic nature of a Markov process.

Jan de Gier
The Australian National University

It is shown that the stationary probability distribution of a particular Markov process has the combinatorial meaning of counting certain symmetry classes of plane partitions. Some of the mathematical and physical implications are sketched of this surprising result.

Special Session on Mathematics Education

Talks in this session are held in room MCC1

SUN 09:00–09:25 97C30

Cognition and problem solving

John Sweller
University of New South Wales

Many of the structures that constitute human cognitive architecture are now well-known and uncontroversial. They include an extremely limited working memory that can be equated with consciousness and a huge long-term memory holding immeasurable amounts of information organised in schematic form. Learning consists of schema construction and is intended not only to increase the information held in long-term memory but also to organise it in a manner that allows it to be processed in limited capacity working memory. This architecture results in problem solving skill in mathematics or any other area being totally reliant on the contents of long-term memory. Many current educational prescriptions that emphasise problem solving skill at the expense of knowledge held in long-term memory have the inevitable effect of reducing problem solving skill.

SUN 09:30–09:55 97

The first year experience

Karen Baker
University of Melbourne

For several years efforts have been made in the Department of Maths/Stats at the University of Melbourne to interest the mathematically very capable students who might otherwise be unchallenged through Year 12 and their early undergraduate years. Programs are ongoing.
One program is the (pure acceleration) MUPHAS Mathematics subject which selected students may take in Year 12. On entry to Maths/Stats at UniMelb these students my proceed to some second year maths in their fresher year.
Another effort is in "Advanced Plus" subjects, which involves students in taking classes in special topics over and above the normal lecture system. These subjects are offered in semester two of first year and also in second year. Most of these special topics reflect the research interests of staff in the Department.

SUN 10:00–10:25 97D

Learning mathematics - the teacher is still the key

Steve Thornton
Australian Association of Mathematics Teachers/University of Canberra

Changes in technology, curriculum, teaching methods or theories of students' learning do not change the one critical ingredient in school mathematics - the teacher. This contribution to the forum on school mathematics will focus on the role of the Australian Association of Mathematics Teachers (AAMT) in promoting high professional standards for teachers of mathematics, and what those standards might mean for the profession, and for mathematics education.

SUN 10:30–10:55 97

Developing a School Mathematics Syllabus

Bill Pender
Sydney Grammar

Another review of NSW Mathematics Syllabuses has begun. It is the latest in an exhausting fifteen-year sequence of reviews which have improved nothing and caused significant damage, although so far the excellent HSC calculus courses in NSW remain unscathed. The present system of reviews is acrimonious and dangerously unstable, with changes initially driven by ever-changing educational fashions and subsequently resisted by groups of experienced teachers and academic mathematicians. A more rational approach is needed in which syllabus development at each stage is guided instead by experienced teachers' knowledge of the realities of classroom teaching and mathematics academics' knowledge of the methods and structures of the subject.

MON 09:00–09:25 97D

The mathematics of decision-making: A project-based first-year business mathematics course

William McCallum
University of Arizona

I will describe a new course at the University of Arizona, developed in collaboration with the College of Business and Public Administration, which uses business decisions to teach students the mathematical and computer skills they will need in their business careers.

MON 09:30–09:55 97B

The Australian Science and Mathematics School

John Rice
Flinders University

The Australian Science and Mathematics School is a year 10, 11 and 12 public school for 450 students, to be built on Flinders University Campus, and opening in 2003. It will offer a comprehensive curriculum focussed on science and mathematics. Its work will be driven by interaction between its staff and scientists and educators at Flinders University. It is intended to change the professional environment in which teachers work, and the culture of science and mathematics teaching. Its network of alliance schools will allow it to influence science and mathematics teaching across the SA state system.

MON 10:00–10:25 97

Mathematics in the Political Arena

Jan Thomas
Australian Mathematical Society

"Mathematical Sciences in Australia: Looking for a Future" preceded the Government's innovation package "Backing Australia's Ability" and the Labor Party's "Knowledge Nation". "Backing Australia's Ability" is already being implemented and has little in it for mathematics. "Knowledge Nation" is, at this stage, not spelt out in policies. It mentions mathematics frequently but has no specific initiatives. This talk will try and summarise the current state of the mathematical sciences in the light of these two documents and related matters.

MON 16:00–16:25 97D4

Hands-on Problems at Tertiary Level

Neville de Mestre
Bond University

Since 1975 I have been developing hands-on mathematical problems at primary and secondary level. Australia is years ahead of any other country in this field, and the Australian Mathematical Society plus ANZIAM have financially supported this development for many years. I feel that it is now time to extend the ideas to tertiary-level teaching and learning. Some initial problems will be given in the hope that this will stimulate mathematicians all over Australia to suggest others so that we all can begin to introduce this added asset to university teaching.

MON 16:30–16:55 97U40

Seeing Maths in Action proves thought-provoking and fun!

Antoinette Tordesillas
and
Christine Mangelsdorf (*)
University of Melbourne

This presentation reports on the highlights of a one-day Maths Fair in Melbourne for year 11-12 students and their teachers. The objective of the fair was to raise public awareness of the importance of mathematics today as well as of career opportunities for mathematics and statistics graduates. The two key events were:

1. Mathematicians Exposed! This showcased career profiles of mathematics and statistics graduates, and gave a snapshot of the breadth of areas where maths is used.
2. Maths in Industry and Technology (MIT) Challenge.

This challenge was for teams of 4 students (the "consultants") to establish a solution approach in 3 hours to a real world problem presented by an industry representative (the "client"). In this talk, I will describe the wide range of activities that participants were engaged in including the MIT Challenge which gave students a taste of "real-world consulting".

MON 17:00–17:25 97A20

Maths Talkback and the SMART program

Jacqui Ramagge
The University of Newcastle

The University of Newcastle has several innovative and constructive outreach schemes in the areas of Science and Engineering. Perhaps the most suprising of these is the "Maths Talkback" session on Radio 2NC, the local ABC radio station. I will (try to) describe the key to its success and put it into context by outlining some of the other activities we run.

TUE 10:00–10:25 97-06

QUT's Mathematics Access Centre: A "Postmodernist" Approach to Flexibility in Mathematics Teaching and Learning

Peter Coutis
School of Mathematical Sciences
Queensland University of Technology

The pressures brought to bear on educators and students of Engineering and Mathematics have increased dramatically over the last decade. A softening of entry prerequisites, substantial increases in the number of mature age, part-time and alternative entry students, and high school curriculum reforms that have de-emphasised manipulative skills have substantially increased the diversity of commencing cohorts. In particular, many students display troubling deficiencies in mathematical preparedness and a large number are lost to the system through attrition. What is required to ameliorate the current situation is a "postmodernist" approach to flexibility in Mathematics teaching and learning where the focus is more about access to ideas and achievement through close personal interaction between students and teachers, than access to materials online.

We are fortunate at QUT that the needs of current Mathematics student cohorts were recently given explicit recognition in the form of a Large Teaching and Learning Development Grant awarded jointly to the Faculties of Science and Built Environment and Engineering. The main product of this grant is the Mathematics Access Centre which will offer supplementary learning support programs to first-year students as of semester 2, 2001. In this seminar I will provide details of each of the Access Centre's programs, highlighting in particular the relationship between these programs and current mainstream teaching activities. Student data will be used to provide a "snapshot" of typical cohorts in Science and Engineering degree programs at QUT, and to motivate the activities of the Access Centre. A summary of program evaluations conducted to date will also be provided.

TUE 10:30–10:55 97C

Gird the loins; don't hide the head! The changing face of undergraduate mathematics.

Patricia Cretchley
University of Southern Queensland

We face major challenges in undergraduate mathematics curricula and delivery, possibly now more than ever before, and there are issues that need our urgent attention and careful consideration. The way in which we respond to these challenges, as educators, is playing a major role in determining the path for the future. This talk will outline some major current national and international initiatives aimed at raising the profile of undergraduate mathematics learning and teaching, and will invite discussion among delegates on further ways in which we can identify and address current and future issues, and consider appropriate responses, both proactive and reactive.

Special Session on Operator Theory and Functional Analysis

Talks in this session are held in room JDG35

SAT 16:00–16:25 47L80

Operator algebras associated with transmission problems

Andreas Axelsson
The Australian National University

Let Ω^+ and Ω^- be two complementary domains in $\mathbf{R}^n$ separated by a Lipschitz surface Σ. Consider the transmission problem consisting of finding a pair of functions $F^\pm(x)$ in $\Omega^\pm$ satisfying an elliptic constant coefficient equation $\mathbf{D}F^\pm(x) = 0$ in $\Omega^\pm$ and some given jump condition on Σ. This problem can be solved by inverting a singular integral equation on Σ. The functional analysis structure behind all this is an operator algebra generated by two idempotents. I will decribe how the classical Gelfand theory for commutative Banach algebras can be extended to "slightly" non-commutative algebras, and how this produces a Clifford algebra valued Gelfand transform for operator algebras generated by two idempotents.

SAT 16:30–16:55 54C65, 46T20, 58C20

Usco selections of set-valued mappings

Warren Moors
and
Sivajah Somasundaram (*)
The University of Waikato
Hamiton, New Zealand

A set-valued mapping $F : X \to 2^Y$ acting between topological spaces X and Y is called an *usco* mapping if for each $x \in X$, $F(x)$ is a non-empty compact subset of Y and for each open set W in Y, $\{x \in X : F(x) \subseteq W\}$ is open in X. Giles and Moors (2001) showed that every lower-semicontinuous mapping (i.e: for every open set W in Y, $\{x \in X : F(x) \bigcap W \neq \emptyset\}$ is open in X) from a Baire space X into non-empty closed subsets of a complete metric space Y contains a densely defined usco selection. In this talk we present a result more general than the one above. Some applications of our result will also be presented.

SAT 17:00–17:25 46B20

A differentiability characterisation of Banach Spaces with the Radon-Nikodym Property

John Giles
School of Mathematical and Physical Sciences
University of Newcastle

It has been shown that a Banach space X is Asplund if and only if for every equivalent norm on X, the corresponding induced norm on $X^{\star\star}$ is Gâteaux differentiable at some point of $\widehat{X}$, [*Bull. AustMS*, **56** (1977), p. 265]. Recently it has been shown that a Banach space X has the Radon Nikodym Property if and only if every continuous weak* lower semi-continuous convex function on $X^\star$ is Gâteaux differentiable at some point of its domain with derivative in $\widehat{X}$, [Bachir and Daniilidis, *Bull. AustMS*, **62** (2000), p. 379]. We extend their result to show that a Banach space X has the Radon-Nikodym Property if and only if every continuous weak* lower semi continuous gauge on $X^\star$ has a point of its domain where its subdifferential is contained in $\widehat{X}$. This provides an extension to our characterisation of Asplund space.

SUN 09:00–09:25 46L55

Some connections between crossed products and number theory

Nathan Brownlowe
University of Newcastle

A Hecke $\mathbf{C}*$-algebra studied by Bost and Connes can be realised as a semigroup crossed product. In this talk, we shall realise semigroup crossed products and the particular examples which yield this and similar $\mathbf{C}*$-algebras. We show through the analysis of subquotients of these semigroup crossed products that interesting number theoretic facts are encoded in the fine structure of these $\mathbf{C}*$-algebras.

MON 16:00–16:25 46L40

Invariant inductive limit decompositions of irrational rotation C∗-algebras

Peter Stacey
La Trobe University

An irrational rotation $C*$-algebra can be written as a direct limit of algebras, each of which is the direct sum of two matrix algebras over the algebra of continuous functions on the circle. The invariance of such direct limit decompositions under some automorphisms and antiautomorphisms will be discussed.
After a definition of irrational rotation algebras the talk will include a brief outline of the direct sum decomposition, due to Elliott and Evans and simplified by Elliott and Lin. This will be followed by a description of toral automorphisms and antiautomorphisms and some results about the possibility of choosing compatible direct sum decompositions.

MON 16:30–16:55 46L05

C^*-algebras of graphs and shift equivalence

Teresa Bates
School of Mathematics
University of New South Wales

A directed graph $E = (E^0, E^1, r, s)$ consists of countable sets E^0 of vertices, and E^1 of edges, together with maps $s : E^1 \to E^0$ and $r : E^1 \to E^0$ describing where the edges begin and end. Alex Kumjian, David Pask and Iain Raeburn have defined a universal C^*-algebra $C^*(E)$ associated to the directed graph E. These graph C^*-algebras form an important class of examples of C^*-algebras.
In this talk we discuss several graph operations which preserve either the isomorphism or Morita-Equivalence class of the C^*-algebra of the original graph. The operations discussed bear a strong relationship with the study of flow-equivalence in topological dynamics.

MON 17:00–17:25 46L55

Proper actions on C*-algebras

Iain Raeburn
University of Newcastle

In studying actions of a compact group G on an algebra A, an important ingredient is the fixed-point algebra A^G. For actions of locally compact groups, though, A^G can easily be $\{0\}$. An action of a group G on a locally compact space P is called proper if the map $(g, p) \mapsto (p, g \cdot p)$ is proper, in the sense that the inverse images of compact sets are compact. The orbit space $G \backslash P$ is then itself locally compact Hausdorff, and the space $C_0(G \backslash P)$ is a good substitute for $C_0(X)^G$.
Rieffel has identified a class of proper actions on noncommutative C^*-algebras for which there is a good "generalised fixed-point algebra" A^G. Examples include dual actions, various actions on induced C^*-algebras, and, most recently, actions on graph algebras arising from coverings. In this talk we shall discuss recent work with Astrid an Huef and Dana Williams in which we have been looking at Morita equivalences associated to Rieffel's proper actions.

TUE 09:00–09:25 47B40

An example in the theory of AC-operators

T.A. Gillespie
and
Ian Doust (*)
University of New South Wales

AC-operators are a generalization in the context of Banach spaces of normal operators on Hilbert space. It had been shown that compact AC-operators have a representation as a conditionally convergent sum reminiscent of the spectral representations for compact normal operators. In this representation, the eigenvalues had to be taken in a particular, rather odd, order to ensure convergence of the sum. A more natural order would have been to have to arrange the eigenvalues $\{\lambda_j\}$ so that $|\lambda_1| \geq |\lambda_2| \geq \dots$. In this talk I shall explain a construction which shows that you can (almost) always construct a compact AC-operator so that the representation does not converge in this more natural order.

TUE 09:30–09:55 47H9, 47H10

Inheriting the weak fixed point property

Brailey Sims
University of Newcastle

A Banach space X enjoys the *weak fixed point property for nonexpansive maps* (w-fpp, for short) if every nonexpansive self mapping of a nonempty weakly compact convex subset of X has a fixed point.
If $\mathcal{P}$ is a Banach space property sufficient for the w-fpp, inheritance/stability results have been of the form: if X is a Banach space with $\mathcal{P}$ and the Banach-Mazur distance between Y and X is sufficiently small then Y has the w-fpp. We explore the potential of using other (non-symmetric) distance measures in this context.

TUE 10:00–10:25

Compactness of the integration maps for vector measures

Werner Ricker, Luis Rodríguez-Piazza
and
Susumu Okada (*)
University of New South Wales

Let $(\Omega, \Sigma, \lambda)$ be a finite measure space and let $1 \leq p < \infty$. Given a continuous linear operator $T : L^p(\lambda) \to L^p(\lambda)$, the $L^p(\lambda)$-valued set function $m_T : E \mapsto T(\chi_E)$, where χ_E is the characteristic function of each set $E \in \Sigma$, is necessarily σ-additive, i.e. a *vector measure*. It is known that the space $L^1(m_T)$ is the largest Banach function space (with order continuous norm) into which $L^p(\lambda)$ is continuously embedded and to which the map T has a continuous extension $I_{m_T} : L^1(m_T) \to L^p(\lambda)$. This extension is the *integration map* $I_{m_T} : f \mapsto \int_\Omega f \, dm_T$. Even when T is compact, its associated integration map may not be compact, in general vector measures m for which the integration map I_m is compact. As an application, some kernel operators such as the Volterra operator on $L^1([0,1])$ and convolution operators on a compact abelian group will be considered.

TUE 10:30–10:55 28A12

Irrational Rotations Motivate Measurable Sets

Rodney Nillsen
Department of Mathematics
University of Wollongong

A major role in the theory of measure and integration is played by the notion of a measurable set. The definition of a measurable set given by Carathéodory in 1915 defines such a set with respect to a given outer measure, which is a non-negative, countably subadditive set function on some given set. The outer measure is then a countably additive set function (or measure) on the family of measurable sets. Carathéodory's definition has frequently been the subject of comment in a way unusual for a mathematical concept. For example, Edwin Hewitt and Karl Stromberg write: "How Carathéodory came to think of this definition seems mysterious, since it is not in the least intuitive." Many results in analysis are stated most naturally in terms of measurable sets. For example, let $\mathbb{T}$ denote the unit circle and let ρ be an irrational rotation on $\mathbb{T}$. Then, if A is a measurable subset of $\mathbb{T}$ such that $\rho(A) = A$ (in this case A is called invariant), A has measure 0 or 1. However, the fact that such results assume a knowledge of measure theory creates a barrier to the student who has not encountered measure theory before.

The approach in the talk is to consider the problem of finding the *outer* measure of an invariant set of an irrational rotation on $\mathbb{T}$. By considering only the outer measure, we avoid the need to consider the notion of measurable set. Rather, we are led to the Carathédory definition of a measurable set by the problem of trying to say something about the outer measures of the invariant sets of an irrational rotation. Thus, Carathéodory's definition is motivated by a specific "problem situation" which, incidentally, leads to new results concerning invariant sets.

Special Session on Partial Differential Equations

Talks in this session are held in room MCC5

SUN 09:00–09:25 83C05, 83C15

Magnetic Spacetimes in General Relativity

Mark Aarons
Monash University

It is well known that the field equations of General Relativity have some striking similarities with Maxwell's equations. Given this correspondence, it is natural to ask whether there exist solutions of the field equations which are analogous to Dirac's magnetic monopole. Whilst this question still remains open, recently a physically plausible perfect fluid solution was discovered by Lozanovski and Aarons (see [1]). This solution obeys the weak, dominant and strong energy conditions, demonstrating that such solutions need not be pathological. We derive this solution, and outline on-going work on the vacuum case.

[1] C. Lozanovski and M. Aarons 1999 *Irrotational perfect fluid spacetimes with a purely magnetic Weyl tensor*, Class. Quantum Grav. 16 4075-4083

SUN 09:30–09:55 53C44

The surface area preserving mean curvature flow

James McCoy
Monash University

Let M_0 be a compact, uniformly convex, n-dimensional hypersurface without boundary, smoothly embedded in $\mathbb{R}^{n+1}$. Then the evolution of M_0 by the surface area preserving mean curvature flow has a smooth solution for all time, which converges exponentially to a round sphere of the same surface area as M_0. We discuss the similarities and differences in the proof of this result to Gerhard Huisken's work in *The volume preserving mean curvature flow*. In particular, to obtain a pinching estimate on the principal curvatures and to estimate higher derivatives of the curvature under this flow, we first establish that as long as the solution exists, it remains within a bounded region of $\mathbb{R}^{n+1}$. We also use versions of the Aleksandrov-Fenchel inequality for mixed volumes. Similar techniques can be applied to simplify the argument for the bound on the gradient of the mean curvature in the volume preserving case.

SUN 10:00–10:25 35B65

Gradient estimates for quasilinear parabolic equations in one space variable

Julie Clutterbuck
The Australian National University

For quasilinear parabolic equations in one space variable

$$u_t = a(u_x)u_{xx} + b(u_x)$$

where $b > 0$, and where we can find positive constants c_1 and c_2 so that $a(p)p^2 \geq c_1$ for all $p > c_2$, we can construct explicit barriers in order to find gradient estimates of the form

$$|u_x| \leq c_3 \left(1 + t^{3/2} \exp(c_4/t)\right)$$

where c_3 and c_4 are dependent on $\sup |u(\cdot, 0)|$.
The technique follows that used by Kruzhkov to find estimates

$$|u_x| \leq c(1 + \sup |u_x(\cdot, 0)|),$$

the improvement here being the removal of dependence on the initial gradient bound.

SUN 10:30–10:55 35J55

Zero Energy Resonance in Trace Formula

Gilles Carron
Nantes

If A is a hermitian matrix then the singularity at $z = 0$ of the function $z \mapsto Tr(A + zId)^{-1}$ is $\dim \ker A/z$. We explain how to generalise this carefully for "laplacian" of asymptotically Euclidian space.

MON 16:00–16:25 35J55

Regularity at the free boundary for solutions of systems of elliptic equations in divergence form

Joseph F. Grotowski
Mathematisches Institut
Universität Erlangen-Nürnberg
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We consider boundary regularity for solutions of certain systems of second-order nonlinear elliptic equations. We obtain a general criterion for a weak solution to be regular in the neighbourhood of a given boundary point, i.e. a so-called epsilon-regularity theorem. The proof yields directly the optimal regularity for the solution in this neighbourhood. This result is new for the situation under consideration (general nonlinear second order systems in divergence form, with inhomogeneity obeying the natural growth conditions).
Even in the special case of quasilinear systems, we are able to provide a new contribution, as existing results were concerned either with special structures ('diagonal form') or with more restrictive structures for the inhomogeneity. We also provide examples showing the optimality of the results obtained.

MON 16:30–16:55 35J60

Weingarten hypersurfaces with prescribed gradient image

John Urbas
The Australian National University

I will describe recent work on the existence of smooth uniformly convex solutions of a class of curvature equations subject to the boundary condition that the gradient image of the solution is prescribed.

MON 17:00–17:25 35J

Some new results on minimizing harmonic maps

Min-Chun Hong
The Australian National University

In 1977, Hildebrandt, Kaul and Widman discovered that $x/|x|$ from n-ball B^n into the sphere S^{n-1} is a weakly harmonic map. The question of whether the map is a minimizer of some energy functional has aroused great interest. There exist two long-standing problems regards to this question. I will survey a lot of interesting results to these two problems. Finally, I will report that two long-standing problems have been completely answered.

WED 09:00–09:25

Patterned solutions as attractors for reaction diffusion problems with spatial inhomogeneities

John Norbury
Mathematical Institute
Oxford University

A class of physically interesting reaction diffusion problems whose reactions and/or diffusions depend on location in the physical domain, but which are odd symmetric in the dependent variable, possess attracting slow manifolds. The geometry of these slow manifolds is characterised by the extremal geodesics of the domain using a metric defined by the small diffusion limit of the problem. This result is established by using an underlying energy functional and gamma convergence in the small diffusion limit. Various existence, stability and numerical results appear in Norbury and Yeh, Nonlinearity, July 2001.

WED 09:30–09:55 81T13

Boundary algebras of hyperbolic monopoles

Paul Norbury
Adelaide University

We prove the conjecture that a monopole in hyperbolic space can be completely determined by its “holographic” image on the conformal boundary two-sphere. The main tool used is an n-point function defined for a given monopole and any ordered collection of points on the conformal boundary two-sphere. The n-point function can be used to define structure coefficients of an interesting associative algebra abstractly generated by the points of the conformal boundary two-sphere.

WED 10:00–10:25 35, 58

Dirichlet eigenfunctions and quantum ergodicity

Andrew Hassell
The Australian National University

This is joint work with Steve Zelditch (Johns Hopkins). It has been shown that if the classical billiard flow on a planar domain is ergodic, then the eigenfunctions for the Dirichlet Laplacian are ergodic (uniformly spread in phase space, in a precise sense). Here we investigate the normal derivatives of the eigenfunctions at the boundary. We show that if the bouncing ball map on the boundary is ergodic, then the sequence of functions consisting of normal derivatives of eigenfunctions is quantum ergodic.

Special Session on Probability and Statistics

Talks in this session are held in room JD1179

MON 09:00–09:25 60I27

Some results on the classical Lotka-Volterra model and its stochastic analogue.

Klebaner Fima
Department of Mathematics and Statistics
University of Melbourne

We give a result on the behaviour of the classical Lotka-Volterra model far from its equilibrium, and results on the time to extinction and a likely path to extinction in a stochastic Lotka-Volterra model. This talk is based on joint work with R. Khasminskii and R. Liptser.

MON 09:30–09:55 62F, 60F

The Local Complexity and the Change-Set Problem

Estate V. Khmaladze
School of Mathematics, UNSW

Suppose $\mathcal{C}$ is a totally bounded subset of some metric space. Fundamentally important measure of "richness" and complexity of $\mathcal{C}$ was suggested in famous paper of Kolmogorov and Tikhomirov(1959) - this is cardinality $N_\delta = N_\delta(\mathcal{C})$ of its minimal ε-net as a function of δ as the latter tends to 0. (The function $\ln N_\delta$ is called the metric entropy of $\mathcal{C}$. Applications of these concepts in approximation theory can be found, e.g., in Lorentz, Golitschek and Makovoz (1996), while very important probabilistic applications are described, e.g., in Pollard (1986), Dudley (1987) or van der Vaart and Wellner (1996).

In a statistical problem, when $\mathcal{C}$ is the range of a parameter of interest, such as a function or a set, the quality of a statistical estimator of the parameter depends on complexity of $\mathcal{C}$, and the combination of exponential inequalities and the covering number should lead, as one could expect, to the optimal rate of convergence.

We will show, however, that this is not the case. Though, as we said, N_δ is very important characteristic of the richness and complexity of the class $\mathcal{C}$ we will realise that to determine the optimal rate of convergence in practically important cases N_δ is not enough and we need much more fine and delicate characteristic of "local" richness of the class - the covering number of the neighbourhood of a given element from the class. Namely, for each $G \in \mathcal{C}$ let $\mathcal{O}(t, G)$ be the neighbourhood of G of the radius t and let

$$N_\delta(t, G) = \text{card } N_\delta \cap \mathcal{O}(t, G).$$

Then we will show how does the combination of exponential inequalities and the local covering number lead to the optimal rate of convergence. As the example we will use the so-called change-set problem for a VC classes—a problem of serious interest of its own. As shown in Khmaladze, Mnatsakanov and Toronjadze (2001) for VC classes the rate of convergence can be either $1/n$ or $\ln n/n$ and these different cases can be characterised.

MON 10:00–10:25 60G20, 92C60

A host-parasite model

Joe Gani
The Australian National University

We consider a population of i parasites distributing itself at random over M hosts, each parasite independently selecting a host with probability $1/M$. This leads to a random allocation model, for which we can derive the probability generating function of the process in a recursive form. The expected number of hosts carrying $0, 1, \dots, i$ parasites is shown to have a binomial form. It is possible to follow a complete breeding cycle through for both hosts and parasites.

MON 16:00–16:25 60F05

Approximating the number of successes in independent trials: Binomial versus Poisson

Aihua Xia
University of Melbourne

Let W be the sum of independent Bernoulli random variables $I_1, ldots, I_n$. It is well-known that W follows binomial distribution if $P(I_i = 1)$, $1 \leq i \leq n$ are equal and approximately Poisson if $P(I_i = 1)$, $1 \leq i \leq n$ are small. In this talk, we present that under some mild conditions, the total variation distance between W and Binomial$(m, EW/m)$ is increasing in m for $m \geq n$. Hence, in modeling the distribution of W, Binomial approximation is generally better than Poisson approximation (joint work with Kwok Pui Choi).

MON 16:30–16:55 60D05

Areas of components of the typical Voronoi polygon in a planar Poisson process

A. Hayen
and
M. P. Quine (*)
School of Mathematics and Statistics
University of Sydney

We study the contribution made by three points or four to certain areas associated with a typical polygon in a Voronoi tessellation of a planar Poisson process. We obtain some new results about moments and distributions and give simple proofs of some known results. We also use Robbins' formula to obtain the first three moments of the area of a typical polygon and hence find the variance of the polygon covering the origin.

MON 17:00–17:25 62J05

Local influence in multivariate elliptical linear regression models

Shuangzhe Liu
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Canberra, ACT 0200

Local influence is a method of sensitivity analysis for assessing the influence of small perturbations in a general statistical model. In the present paper, this popular method is applied to multivariate elliptical linear regression models. Several schemes of perturbations including perturbations in case-weights, explanatory variables and response variables are considered. The observed information matrix under the postulated model and Delta matrices under the corresponding perturbed models are derived. Assessment of local influence is made.

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