Abstracts, ANZAMP 2013

Title: Integrable structure of Quantum Field Theory: Classical flat connections versus quantum stationary states
Presenter: Vladimir Bazhanov
Affiliation: Australian National University
Authors: Vladimir Bazhanov and Sergei Lukyanov
Abstract: We establish an intriguing correspondence between a special set of classical solutions of the modified sinh-Gordon equation (i.e., Hitchin's "self-duality" equations) on a punctured Riemann sphere and a set of stationary states in the finite-volume Hilbert space of the integrable 2D QFT introduced by V.A. Fateev. Potential applications of this correspondence to the problem of non-perturbative quantization of classically integrable non-linear sigma models are briefly discussed.

Title: The polymer collapse transition in the presence of crossings
Presenter: Andrea Bedini
Affiliation: The University of Melbourne
Authors: Andrea Bedini, Aleks Owczarek, Thomas Prellberg
Abstract: The collapse transition of a polymer in a dilute solution is usually modelled with a self-avoiding walk with an attractive interaction between nearest-neighbours. The balance of the attracting and repulsing forces identifies a tri-critical point, known as the θ-point, which can be described as the tri-critical point of magnetic system with $O(n)$ symmetry in the limit $n \to 0$. This description based on self-avoiding walks might not be the most general and the introduction of crossings might leads to a different and largely unexplored universality class. I will review some recent results on this topic.

Title: Alternative Tableaux and the ASEP model
Author: Richard Brak
Affiliation: The University of Melbourne
Abstract: The stationary state of the asymmetric simple exclusion model is determined by a non-commutative diffusion algebra. This talk will discuss the connection between alternative tableaux, Catalan numbers and the standard basis for the algebra. To prove the Catalan connection we use a new type of bijection called an "embedded" bijection which is determined by an isomorphism preserving the Catalan product structure.

Title: Classification of Super Virasoro Indecomposables
Author: Michael Canagasabey
Affiliation: Australian National University

Title: ADHM: Quivers and Monopoles
Author: Joseph Chan
Affiliation: University of Melbourne
Abstract: The Atiyah-Drinfeld-Hitchin-Manin (ADHM) construction can be seen as a correspondence between representations of the ADHM quiver and instantons over $\mathbb{R}^4$. For $SU(2)$ gauge field theory, Austin and Braam showed, via ADHM that circle-invariant instantons - hyperbolic magnetic monopoles in disguise - are solutions of a discretisation of Nahm's equations. We attempt to do the same for higher rank hyperbolic monopoles.

Title: Accurate lower bounds on two-dimensional constraint capacities
Presenter: Yao-ban Chan
Affiliation: The University of Queensland
Authors: Yao-ban Chan and Andrew Rechnitzer
Abstract: In this talk, we study the problem of data storage in a two-dimensional array. Hardware considerations induce constraints in the possible configurations of magnetic spins in this array, and the storage capacity can be found by modelling the constraints as lattice spin models. Using Baxter's corner transfer matrix formalism, we derive very accurate lower bounds on the capacities of several families of such constraints. Our results strongly improve on all previous known lower bounds, and lead to a surprising conjecture that the capacity of two of our studied constraints are equal.

Title: The inhomogeneous asymmetric exclusion process
Presenter: Jan de Gier
Affiliation: University of Melbourne
Authors: Kayed Al Qasemi, Luigi Cantini, Jan de Gier
Abstract: I will discuss an inhomogeneous version of the asymmetric exclusion process. Using the Noumi representation of the Hecke algebra it is shown that the stationary state of this process is given in terms of elementary symmetric functions in the case of periodic boundary conditions, and in terms of non-symmetric one-column Koornwinder polynomials in the case of open, non-diagonal boundary conditions. As a corollary we find that one-column Koornwinder polynomials can be expressed explicitly in terms of matrix product states.

Title: Exactly solvable models in ultracold physics
Author: Angela Foerster
Affiliation: Instituto de Fisica da UFRGS, Porto Alegre, RS-BRAZIL
Abstract: The study of exact solutions of quantum mechanical models has its origins in the work of Bethe in 1931 on the Heisenberg model. The field received a great impulse in the 1960s and 1970s with the work of Baxter, Lieb and Yang, among others, having prospered ever since. A significant aspect of exactly solvable models is that they can be found in different areas of physics, such as statistical mechanics, quantum field theory, condensed matter, string theory and more recently in cold atoms. The impressive development in cooling and trapping atoms in one-dimensional tubes brought this discipline to a new audience, when it became clear that exactly solvable models can be realized in the lab. Prominent examples include the Lieb-Liniger model for spinless bosons and the Gaudin-Yang model for two-component fermions.

In this talk I will give an overview of these ongoing developments, with particular emphasis on the one-dimensional attractive Fermi gas with spin imbalance, for which some recent results will also be presented. This model exhibits a number of distinct quantum phases and provides an ideal testbed for exploring the physics of quantum phase transitions. In addition, other exactly solvable models relevant in this ultracold scenario will be discussed.

Title: Inter-relationships in random matrix theory
Author: Peter Forrester
Affiliation: University of Melbourne
Abstract: In the early 1960's Dyson and Mehta found that the circular symplectic ensemble relates to the circular unitary ensemble. I'll discuss generalizations as well as other settings in random matrix theory in which β relates to $4/\beta$.

Title: Mixing time of the Swendsen-Wang process on the complete graph
Presenter: Tim Garoni
Affiliation: Monash University
Authors: Tim Garoni and Peter Lin
Abstract: The Potts model is a fundamental model in equilibrium statistical mechanics. The Swendsen-Wang process is the most widely used Markov-chain Monte Carlo algorithm for studying the Potts model. We study the Swendsen-Wang process for the Potts model with $q \geq 3$ states on the complete graph K_n, and obtain the large n asymptotics of the mixing time as a function of the inverse temperature λ. We show that the mixing time is exponentially large in a power of n throughout a non-trivial neighbourhood $(\lambda_{\rm o}(q), \lambda_{\rm d}(q))$ of the equilibrium transition temperature. In the low temperature regime $\lambda \geq \lambda_{\rm d}(q)$, we find the mixing time is $\Theta(\log n)$, while for high temperatures $\lambda < \lambda_{\rm o}(q)$ the mixing time is $O(1)$. At $\lambda = \lambda_{\rm o}(q)$ the mixing time exhibits a non-trivial power-law scaling $\Theta(n^{1/3})$.

Title: Pulling adsorbed self-avoiding walks and polygons from a surface
Presenter: Tony Guttmann
Affiliation: The University of Melbourne
Authors: Tony Guttmann, Iwan Jensen, Stu Whittington
Abstract: We consider a self-avoiding walk model of polymer adsorption where the adsorbed polymer can be desorbed by the application of a force, concentrating on the case of the square lattice. We also consider self-avoiding polygons in a similar geometry, as models of adsorbed vesicles. Using series analysis methods we investigate the behaviour of the free energy of the system when there is an attractive potential ϵ with the surface and a force f applied at the last vertex (or top edge in the case of polygons), normal to the surface, and extract the phase boundaries between the ballistic and adsorbed phases. We believe these to be exact to graphical accuracy. We give precise estimates of the location of the transition from the free phase to the ballistic phase, which we find to be at $y_c = \exp(f/k_B T_c) = 1$, and from the free phase to the adsorbed phase, which we estimate to be at $a_c = \exp(\epsilon/k_B T_c) = 1.775615 \pm 0.000005$. In addition we prove that the phase transition from the ballistic to the adsorbed phase is first order in the case of SAWs. Various results about the phase boundaries are proved.

Title: DBI potential, DBI inflation action and general Lagrangian relative to phantom, K-essence and quintessence
Author: Yong-Chang Huang
Affiliation: Institute of Theoretical Physics, Beijing University of Technology

Title: The hard hexagon partition function for complex fugacity
Presenter: Iwan Jensen
Affiliation: The University of Melbourne
Authors: Michael Assis, Jesper L Jacobsen, Iwan Jensen, Jean-Marie Maillard and Barry M McCoy
Abstract: We study the partition function of the hard hexagon model in the complex fugacity plane by computing zeros and transfer matrix eigenvalues for large finite size systems. We find that the partition function per site computed by Baxter in the thermodynamic limit for positive real values of the fugacity is not sufficient to describe the behaviour in the full complex fugacity plane.

Title: Superintegrability both classical and quantum
Author: Ernie Kalnins
Affiliation: University of Waikato

Title: Generalized Verma and Wakimoto Modules
Author: Masoud Kamgarpour
Affiliation: University of Queensland
Abstract: Smooth representations of p-adic groups play an important role in number theory, in particular, in the Langlands program. Their characteristic zero analogues, smooth representations of affine Kac-Moody algebras, are crucial ingredients in Beilinson and Drinfeld's approach to the geometric Langlands program. In addition, these representations play a role in conformal field theories with affine Kac-Moody symmetries. In this talk, I will introduce two classes of representations of affine Kac-Moody algebras: generalized Verma modules and generalized Wakimoto modules. I will also explain the relationship between these modules and their more classical analogues.

Title: On a refactorisation of the QRT map
Presenter: Pavlos Kassotakis
Affiliation: The University of Sydney
Authors: N. Joshi and P. Kassotakis
Abstract: A QRT map is the composition of two actions on a biquadratic curve: one switching the x-coordinates of two intersection points with a given horizontal line, and the other switching the y-coordinates of two intersections with a vertical line. In this talk I will exploit the outcomes of a decomposition of each QRT action into two consecutive ones.

Title: Integrable aspects of Yang-Baxter maps
Author: Theodoros Kouloukas
Affiliation: La Trobe University, Melbourne
Abstract: We present rational solutions of the set theoretical Yang-Baxter equation (Yang-Baxter maps) that admit a Lax representation in terms of polynomial matrices. By considering periodic initial value problems on two dimensional lattices, families of transfer maps which preserve the spectrum of the corresponding monodromy matrix are derived. The integrability of these maps follows by considering a suitable Poisson structure on phase space.

Title: Symmetries of Curved Superspace
Author: Sergei M. Kuzenko
Affiliation: UWA
Abstract: The formalism to determine (conformal) isometries of a given curved superspace was elaborated almost two decades ago in the context of the old minimal formulation for N=1 supergravity in four dimensions. This formalism is universal, for it may readily be generalized to supersymmetric backgrounds associated with any supergravity theory formulated in superspace. In the last two years, there have appeared a number of publications devoted to the construction of supersymmetric backgrounds in off-shell four-dimensional N=1 supergravity theories using component field considerations. Here we demonstrate how to read off the key results of these recent publications from the more general superspace approach developed in the

1990s. This talk is based on arXiv:1212.6179.

Title: Off-critical parafermionic observables
Presenter: Alex Lee
Affiliation: University of Melbourne
Authors: Jan de Gier, Andrew Elvey Price, Tony Guttmann, Alex Lee, Jorgen Rasmussen
Abstract: Parafermionic observables have become an important tool in understanding the scaling limit of critical two-dimensional lattice models. These are functions defined on the lattice, satisfying some linear condition that is a discrete analogue of holomorphicity. They have been used to prove various conformal invariance conjectures related to the Ising model and percolation and more recently their connections with integrability have been investigated. In this talk we consider these observables away from the critical point. We show how such off-critical parafermionic observables can be used to determine the winding angle distribution of self-avoiding walks, first predicted by Duplantier and Saleur using Conformal Field Theory, and we also discuss their integrabliity.

Title: Molecular fraction calculations for an atomic-molecular Bose-Einstein condensate model
Author: Jon Links
Affiliation: The University of Queensland
Abstract: A model describing the interconversion between condensates of atomic and molecular bosonic degrees of freedom will be introduced. The problem of deriving a formula to quantify the molecular fraction will be discussed, with emphasis on its role in characterising a quantum phase transition of the system.

Title: Properties of the Bethe Ansatz equations for Richardson-Gaudin models
Presenter: Inna Lukyanenko
Affiliation: School of Mathematics and Physics, The University of Queensland
Authors: Phillip Isaac, Jon Links, Inna Lukyanenko
Abstract: We investigate the quasi-classical limit of Sklyanin's boundary quantum inverse scattering method, which leads us to Richardson-Gaudin type models. They constitute an important class of quantum integrable models related to the BCS theory of superconductivity. Remarkable properties of the Bethe Ansatz equations are unveiled in this approach.

Title: On the Yang-Baxter equation for the six-vertex model
Presenter: Vladimir Mangazeev
Affiliation: ANU
Authors: Vladimir Mangazeev, Vladimir Bazhanov, Sergey Sergeev
Abstract: We study a quantum XXZ spin chain from a 3D perspective. Starting from the trigonometric solution of the tetrahedron equation we derive a new explicit expression for the $U_q(sl(2))$ R-matrix acting in the tensor product of two highest weight representations. We also construct a new representation for the Q-operator of the XXZ chain of spin s. Our construction can be naturally extended to arbitrary real values of spin and the limit to (half)-integer values of s is non-singular.

Title: Quantum system with the fourth Painleve transcendent, rational solutions and new ladder operators
Presenter: Ian Marquette
Affiliation: University of Queensland, School of Mathematics and Physics
Authors: Ian Marquette, Christiane Quesne
Abstract: I will present a brief review of quantum systems related with Painleve transcendents. I will present results on a quantum system involving the fourth Painleve transcendent and how this Hamiltonian is connected with supersymmetric quantum mechanics and also superintegrability. I will explain how this system in the reducible case contains families of systems related to Hermite exceptionnal orthogonal polynomials. I will show how we can construct new ladder operators in such case and how this is important in regard of applications in context of superintegrable systems and algebraic derivation of their energy spectrum.

Title: Rogue waves in 1+1 and 2+1 integrable models
Author: Vladimir B. Matveev
Affiliation: Universite de Bourgogne, Institut de Mathematiques de Bourgogne, Dijon, France
Abstract: This lecture will contain the following points.

1. Short description of the rogue wave events in the ocean and nonlinear optics.
2. Brief outlook of the theory of rational solutions of the integrable nonlinear PDE's.
3. Construction of quasi-rational (multi-rogue waves = MRW solutions) of the focusing NLS equation with finite density boundary conditions at infinity and discussion of their behaviour: Peregrine breather and its higher versions (P_n-breathers). Multi-rogue waves solutions as deformations of higher Peregrine breathers (=P_n-breathers).
4. NLS-KP-I correspondence and "extreme" rogue waves solutions in KP-I model.
5. The last point will be illustrated by some movies showing different scenario of collisions of the "simple" rogue waves in the KP-I model.
6. Concluding remarks.

Title: Functional relations in logarithmic minimal models
Presenter: Alexi Morin-Duchesne
Affiliation: University of Queensland
Authors: Alexi Morin-Duchesne, Paul A. Pearce, Jorgen Rasmussen
Abstract: Planar algebras have found applications in the description of lattice models in statistical mechanics with non-local degrees of freedom. Of particular importance are the diagrammatic objects known as transfer tangles since certain representations thereof correspond to lattice model transfer matrices. Working in the planar Temperley-Lieb algebra, we discuss how the corresponding transfer tangles satisfy various functional relations. A fusion procedure based on applications of the Wenzl-Jones projectors is used to describe and prove these relations. This approach gives rise to a fusion hierarchy which can be reformulated as so-called Y-systems of importance in the analysis of integrable models.

Title: The Toda lattice and a quantum curve.
Author: Paul Norbury
Affiliation: University of Melbourne
Abstract: I will describe interesting rational solutions to a linear difference equation coming from the Lax operator for the Toda lattice. This gives an example of a quantum curve related to the Gromov-Witten invariants of the two-sphere. It confirms

one case of a conjecture of Gukov and Sulkowksi regarding the existence of quantum curves.

Title: Electromagnetic Spikes
Presenter: Ernesto Nungesser
Affiliation: Trinity College Dublin
Authors: Ernesto Nungesser, Woei Chet Lim
Abstract: I will present a new solution found which corresponds to large inhomogeneities - also called spikes - with an electromagnetic field within the context of General Relativity, more specifically, cosmology. Apart from describing its properties I will point out why this solution is interesting. It is related to a certain symmetry, called Gowdy symmetry. Gowdy symmetric cosmologies are extremely popular within Theoretical Cosmology. The reason is, that it is a toy model which is easy to handle but which still corresponds to an inhomogeneous spacetime. The presented work is based on a transformation between Vacuum Gowdy spacetimes and Polarized Gowdy spacetimes with a Maxwell field. I would like to understand better the existence of this transformation and the possible relation to a discrete symmetry property of these spacetimes.

Title: Modular Properties of Non-Rational Conformal Field Theories
Presenter: David Ridout
Affiliation: Australian National University
Authors: Collaborations with Andrei Babichenko (Weizmann), Michael Canagasabey (ANU), Thomas Creutzig (Alberta) and Simon Wood (Tokyo).
Abstract: Conformal field theories should be definable on tori, hence their partition functions must be invariant under the natural action of the modular group $\mathsf{SL}2;\mathbb{Z}$. Thus, it is not surprising to find that the characters of the irreducible chiral algebra modules typically span an $\mathsf{SL}2;\mathbb{Z}$-module. All this works beautifully in the rational case where all modules are completely reducible and there are finitely many inequivalent irreducible modules. Thus, it is not surprising to find that many groups have studied the modular properties of characters in the C_2-cofinite case where there are still only finitely many inequivalent irreducibles, but complete reducibility is dropped. However, the results are not particularly encouraging. Here, I outline a much more encouraging formalism for non-rational theories in which we drop the finiteness condition instead (and, optionally, the complete reducibility). The C_2-cofinite case can, at least in examples, be recovered using orbifold technology.

Title: Nonlocal asymmetric exclusion process on a ring and conformal invariance
Presenter: Vladimir Rittenberg
Affiliation: Bonn University
Authors: Francisco Alcaraz and Vladimir Rittenberg
Abstract: We present a one-dimensional nonlocal hopping model with exclusion on a ring. The model is related to the Raise and Peel growth model. A nonnegative parameter u controls the local backwards and nonlocal forwards hopping rates. The phase diagram and consequently the values of the current depend on u and the density of particles. In the special case of half-filling and u = 1 the system is conformal invariant and an exact value of the current for any size L of the system is conjectured and checked in Monte Carlo simulations. We discuss various aspects of the model.

Title: Integrable lattice equations, slow degree growth and possible signatures over finite fields
Presenter: John A. G. Roberts
Affiliation: School of Mathematics and Statistics, UNSW Sydney 2052
Authors: J. A. G. Roberts and T. D. Tran
Abstract: Integrable partial difference equations (or lattice equations) have been systematically studied since the 1980s and have seen an explosion of interest in recent years. Some of them yield well-known integrable partial differential equations like the Korteweg-de Vries or Sine-Gordon equations in the continuum limit.

What do we mean by the term "Integrable"? This meaning is itself part of the research impetus in Discrete Integrable Systems. Integrable means "special", loosely-speaking, and may refer to one or more "special" properties that the dynamics possesses. Here we focus on the property of algebraic entropy of lattice equations: growth of degree in an indeterminate variable inserted in the boundary conditions as the lattice rule is iterated. Exponential growth is the norm, but integrable rules are distinguished numerically by polynomial growth which means vanishing algebraic entropy.

In the first part of the talk, we provide exact results that prove polynomial growth for a whole class of equations, including most of the much-studied Adler-Bobenko-Suris list. For other equations where the degree of cancelled terms at each vertex is not high enough, we prove exponential growth. In the second part of the talk, we study integrable lattice equations and their non-integrable perturbations over finite fields. We propose some models and discuss some tests that can distinguish different growth properties between them, and discuss the limitations of these tests.

Both parts of the talk are joint work with Dinh Tran.

Title: Multiple interacting directed walks
Presenter: Rami Tabbara
Affiliation: The University of Melbourne
Authors: Rami Tabbara, Aleks Owczarek and Andrew Rechnitzer
Abstract: We review a model of two friendly walks near a wall with shared and surface interactions. The full solution of the corresponding generating function and phase diagram are presented. We then discuss what insights our solution provides when considering the model of $n > 2$ interacting friendly walks in the bulk, introducing some preliminary results for $n = 3$.

Title: Off-shell conformal supergravity in three dimensions
Presenter: Gabriele Tartaglino-Mazzucchelli
Affiliation: School of Physics, The University of Western Australia
Authors: Daniel Butter, Sergei Kuzenko, Joseph Novak, Gabriele Tartaglino-Mazzucchelli
Abstract: We propose a new off-shell formulation for N-extended conformal supergravity in three spacetime dimensions. Our construction is based on the gauging of the N-extended superconformal algebra in superspace. By using our new formulation we construct the off-shell actions for conformal supergravity theories with $N = 1, 2, \ldots, 6$.

Title: Transformation Optics and the mathematics of invisibility
Author: Robert Thompson

Affiliation: Department of Mathematics and Statistis, University of Otago

Abstract: In 2006, science fiction became science fact with the construction of the world's first invisibility, or cloaking, device. The physical realization of the cloak resulted from the confluence of the recent development of "metamaterials" – engineered materials that derive their characteristic electromagnetic response properties from embedded structural elements – with a new mathematical approach to designing field-controlling devices that is becoming known as the transformation method. In a nutshell, the transformation method is based on the covariance of a governing system of equations under some set of transformations, together with the interpretation of the transformations as "active" rather than "passive." One is then required to solve the inverse problem of: given a desired field behaviour (e.g. light passing through a cloaking device), what are the required system parameters that will support the desired fields as a solution to the equations? Whether the necessary system parameters can be physically realized is largely an engineering problem, but through further study we may find techniques to improve the chances of success.

I will give an introduction to the field of transformation optics, show how one goes about designing a cloaking device, and discuss how the transformation method has been extended beyond optics, in particular to acoustics and thermodynamics. In the process I hope to show that there is a lot of interesting mathematics and physics lurking under the metamaterial-clad surface.

Title: Logarithmic conformal field theory based on sl(2|1) quantum group
Presenter: Ilya Tipunin
Affiliation: Lebedev Physics Institute
Authors: Alexei Semikhatov, Ilya Tipunin
Abstract: We construct a series of logarithmic conformal field models using an ideology of screenings. In the space generated by several free fields we consider a system of screenings that generate quantum sl(2|1) with the deformation parameter at root of unity. The vacuum module of the logarithmic models is obtained as an intersection of kernels of two screenings.

Title: The master T-operator and Baxter Q-operators for quantum integrable systems
Presenter: Zengo Tsuboi
Affiliation: The Australian National University
Authors: Alexander Alexandrov, Vladimir Kazakov, Sebastien Leurent, Zengo Tsuboi, Anton Zabrodin, Sergey Khoroshkin
Abstract: The Baxter Q-operators were originally introduced by Baxter when he solved the 8-vertex model. His method of the Q-operators is recognized as one of the most powerful tools in quantum integrable systems.

Our goal is to construct the Q-operators systematically, to express the T-operators (transfer matrices) in terms of the Q-operators, and to establish functional relations among them. For this purpose, we consider an embedding of the quantum integrable systems into the soliton theory. The key object is the master T-operator (tau-function in the soliton theory), which is a sort of a generating function of the transfer matrices. The Q-operators are defined as residues of the master T-operator.

The Q-operators can also be defined as the trace of monodromy matrices, which are product of some L-operators. In general, such L-operators are image of the universal R-matrix for q-oscillator representations of a Borel subalgebra of the quantum affine algebra. I will also mention the construction of such L-operators for the Q-operators.

Title: Higher spin fields: cubic and higher order interactions
Presenter: Mirian Tsulaia
Affiliation: University of Canberra
Authors: I. L. Buchbinder, P. Dempster, A. Fotopoulos, and M. Tsulaia
Abstract: We consider a problem of cubic and quartic interactions for massless and massive higher spin fields on flat and AdS backgrounds. After describing the procedure of building of the corresponding cubic and quartic vertices and showing some explicit examples we perform various consistency checks on the interaction terms. In particular for vertices for massive higher spin fields on a flat background we perform the Velo - Zwanziger analysis, and for vertices for massless higher spin fields on a flat background we perform the analysis of the symmetries of the S-matrix.

Title: Matrix elements of the Lie superalgebra $gl(m|n)$
Presenter: Jason Werry
Affiliation: University of Queensland
Authors: Mark Gould, Phillip Isaac, Jason Werry
Abstract: I will give an introduction to the Lie superalgebra $gl(m|n)$ and their representations in a Gelfand-Tsetlin basis. The problem of determining matrix element formulae for the $gl(m|n)$ generators is discussed. We determine these results via the characteristic identity and shift operator formalism. I will introduce this technique and show how the resulting factorization allows a direct, non-recursive formula for the non-elementary generators to be given for a large class of finite dimensional modules.

Title: Geometric structure of percolation clusters
Author: Zongzheng Zhou
Affiliation: Monash University