Quantum Science Seminar Schedule for 2007
1pm every Tuesday in the Physics Conference Room (Rm 407)

The talks during these seminars are intended to be 45-50 min long and as interactive as possible (e.g. questions and discussion during the talks are encouraged). We would like to encourage presentations on a broad range of topics from all research groups in the Department as well as talks given by visitors. This is also a good opportunity for students to find out more about research topics being pursued in the Department.

If you would like to arrange a seimar, please contact Sarah Brownfield (brownfield@physics.uq.edu.au or 53778).

Date	Person	Affiliation	Title	Abstract
6 Feb	Andreas Winter	University of Bristol	Entanglement and the Foundations of Statistical Mechanics (with S. Popescu and T. Short, Nature Phys. 2(11):754-758, 2006)	We consider an alternative approach to the foundations of statistical mechanics, in which subjective randomness, ensemble-averaging or time-averaging are not required. Instead, the universe (i.e. the system together with a sufficiently large environment) is in a quantum pure state subject to a global constraint, and thermalisation results from entanglement between system and environment. We formulate and prove a "General Canonical Principle", which states that the system will be thermalised for almost all pure states of the universe, and provide rigorous quantitative bounds using Levy's Lemma.
13 Feb	Kyoko Furuya	Univesidade Estadual de Campinas, Brazil	Phase loss channel via cross-Kerr interaction, cluster of trapped ions interacting with a field mode and generation of entangled cat states.	A phase damping reservoir composed of N bosons coupled to system of interest through a cross-Kerr interaction is proposed and its effects on quantum superpositions are investigated. Analytical calculations show that (i) the reservoir induces a gaussian decay of coherences; and (ii) the inherent incommensurate character of the spectral distribution yields irreversibility. A state independent decoherence time and a master equation are derived analytically for each temperature. As an example of a finite cluster of N bosons interacting via cross-Kerr interaction, the mode-mode entanglement between trapped ions and cavity field is investigated in a dispersive regime. A simple initial preparation of coherent states and a postselection may be used to generate motional non-local mesoscopic states involving two ions in different cavities. We also present a study of global entanglement induced by dynamical Stark-shifts considering a cluster of N trapped ions.

Date	Person	Affiliation	Title	Abstract
20 Mar	Ross McKenzie	Physics, UQ	Electronic excited states in optically active biomolecules: quantum systems with a tuneable environment interaction	Optically active molecules (chromophores) are crucial to the function of wide range ofbiomolecules. Examples, include the green flourescent protein, porphyrins associated with photosynthesis, and retinal associated with vision. The electronic states of the chromophores can be viewed as discrete quantum systems which are interacting with an environment composed of the surrounding protein and water. The interaction of the chromophorewith its environment may be modelled quantum mechanically by an independent boson model which describes a two-level quantum system interacting with a bath of harmonic oscillators. Ultrafast laser spectroscopy provides information to determine the spectral density describing this interaction for a wide range of chromophores and environments. This spectral density completely determines the quantum dynamics and decoherence of electronic excited states. We have recently proposed and analysed several continuum dielectric models of the environment [J. Gilmore and R.H. McKenzie, quant-ph/0609075]. Our results provide a framework to understand experimental measurements and molecular dynamics simulation including the relative importance of the contributions of the protein, the water bound to the surface of the protein, and the bulk water to decoherence. Our results show that because biomolecules function in a ``hot and wet'' environment, quantum coherence will generally not be significant for processes occuring slower than a picosend, the timescale for the dielectric relaxation of water.

Date	Person	Affiliation	Title	Abstract
27 Mar	Yeong-Cherng Liang	Physics, UQ	Bounds on quantum correlations in Bell Inequality experiments	Bell inequality violation is one of the most widely known manifestations of entanglement in quantum mechanics; indicating that experiments on physically separated quantum mechanical systems cannot be given a local realistic description. However, despite the importance of Bell inequalities, it is not known in general how to determine whether a given entangled state will violate a Bell inequality. This is because one can choose to make many measurements on a quantum system to test any given Bell inequality and the optimization over measurements is a high-dimensional variational problem. In order to better understand this problem we present algorithms that provide, for a given quantum state, both a lower bound and an upper bound on the observed value of the combination of correlation functions occurring in the Bell inequality. Both bounds apply techniques from convex optimization and the methodology for creating upper bounds allows them to be systematically improved. In many cases these bounds determine measurements that would demonstrate violation of the Bell inequality or provide a bound that rules out the possibility of a violation. Examples are given to illustrate how these algorithms can be used to conclude definitively if some quantum states violate a given Bell inequality.
3 Apr	Mark Lee	Clarendon Lab, University of Oxford, UK	Three-body Efimov states and recombination in ultra-cold gases	Since the early days of quantum physics the complex behavior of three interacting particles has been the subject of numerous experimental and theoretical studies. This is of practical interest due to the importance of three-body recombination in limiting the lifetime of ultra-cold gases. Novel three-body bound states known as Efimov states can exist when there is no corresponding two-body bound state. These quantum states refer to an infinite series of energy levels of three identical Bose particles, accumulating at the threshold for dissociation as the scattering length of each pair is tuned to infinity. In this talk, I will discuss recent experimental evidence for such three-body states [1], and compare with an earlier study in Helium. I will show that evidence of the same quantum state is seen in both experiments, however the ^{133}Cs$_3$ resonance refers to a previously unobserved Borromean molecular state. Numerical calculations of the three-body recombination rates of such gases will also be presented, incorporating a detailed description of the two-body physics. Such an approach shows the imporatance of including the detailed interactions, as opposed to universal treatments which I will argue are often incomplete.

Date	Person	Affiliation	Title	Abstract
10 Apr	Karen Kherutsyan	Physics, UQ	Formation of a quasi-condensate in a 1D Bose gas	1D Bose gases are remarkably rich physical systems exhibiting properties not encountered in 2D or 3D. After giving an introduction into the physics of 1D Bose gases, I will discuss how the conventional scenario of Bose-Einstein condensation in an ideal gas becomes inapplicable to a weakly interacting 1D gas in a harmonic trap, in sharp contrast to the 3D case. Instead, one has an interaction-induced crossover to a coherent quasi-condensate regime, and I will present our new results for the corresponding "critical" parameters – the crossover temperature and crossover atom number.
17 Apr	Joshua Wilke	Simon Fraser University/UQ	Pathology of an isolated flawed quantum computer	Static one-body flaws and residual two-body interactions in an isolated quantum computer result in internal decoherence and other errors. The phenomenology of these infidelities is quite different from that of standard spin-boson models employed in quantum optics. I will use exact and master equation simulations to illustrate a number of these effects.
1 May	David Broun	Simon Fraser University, Canada	Microwave spectroscopy of superconductors at milliKelvin temperatures	Many correlated electron materials of current interest exhibit unconventional superconducting states. The heavy fermion compounds are a particularly interesting example, with low temperature superconducting states that exist in the vicinity of magnetic order. We have recently built a system for studying these materials that allows us to carry out microwave spectroscopy down to temperatures less than 50 mK. Two aspects of the heavy fermion compounds make microwave spectroscopy a particularly useful experimental probe. The first is the possibility that the Cooper pairs themselves will have internal degrees of freedom - order parameter collective modes - that can be excited by high frequency fields. The second is the strong renormalization of the quasiparticle mass. This brings important time scales such as the quasiparticle relaxation rate down into the GHz range, allowing microwave experiments to capture most of the conductivity spectral weight. We have so far used the system to study a number of heavy fermion compounds, including CeCoIn5, PrOs4Sb12 and URu2Si2.

Date	Person	Affiliation	Title	Abstract
22 May	Matthias Troyer	Physics, UQ	Adiabatic Quantum Simulation Using Ultracold Fermionic Atoms: d-wave RVB States and the Phase Diagram of the Fermionic Hubbard Model	We propose a controlled route to obtaining the ground state properties of the two-dimensional fermionic Hubbard model in an adiabatic quantum simulation using ultracold fermionic atoms. We present a route for the controlled generation and measurement of superfluid d-wave resonating valence bond (RVB) states of fermionic atoms in 2D optical lattices. Starting from loading spatial and spin patterns of atoms in optical superlattices as pure quantum states from a Fermi gas, we adiabatically transform this state to an RVB state by a change of the lattice parameters. Results of exact time-dependent numerical studies for ladders systems are presented, suggesting generation of RVB states on a time scale smaller than typical experimental decoherence times. Reference: S. Trebst, U. Schollwock, M. Troyer, and P. Zoller, Phys. Rev. Lett. 96, 250402 (2006).
5 Jun	Vladimir Bazhanov	Australian National University	Dissipative quantum systems: exact results	Over the last fifteen years several exact results were obtained for the so-called boundary sine-Gordon model. In the conformally symmetric case this two-dimensional quantum field theory describes a one-dimensional quantum Brownian motion in a periodic (cosine) potential. The massless bulk 2D field plays the role of the Caldeira-Leggett quantum heat bath with ohmic dissipation. The model finds many application to problems of quantum tunneling in presence of a strong coupling to the dissipative environment. For example, it describes the tunneling of the fractionally charged edge excitations through a point contact in the quantum Hall effect. It also describes a dissipation-driven superconductor-insulator phase transition in resistively shunted Josephson junctions. In my talk I will give a review of the theory of quantum Brownian motion. I will discuss the Langevin and Fokker-Plank equations in the classical case, the Feynman-Vernon-Caldeira-Leggett theory of the quantum thermostat, then move on to the Schwinger-Keldysh approach to a non-equilibrium transport in quantum systems. Finally I will derive the exact expression for the non-linear mobility for a dissipative quantum particle moving in a ``washboard'' potential at arbitrary bias and temperature. The talk is indented for a general physical and mathematical audience, no specialized knowledge will be required. This talk is based on the results previously obtained by V.Bazhanov, S.Lukyanov and A.Zamolodchikov.

Date	Person	Affiliation	Title	Abstract
12 Jun	Anders Sandvik	University of Boston, USA	Deconfined quantum-critical point in a 2D Heisenberg model with four-spin couplings	Phase transitions driven by quantum fluctuations in 2D antiferromagnets have formed a central topic in condensed matter physics since the discovery of high-Tc superconductivity in layered cuprates. While spin-liquid and valence-bond-solid (VBS) states have been the subjects of numerous theoretical studies, large-scale numerical simulations have been lacking because of Monte Carlo "sign problems" affecting the frustrated spin models in which these ground states and phase transitions should exist. Here I will show that a transition from the Neel state to a VBS state also occurs in a 2D Heisenberg model including a particular type of four-spin interaction which is not frustrated in the standard sense, and therefore can be studied on large lattices using Monte Carlo methods. There is compelling evidence that the Neel-VBS transition in this model is the first example of the recently proposed "deconfined" quantum critical point: The transition appears to be continuous with dynamic exponent z=1, the critical correlation function exponent is anomalously large, and an emergent U(1) symmetry can be seen explicitly in the VBS order-parameter fluctuations. The model thus offers opportunities for detailed unbiased studies of aspects of quantum-criticality falling outside the standard Landau-Ginzburg-Wilson framework.
19 Jun	Chris Hamer	University of New South Wales	Frustrated Spin Models and the Union Jack Antiferromagnet	There has been great interest for the last decade or more in two-dimensional lattice spin models of magnetic materials involving 'frustration', or competing interactions. Theoretical discussions have raised the possibility of new states of matter such as 'spin liquid' states without magnetic order, and new classes of phase transitions such as 'deconfined' quantum critical points. After briefly reviewing some of these ideas, we shall discuss a new example of a frustrated spin system, the spin-1/2 antiferromagnet on the Union Jack lattice, which exhibits a phase transition from a Neel ordered state to a 'canted ferrimagnetic' state. Results from both series analysis and spin-wave expansions will be presented.

Date	Person	Affiliation	Title	Abstract
26 Jun	Ben Powell	Physics, UQ	RVB easy as 123	What is the mechanism of high temperature superconductivity in the cuprates? This remains one of the most important questions in all of physics. But would we care so much if the critical temperature wasn't high? While anyone interested in fundamental physics might hope that the answer would be yes, I will argue that empirically the answer is found to be no. The organic superconductors represent a challenge every bit as interesting as the cuprates. However, these materials have received far less attention in part because all of the energy scales involved (and hence the critical temperatures) are an order of magnitude smaller than those in the cuprates. Twenty years ago, just a few months after the discovery of high temperature superconductivity, Phillip Anderson published a seminal paper [1] containing (at least) three great insights: (i) Anderson proposed that the physics of the cuprates is that of a doped Mott insulator; and, as such, (ii) can be described by a Hubbard model; (iii) he also argued that the ground state of this model is well described by a variational wavefunction he named the resonating valence bond (RVB) wavefunction. Having reviewed some relevant experiments and introduced RVB theory, I will discuss the applicability of RVB theory to the organic superconductors [2]. In addition I will discuss how the spin fluctuations in the parent Mott insulator determine the symmetry of the superconducting state [3]. [1] PW Anderson, Science **235**, 1196 (1987) [2] BJ Powell and RH McKenzie, Phys. Rev. Lett. **94**, 047004 (2005). [3] BJ Powell and RH McKenzie, Phys. Rev. Lett. **98**, 027005 (2007).

Date	Person	Affiliation	Title	Abstract
3 Jul	John Dobson	Griffith University	Electron correlation and the surface energy of metals: A new look at an old problem	The surface or cleavage energy of simple metals has been studied theoretically since the early 20th century. It is important not only for surface properties but also in the study of voids and vacancies, and in simplified theories for nanostructures. It turns out to depend strongly on correlation properties of the electron gas near a metallic surface. Its successful prediction was considered to be a major success of the Local Density Approximation (LDA) in the 1970s. In the 1980s, however, more microscopic approaches - e.g. Fermi Hypernetted Chain, (FHNC) and some Quantum Monte Carlo work - gave considerably different answers. Many more sophisticated density functional theory (DFT) approaches were tried since then, including so-called “fifth-rung” density functionals building on the nonlocal random-phase-approximation RPA correlation energy. These have mostly given similar answers to the LDA. The FHNC proponents had suggested, however, that their scheme included a level of selfconsistent nonlocality that was not attainable by local density-based corrections to the coulomb kernel in RPA-style approaches. Here we describe work that we believe resolves this long-standing issue, largely in favour of the LDA and fifth-rung DFT results. In the process we discuss a correlation approach developed in Brisbane that may be useful for a variety of problems. (Work done in collaboration with the groups of J. M. Pitarke and J. P. Perdew)
10 Jul	Murray Olsen	Physics, UQ	Having fun with the quantum statistics of an atom laser	We show theoretically how quantum information can be transferred between atoms and light using a Raman coupling process. This allows for the production of atom laser beams with nonclassical statistics and the indirect measurement of these statistics via homodyne measurements on an optical field. Combining these processes enables us to propose a type of matter wave teleportation without the necessity of shared entanglement, which is close in spirit to the beloved teleportation of science fiction fans. Murray Olsen, Ashton Bradley and Simon Haine

Date	Person	Affiliation	Title	Abstract
17 Jul	Bill Unruh	University of British Columbia, Canada	Dumb Holes	In this talk Bill Unruh draws analogies between black holes (singularities in space-time) and a fluid-mechanical model of "dumb holes." It is shown that the horizon of a black-hole is analogous to the point in a fluid system where the background fluid flow exceeds the velocity of sound (and thus sound waves travelling against the flow cannot propagate across this boundary). Unruh comments on the possibility of performing experiments on fluid systems to observe the acoustic analogue of Hawking radiation. This would require measuring power on the order of ~10^-16 Watts in liquid helium, or ~10^-33 Watts in a Bose-Einstein condensate. There is some hope that these miniscule powers might be accessible to experimenters.
24 Jul	Hsi-Sheng Goan	National Taiwan University, Thailand	Quantum decoherence and disentanglement in continuous variable systems and central spin models	In this talk, we will first discuss the concept of decoherence and dissipation in open quantum systems with illustrations of several examples of commonly used models of bosonic or/and fermionic environments or reservoirs. We will then study two continuous variable systems (or two coupled harmonic oscillators) and investigate their entanglement evolution under the influence of non-Markovian thermal environments using the quantum master equation approach [1]. After that, we will discuss two central-spin models [2,3] in which the time evolution of the reduced density matrix can be directly calculated rather than through the quantum master equation. In the first spin model, the exact quantum dynamics of the reduced density matrix of two coupled central spin qubits and their entanglement evolution in a quantum Heisenberg XY spin star environment in the thermodynamic limit at arbitrarily finite temperatures are obtained using a novel operator technique [2]. In the second spin model, we study, using the spin wave approximation, the decoherence dynamics of a central spin coupled to an antiferromagnetic environment under the application of an external global magnetic field [3]. When the values of the external magnetic field is increased to the critical field point at which the spin-flop transition (a first-order quantum phase transition) happens in the antiferromagnetic environment, the decoherence of the central spin reaches its highest point. This result is consistent with several recent quantum phase transition witness studies. References: 1. K.-L. Liu and H.-S. Goan, to appear in Phys. Rev. A (2007); [arXiv: quant-ph/0706.0996] 2. X. Z. Yuan, H.-S. Goan and K. D. Zhu, Phys. Rev. B 75, 045331 (2007). 3. X. Z. Yuan, H.-S. Goan and K. D. Zhu, New J. of Phys. 9, 219 (2007).

Date	Person	Affiliation	Title	Abstract
31 Jul	Jaime Merino	Universidad Autonoma de Madrid, Spain	Coulomb correlations in strongly correlated layered metals: insights from dynamical mean-field theory	Our understanding of the electronic properties of layered metals in which the Coulomb repulsion between electrons is large is still limited. A remarkable example is the case of the high-Tc cuprates for which the 'normal' phase properties are different from predictions of the conventional theory of metals. The Hubbard model is the simplest minimal model that captures the competition between kinetic energy delocalization and localization due to the strong Coulomb repulsion. In spite of its simplicity, there is no exact solution to the Hubbard model in two dimensions and approximations are necessary. Important progress in the understanding of strongly correlated metals has been achieved with the development of dynamical mean-field theory (DMFT)-a strong coupling approach which captures local electronic correlations exactly. A remarkable result arising from DMFT is that close to the Mott transition there is a low temperature scale, T*, much lower than the Fermi temperature, below which Fermi liquid behavior occurs becoming a 'bad' metal at temperatures above T*. I will show how this behavior is consistent with experimental observations in strongly correlated layered metals such as the quasi-two-dimensional family of organic conductors: kappa-(BEDT-TTF)2X and the cobalt oxide, NaxCoO2.
7 Aug	Guifre Vidal	Physics, UQ	Entanglement renormalization, quantum criticality and topological order	The renormalization group (RG) is one of the conceptual pillars of statistical mechanics and quantum field theory, and a key theoretical element in the modern formulation of critical phenomena and phase transitions. RG transformations are also the basis of numerical approaches to the study of low energy properties and emergent phenomena in quantum many-body systems. Most numerical real-space RG approaches, however, fail to fulfil some natural expectations, such as that of having (scale invariant) critical systems as fixed points, and can not properly describe critical systems. Recently, a novel RG transformation has been proposed, based on the idea of renormalizing the amount of entanglement, that does not suffer from any such deficiencies. I will explain what entanglement renormalization is and describe how it can be applied to describe quantum criticality and topological order. I will use plenty of colourful diagrams.

Date	Person	Affiliation	Title	Abstract
14 Aug	Howard Wiseman	Griffith University	Grounding Bohmian Mechanics in Weak Values and Bayesianism	Bohmian mechanics (BM) is a popular interpretation of quantum mechanics in which particles have real positions. The velocity of a point x in configuration space is defined as the standard probability current j(x) divided by the probability density P(x). However, this “standard” j is in fact only one of infinitely many that transform correctly and satisfy dP/dt + div j = 0. In this talk I will show that a particular j is singled out if one requires that j be determined experimentally as a weak value, using a technique that would make sense to a physicist with no knowledge of quantum mechanics. This “naively observable” j seems the most natural way to define j operationally. Moreover, I show that this operationally defined j equals the standard j, so, assuming dx/dt = j/P one obtains the dynamics of BM. It follows that the possible Bohmian paths are naively observable from a large enough ensemble. Furthermore, this justification for the Bohmian law of motion singles out x as the hidden variable, because (for example) the analogously defined momentum current is in general incompatible with the evolution of the momentum distribution. Finally I discuss how, in this setting, the usual quantum probabilities can be motivated from a Bayesian standpoint, via the principle of indifference.
28 Aug	Jon Links	Maths, UQ	The Glazek-Wilson model and cyclic renormalisation group	In 1971 Wilson surmised the existence of cyclic renormalisation group maps. However, it is only recently that examples of these have been found. In 2002, Glazek and Wilson provided a simple one-body, quantum mechanical model which displays a cyclic renormalisation group map when high energy degrees of freedom are eliminated from the system. In this seminar I will review the Glazek-Wilson model and highlight some of its unusual features. I will also discuss a many-body generalisation of the Glazek-Wilson model, which takes the form of a BCS type model where the Cooper pairs obey anyonic statistics. This is joint work with German Sierra (Madrid) and Shao-You Zhao (UQ).
11 Sep	David Kielpinski	Griffith University	Quantum Computing with Trapped Ions	Quantum computing has the potential to revolutionize many fields of information technology. A large-scale quantum computer could efficiently solve important computing tasks that are exponentially difficult on classical computers. One of the most promising implementations of quantum computing uses trapped ions controlled by laser excitation. Small trapped-ion quantum processors have already been demonstrated and there is a viable roadmap from these small devices to a large-scale quantum computer. I will review recent experimental results and describe the challenges that lie on the road to large-scale ion-trap quantum computing. I will also discuss the ion-trap quantum computing experiments getting underway in my group at Griffith University.

Date	Person	Affiliation	Title	Abstract
18 Sep	Rajiv Singh	UC Davis, USA	Kagome Lattice Antiferromagnets	Kagome-Lattice is a two-dimensional lattice made up of corner sharing triangles. Antiferromagnetism on this lattice has been called the Holy-Grail of frustrated magnetism. There are many proposals for novel and exotic quantum phases for this system. Recent experimental discovery of a novel material with structurally perfect Kagome-layers of copper atoms (with spin-half) separated by non-magnetic layers containing zinc atoms has brought further attention to this model. We will discuss recent theoretical calculations that show evidence for a Valence Bond Crystal phase with a large (36-site) unit cell. We will also summarize the highly unexpected experimental behavior and suggest possible explanations for them involving impurities and Dzyloshinski-Moria interactions.
25 Sept	Tim Ralph	Physics, UQ	Quantum Gravity Information Paradoxes	I will discuss a toy model of the interaction of a qubit with an exotic space-time containing a time-like curve (i.e. a time machine). Consistency seems to require that the global evolution of the qubit be non-unitary. Given that quantum mechanics is globally unitary, this then is an example of a quantum gravity information paradox. However, I will show that a careful analysis of the problem in the Heisenberg picture reveals an underlying unitarity, thus resolving the paradox.
2 Oct	Seth Olsen	School of Molecular and Microbial Sciences, UQ	The Bridge Isomerization of Fluorescent Protein Chromophore Models	The superfamily of fluorescent proteins (a.k.a. GFP homologues) includes many proteins which have proven extremely useful as expressible fluorescent markers in a variety of biological research contexts. The proteins owe their photoproperties to the presence of an autocatalytically forming chromophore containing a /p-/hydroxybenzylidene-imidazolinone motif. Different subfamilies of the FPs are distinguished by the presence of specific chemical substitutions to this core motif. The chromophores of most FPs are non-fluorescent when removed from the protein, indicating that fluorescence is induced by the protein itself. The need for brighter FPs for biological labelling applications motivates us to examine the decay pathways which compete with fluorescence in the chromophore itself. There is a substantial body of evidence indicating that /cis-trans/ photoisomerization of the exocyclic bridge is one such decay pathway. We examine the structure of the potential surfaces governing bridge photoisomerization in FP chromophores as determined by ab initio quantum chemistry techniques. These studies indicate that there is at least one barrierless or near-barrierless pathway for each chromophore subvariety. We also emphasize that significant charge separation accompanies photoisomerization, and that the sense of charge localization is different for different pathways. The implications for photoisomerization in the protein are discussed.

Date	Person	Affiliation	Title	Abstract
9 Oct	Hui Hu	Physics, UQ	Theory of strongly interacting ultracold Fermi gases	Mean-field Bardeen-Cooper-Schrieffer (BCS) theory provides a satisfactory description of the traditional low-temperature superconductors. Recent observations of the Feshbach resonance in cold atoms leads to strongly interacting Fermi systems with extremely high superfluid transition temperature, even higher than that of all known high-temperature superconductors. This new type of superfluids exhibits many interesting behaviors that require timely theoretical investigations. In this talk, after a brief review of the current experimental break-throughs, I will introduce a reliable strong-coupling theory of the ultracold Fermi systems [1] and several applications. In particular, I will show the universal thermodynamics of Fermi gases in the strongly interacting unitarity limit [2], where the system behaves remarkably like its non-interacting counterpart. I will also discuss the Bragg probe of two-fluid hydrodynamics of the strongly interacting Fermi gases [3], and suggest that it offers a unique opportunity to observe the out-of-phase mode -- the second sound mode -- between the superfluid and normal superfluids, which has been observed so far only in the superfluid Helium. [1] HH, Xia-Ji Liu, and Peter D. Drummond, Europhys. Lett. 74, 574 (2006). [2] HH, Peter D. Drummond, and Xia-Ji Liu, Nature Physics 3, 469 (2007). [3] Edward Taylor, HH, Xia-Ji Liu, and Allan Griffin, arXiv::0709.0698, submitted to Phys. Rev. Lett.
16 Oct	Matt Davies	Physics, UQ	Spontaneous formation of quantized vortices in Bose-Einstein condensation	Phase transitions are ubiquitous in nature, from classical to quantum physics and from the subatomic length scales of quark condensation to the decoupling of forces in the early universe. Remarkably, continuous phase transitions in numerous systems display generic phenomena such as spontaneous symmetry breaking and topological defect formation. Thus a complete microscopic description of a transition in one system may impact the understanding of transition dynamics at a universal level. Here we explore spontaneous symmetry breaking in a temperature quench through the Bose-Einstein condensation transition. We describe experiments that observe spontaneous vortex formation during the quench and find quantitative agreement with calculations based on microscopic theory. Our results are consistent with the Kibble-Zurek mechanism, a universal model for topological defect formation in continuous phase transitions.

Date	Person	Affiliation	Title	Abstract
23 Oct	Geoff Pryde	Griffith University	Entanglement-free, Heisenberg-limited phase estimation	Measurement underpins all quantitative science, and advances in precision measurement often lead to new physical understanding. When all technical noise is stripped away, the ultimate limit to measurement precision is set by the Heisenberg uncertainty principle. We demonstrate the first experimental Heisenberg-limited scaling of the phase variance in optical phase measurements. Our algorithm replaces complicated entangled states – widely thought to be essential for Heisenberg scaling - with single photons, multiple passes through a phase shift, and adaptive measurement. We show that although a single-photon version of Kitaev's phase estimation algorithm has standard-quantum-limited variance, our generalized technique is within a small constant factor of the ultimate quantum limit.
30 Oct	Roman Orus	Physics, UQ		
6 Nov	Ashton Bradley	Physics, UQ		
13 Nov	Jacob Jordan	Physics, UQ		
20 Nov	Andrew Doherty	Physics, UQ		
27 Nov	Marco Barbieri	Physics, UQ		
4 Dec	Michael Smith	Physics, UQ		
11 Dec	Ian McCulloch	Physics, UQ		
18 Dec	Xia-Ji Liu	Physics, UQ	Strongly Interacting Polarized Fermi Gases	