Quantum-Atom Optics Downunder

December 3–6, 2007
Wollongong, Australia
Novotel North Beach Hotel

Housing and Travel Information

This will be the first conference devoted to the overlap of Quantum and Atom Optics - providing new fundamental insights and experimental realizations of concepts common to both fields. This conference will bring together key researchers from across the world to discuss the latest results in areas such as:

- Statistical effects and correlations in ultracold quantum gases - including BEC's, atom lasers and degenerate Fermi gases
- The generation and measurement of macroscopic quantum states
- Optical entanglement and quantum imaging
- Applications of atom-light entanglement including quantum communication
- Quantum properties of lattices and periodic systems

Co-Sponsor

AUSTRALIAN RESEARCH COUNCIL CENTRE OF EXCELLENCE FOR QUANTUM-ATOM OPTICS

About QAO Downunder

December 3–6, 2007

Meeting Topics

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- The generation and measurement of macroscopic quantum states
- Optical entanglement and quantum imaging
- Applications of atom-light entanglement including quantum communication
- Quantum properties of lattices and periodic systems

Program Committee

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Kenneth G. Baldwin; *Australian Natl. Univ., Australia,* **Co-Chair**

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Ruth Wilson, *Australian Natl. Univ., Australia*

QAO Invited and Keynote Speakers

Keynote Speakers

QMA1, Rotational Bragg Scattering: Spinning Atoms with the Orbital Angular Momentum of Light, *William D. Phillips[1], Mikkel F. Andersen[2], Pierre Cladé[3], Kristian Helmerson[1], Vasant Natarajan[4], Anand Ramanathan[1], Changhyun Ryu[5], Alipasha Vaziri[6]; [1]NIST, USA, [2]Univ. of Otago, New Zealand, [3]Ecole Normale Superieuré, France, [4]Indian Inst. of Science, India, [5]Los Alamos Natl. Lab, USA, [6]Howard Hughes Medical Inst., Janelia Farms Campus, USA.*

QMA2, Two-Dimensional Transport and Transfer of Individual Atomic Qubits in Optical Tweezers, *J. Beugnon, C. Tuchendler, A. Gaetan, Y. Miroshnychenko, H. Marion, A. M. Lance, M. P. A. Jones, Y. R. P. Sortais, G. Messin, A. Browaeys, Philippe Grangier; Lab Charles Fabry de l'Inst. d'Optique, France.*

QTuA1, Quantum State Generation in Many-Body Quantum Optical Systems, *Diego Porras, Christine Muschik, Inés de Vega, J. Ignacio Cirac; Max-Planck Inst., Germany.*

QTuA2, To Be Announced, *Daniel J. Heinzen; Univ. of Texas, USA.*

QWA1, Quantum Parameter Estimation with Cold Atomic Spins, *Anthony Miller, John Stockton, Magnus Hsu, Orion Crisafulli, Gopal Sarma, Luc Bouten, Andrew Silberfarb, Hideo Mabuchi; Caltech, USA.*

QWA2, Mysteries of Quantum Entanglement: Why $\cos^2\alpha > \cos\alpha$ for All Values of α, *Joseph H. Eberly; Univ. of Rochester, USA.*

QThA1, To Be Announced, *Alain Aspect; Inst. d'Optique, France.*

QThA2, Quantum Atom Optics with Spin Polarized Atomic Ensembles, *Eugene Polzik; QUANTOP Ctr., Niels Bohr Inst., Copenhagen Univ., Denmark.*

Invited Speakers

QMB1, Ultracold Gases in Microgravity, *Wolfgang Ertmer; Univ. of Hannover, Germany.*

QMC1, Number Counting in a Bose Josephson Junction, *Joseph H. Thywissen; Univ. of Toronto, Canada.*

QMD1, Quantum-Opto-Mechanics: From Laser-Cooling to Quantum Entanglement of Micromechanical Systems, *Markus Aspelmeyer; IQOQI, Austrian Acad. of Sciences, Austria.*

QMD4, Storage of Quantum Variables in Atomic Media, *J. Cviklinski, J. Ortalo, V. Josse, A. Dantan, M. Pinard, A. Bramati, Elisabeth Giacobino; Lab Kastler Brossel, Univ. Paris, ENS, CNRS, France.*

QTuB1, Quantum Degenerate Gases in Optical Lattices, *Massimo Inguscio; LENS and Dept. di Fisica, Univ. di Firenze, Italy.*

QTuC1, Quantum Stochastic Heating of a Trapped Ion through Resonance Fluorescence, *Levente Horvath[1], Matthew J. Collett[1], Howard Carmichael[1], Robert Fisher[2]; [1]Univ. of Auckland, New Zealand, [2]Technical Univ. of Munich, Germany.*

QTuD1, Quantum Aspects of Frequency Combs, *Claude Fabre, N. Treps, G. De Valcarcel, G. Patera, B. Lamine; Lab Kastler Brossel, Univ. Pierre et Marie Curie, France.*

QTuD4, $^{171}Yb^{+}$ Single-Ion Optical Frequency Standards and Search for Variations of the Fine Structure Constant , *Ekkehard Peik, B. Lipphardt, H. Schnatz, I. Sherstov, B. Stein, Chr. Tamm, S. Weyers, R. Wynands; Physikalisch-Technische Bundesanstalt, Germany.*

QWB1, To Be Announced, *Klaus Sengstock; Univ. of Hamburg, Germany.*

QWC1, Photon Anti-Bunching and "Hole"-Entanglement with Homodyne Detections, *T. Symul[1], N. B. Grosse[1], D. J. Alton[1], S. M. Assad[1], Ping Koy Lam[1], M. Stobinska[2], Philippe Grangier[3], T. C. Ralph[4]; [1]Australian Natl. Univ., Australia, [2]Univ. Warszawski, Poland, [3]Lab Charles Fabry de l'Inst. d'Optique, France, [4]Univ. of Queensland, Australia.*

QWD1, Schlieren Nanoscope in Atom Optics, *Jules Grucker, Jean-Christophe Karam, Valja Bocvarski, Francisco Perales, Gabriel Dutier, Jacques Baudon, Martial Ducloy; Lab de Physique des Lasers, Univ. Paris Nord, France.*

QThB1, Extreme Control of Molecular States: On the Way to Super Chemistry, *Christian Lisdat, Oleg Bucicov, Marcin Nowak, Sebastian Jung, Eberhard Tiemann; Inst. of Quantum Optics, Germany.*

QThC1, Ultracold Magnesium, *Ernst Rasel; Univ. of Hannover, Germany.*

QThD1, Temperature and Degeneracy of Ultra-cold Bosons in Optical Lattices, *P. Blair Blakie; Univ. of Otago, New Zealand.*

QThD4, Strongly-Correlated Quantum Gases: Atomtronics and Rotating Optical Lattices, *Murray Holland; JILA and Dept. of Physics, Univ. of Colorado, USA.*

Agenda of Sessions

Sunday, December 2, 2007		
6:00 p.m.	**Welcome Reception**	*Illawarra Gallery*
Monday, December 3, 2007		
8:15 a.m.—8:30 a.m.	**Opening Remarks**	*Illawarra Room*
8:30 a.m.—10:00 a.m.	**QMA • Monday Session I**	*Illawarra Room*
10:00 a.m.–10:30 a.m.	**Tea Break**	*Illawarra Foyer*
10:30 a.m.—12:00 p.m.	**QMB • Monday Session II**	*Illawarra Room*
12:00 p.m.—2:30 p.m.	**Lunch Break**	
2:30 p.m.—4:00 p.m.	**QMC • Monday Session III**	*Illawarra Room*
4:00 p.m.—4:30 p.m.	**Tea Break**	*Illawarra Foyer*
4:30 p.m.—5:40 p.m.	**QMD • Monday Session IV**	*Illawarra Room*
5:40 p.m.—8:00 p.m.	**Dinner Break**	
8:00 p.m.—9:30 p.m.	**QME • Monday Poster Session I**	*Illawarra Foyer*
Tuesday, December 4, 2007		
8:30 a.m.—10:00 a.m.	**QTuA • Tuesday Session I**	*Illawarra Room*
10:00 a.m.—10:30 a.m.	**Tea Break**	*Illawarra Foyer*
10:30 a.m.—12:00 p.m.	**QTuB • Tuesday Session II**	*Illawarra Room*
12:00 p.m.—2:30 p.m.	**Lunch Break**	
2:30 p.m.—4:00 p.m.	**QTuC • Tuesday Session III**	*Illawarra Room*
4:00 p.m.—4:30 p.m.	**Tea Break**	*Illawarra Foyer*
4:30 p.m.—6:10 p.m.	**QTuD • Tuesday Session IV**	*Illawarra Room*
7:00 p.m.–7:30 p.m.	**Pre-Dinner Drinks**	*Ballroom Gallery*
7:30 p.m.	**Conference Dinner**	*Ballroom*
Wednesday, December 5, 2007		
8:30 a.m.—10:00 a.m.	**QWA • Wednesday Session I**	*Illawarra Room*
10:00 a.m.—10:30 a.m.	**Tea Break**	*Illawarra Foyer*
10:30 a.m.—12:00 p.m.	**QWB • Wednesday Session II**	*Illawarra Room*
12:00 p.m.—2:30 p.m.	**Lunch Break**	
2:30 p.m.—4:00 p.m.	**QWC • Wednesday Session III**	*Illawarra Room*
4:00 p.m.—4:30 p.m.	**Tea Break**	*Illawarra Foyer*
4:30 p.m.—6:00 p.m.	**QWD • Wednesday Session IV**	*Illawarra Room*
6:00 p.m.—8:00 p.m.	**Dinner Break**	
8:00 p.m.—9:30 p.m.	**QWE • Wednesday Poster Session II**	*Illawarra Foyer*
Thursday December 6, 2007		
8:30 a.m.—10:00 a.m.	**QThA • Thursday Session I**	*Illawarra Room*
10:00 a.m.—10:30 a.m.	**Tea Break**	*Illawarra Foyer*
10:30 a.m.—12:00 p.m.	**QThB • Thursday Session II**	*Illawarra Room*
12:00 p.m.—2:30 p.m.	**Lunch Break**	
2:30 p.m.—4:00 p.m.	**QThC • Thursday Session III**	*Illawarra Room*
4:00 p.m.—4:30 p.m.	**Tea Break**	*Illawarra Foyer*
4:30 p.m.—6:10 p.m.	**QThD • Thursday Session IV**	*Illawarra Room*
6:10 p.m.—6:25 p.m.	**Closing Remarks**	*Illawarra Room*

•Sunday, December 2, 2007•

Ballroom Gallery
6:00 p.m.
Welcome Reception

•Monday, December 3, 2007•

Ballroom
8:15 a.m.–8:30 a.m.
Opening Remarks
Hans Albert Bachor; Australian Natl. Univ., Australia.

QMA • Monday Session I

Ballroom
8:30 a.m.–10:00 a.m.
QMA • Monday Session I
Kenneth G. Baldwin; Australian Natl. Univ., Australia, Presider

QMA1 • 8:30 a.m.
Keynote
Rotational Bragg Scattering: Spinning Atoms with the Orbital Angular Momentum of Light, *William D. Phillips[1], Mikkel F. Andersen[2], Pierre Cladé[3], Kristian Helmerson[1], Vasant Natarajan[4], Anand Ramanathan[1], Changhyun Ryu[5], Alipasha Vaziri[6]; [1]NIST, USA, [2]Univ. of Otago, New Zealand, [3]Ecole Normale Supérieure, France, [4]Indian Inst. of Science, India, [5]Los Alamos Natl. Lab, USA, [6]Howard Hughes Medical Inst., Janelia Farms Campus, USA.* We demonstrate the coherent, quantized transfer of the orbital angular momentum of light to a Bose-Einstein condensate of sodium atoms by means of a stimulated, two-photon transition between the static, non-rotating BEC and a rotating state moving with the linear momentum of two photons. By reversing the transfer of linear momentum, without any angular momentum, we create either vortex states (in a simply connected trap) or persistent atom currents (in a toroidal trap). The persistent current in the toroidal trap lasts about 20 times longer than a vortex under similar conditions in the simply connected trap.

QMA2 • 9:15 a.m.
Keynote
Two-Dimensional Transport and Transfer of Individual Atomic Qubits in Optical Tweezers, *J. Beugnon, C. Tuchendler, A. Gaetan, Y. Miroshnychenko, H. Marion, A. M. Lance, M. P. A. Jones, Y. R. P. Sortais, G. Messin, A. Browaeys, Philippe Grangier; Lab Charles Fabry de l'Inst. d'Optique, France.* Abstract not available.

Ballroom Gallery
10:00 a.m.–10:30 a.m.
Tea Break

QMB • Monday Session II

Ballroom
10:30 a.m.–12:00 p.m.
QMB • Monday Session II
Alain Aspect; Inst. d'Optique, France, Presider

QMB1 • 10:30 a.m.
Invited
Quantum-Opto-Mechanics: From Laser-Cooling to Quantum Entanglement of Micromechanical Systems, *Markus Aspelmeyer; IQOQI, Austrian Acad. of Sciences, Austria.* The quantum regime of mechanical systems promises fascinating new fields of research both for applications and for fundamental physics. Quantum optics provides a well-developed toolbox to enter this regime. My talk will cover recent advances in quantum-opto-mechanical systems such as laser-cooling towards the quantum ground state. I will also discuss the prospects of generating quantum entanglement involving mechanical resonators, which is an important resource for quantum information processing and is also at the heart of Schrödinger's cat paradox.

QMB2 • 11:00 a.m.
XMDS 2.0, *John Hedditch, Timothy Vaughan, David Barry, Scott Hoffmann, Scott Wales, Peter D. Drummond; Australian Ctr. of Excellence for Quantum-Atom Optics, Univ. of Queensland, Australia.* We outline a new version of the XMDS code-generator for computational simulations, with many new features and applications to quantum-atom optics.

QMB3 • 11:20 a.m.
An Efficient Source of Continuous Variable Polarization Entanglement, *Ruifang Dong[1], Joel Heersink[1], Jun–ichi Yoshikawa[2], Oliver Gloeckl[1], Ulrik L. Andersen[1,3], Gerd Leuchs[1]; [1]Inst. for Optics, Information and Photonics, Max-Planck Res. Group, Univ. of Erlangen-Nuremberg, Germany, [2]Dept. of Applied Physics, School of Engineering, Univ. of Tokyo, Japan, [3]Dept. of Physics, Technical Univ. of Denmark, Denmark.* We have experimentally demonstrated a highly efficient continuous variables polarization entangled source. The polarization entanglement was generated by interfering two independent polarization squeezed fields on a symmetric beam splitter and the resultant beams exhibit strong quantum noise correlations. Carrying out measurements on an optimized set of conjugate Stokes parameters, correlations of -3.6±0.3 dB and -3.4±0.3 dB have been observed.

QMB4 • 11:40 a.m.
Demonstrating Spatial Entanglement for the Position and Momentum of Laser Beams, *Charles Harb[1,2], Katherine I. Wagner[1,3], Hongxin Zou[1], Jiri Janousek[2], Vincent Delaubert[3], Nicolas Treps[3], Ping Koy Lam[1], Hans A. Bachor[1]; [1]ARC Ctr. of Excellence for Quantum-Atom Optics, Australian Natl. Univ., Australia, [2]Technical Univ. of Denmark, Denmark, [3]Lab Kastler-Brossel, France.* We present the latest results on the experimental generation of the position and momentum (x-p) entanglement for bright optical beams [1]. Spatial entanglement of light is a direct demonstration of entanglement of the momentum and position of laser beam as envisioned in the original publication by Einstein, Podolsky and Rosen [2]. Spatial entanglement has potential applications in quantum imaging systems and for quantum communication protocols. The position-momentum entanglement was observed in the form of the degree of inseparability, which was measured to be no larger than 0.76.

12:00 p.m.—2:30 p.m.
Lunch Break

QMC • Monday Session III

Ballroom
2:30 p.m.–4:00 p.m.
QMC • Monday Session III
Andrew Truscott, Australian National University, Presider

QMC1 • 2:30 p.m.
Invited
Number Counting in a Bose Josephson Junction, *Joseph H. Thywissen; Univ. of Toronto, Canada.* Correlations in quantum degenerate matter can be created by even weak interactions. A double well provides a simple system in which to observe this effect, since relative occupation has sub-Poissonian fluctuation when the charging energy becomes greater than the Josephson energy of the superfluid. I will discuss our efforts to observe this effect directly in the number statistics of a split Bose-Einstein condensate. We have a sensitivity to standard deviation at the level of tens of atoms, giving us

sub-Poissonian noise and uncertainty in our measurement of several thousand atoms. We report statistical results for various preparations and splitting sequences.

QMC2 • 3:00 p.m.
Universal Thermodynamic Behavior of Strongly Interacting Fermi Gases, *Xia-Ji Liu, Peter D. Drummond, Hui Hu; ACQAO, Univ. of Queensland, Australia.* Theoretical predictions for the universal thermodynamics of strongly interacting Fermi gases are compared with three recent experimental results for the entropy-energy relation of ultracold trapped gases of ^{6}Li and ^{40}K atoms. Our calculations are based on an analytic theory that includes pair fluctuations beyond mean-field. Excellent agreement with all experimental measurements is obtained, without any free parameters.

QMC3 • 3:20 p.m.
Development of the Atom Laser, *Nicholas P. Robins, Cristina Figl, Matthew Jeppesen, Julien Dugue, John D. Close; Australian Natl. Univ., Australia.* We discuss recent developments in our laboratory, in particular focusing on continuous Raman output coupling. We show how recent advances allow the atom laser beam quality to approaching the Heisenberg limit.

QMC4 • 3:40 p.m.
Quantum Control of a Multimode Atom Laser, *Joseph J. Hope[1,2], Michael Hush[1], Andre R. R. Carvalho[1], Stuart Wilson[1], Matthew James[1]; [1]Australian Natl. Univ., Australia, [2]Australian Ctr. for Quantum-Atom Optics, Australia.* We derive a quantum filter equation for a pumped multimode atom laser interacting with a far-detuned laser field that is measured on an array of photodetectors. This system measures atomic density, which is equivalent to a measurement of position (and higher order moments of position) in the single atom limit, and atom number in the single mode limit. Both of these limits have important control schemes associated with them in the literature, and these control schemes operate in significantly different parameter regimes. We examine methods for solving the multimode filter equation in the presence of feedback control.

Ballroom Gallery
4:00 p.m.—4:30 p.m.
Tea Break

QMD • Monday Session IV

Ballroom
4:30 p.m.–5:40 p.m.
QMD • Monday Session IV
Yuri Kivshar; Australian Natl. Univ., Australia, Presider

QMD1 • 4:30 p.m.
Invited
Storage of Quantum Variables in Atomic Media, *J. Cviklinski, J. Ortalo, V. Josse, A. Dantan, M. Pinard, A. Bramati, Elisabeth Giacobino; Lab Kastler Brossel, Univ. Paris, ENS, CNRS, France.* Storage and read-out of non classical states of light is a critical element for quantum information networks. Simultaneous storage of two non-commuting variables carried by light and subsequent read-out is shown to be possible in atomic ensembles. Interaction of light fields with three-level systems allows direct mapping the quantum state of light into long lived coherences in the atomic ground state. We show that excess noise linked to atomic transitions can be made negligible. Experimental developments are discussed for atomic vapours and cold atoms.

QMD2 • 5:00 p.m.
Toward Quantum Optics Experiments with Silicon Micro-Mechanical Oscillators, *Tristan Briant, Chiara Molinelli, Olivier Arcizet, Pierre-François Cohadon, Antoine Heidmann; Lab Kastler Brossel, Ecole Normale Supérieure, France.* We present an experiment where the motion of a silicon micro-mechanical resonator is optically monitored in a high-finesse cavity with a quantum-limited sensitivity of $4\ 10^{-19}$ m/√Hz. Directs effects of intracavity radiation pressure are experimentally demonstrated: we have observed a self-cooling of the resonator to an effective temperature in the 10 K range. Further experimental progress and cryogenic operation may allow for quantum optics experiments and lead to the experimental observation of the quantum ground state of a mechanical resonator.

QMD3 • 5:20 p.m.
Controlling Entanglement by Quantum-Jump-Based Feedback, *André R. R. Carvalho[1], Joseph J. Hope[2]; [1]Dept. of Physics, Australian Natl. Univ., Australia, [2]Australian Ctr. for Quantum-Atom Optics, Australian Natl. Univ., Australia.* We describe how feedback methods can be implemented to produce and stabilize entangled states of two atoms inside a cavity. Feedback control is used to engineer an effective environment dynamics, such that the entangled state to be protected is a steady state of the system. The control strategy is therefore robust with respect to external noises and fundamental decoherence sources, as spontaneous emission, for example. We also show that the scheme is mostly insensitive to practical imperfections, as detection inefficiencies and laser fluctuations.

QMD4 • 5:40 p.m.
Many-Body Dynamics of Repulsively Bound Pairs of Particles in a Periodic Potential, *David Petrosyan[1], Bernd Schmidt[2], James R. Anglin[2], Michael Fleischhauer[2]; [1]Inst. of Electronic Structure and Laser, Foundation for Res. and Technology, Hellas (FORTH), Greece, [2]Univ. of Kaiserslautern, Germany.* Repulsively interacting particles in a periodic potential can form bound composite objects, whose dissociation is suppressed by a band gap. Nearly pure samples of such repulsively bound pairs of cold atoms—"dimers"—have recently been prepared by Winkler et al. [Nature 441, 853 (2006)]. We derive an effective Hamiltonian for a lattice loaded with dimers only, and discuss its implications for many-body dynamics of the system. We show that strong on-site repulsion and nearest-neighbor attraction favor clusters of dimers with minimum surface area and uniform, commensurate filling, representing thus incompressible "droplets" of a lattice liquid.

6:00 p.m.—8:00 p.m.
Dinner Break

QME • Monday Poster Session I

Ballroom Gallery
8:00 p.m.–9:30 p.m.
QME • Monday Poster Session I

QME1
Barriers to Producing Macroscopic Superpositions of Superfluid Flow, *David W. Hallwood[1], Jacob Dunningham[2], Keith Burnett[1]; [1]Univ. of Oxford, UK, [2]Univ. of Leeds, UK.* Quantum behaviour appears to be lost in macroscopic objects. They do not, for example, form superpositions. In this paper I present two schemes that produce multiparticle superpositions of superfluid flow. By studying the effect of external parameters on the superposition, I have found three conditions that must be satisfied for a superposition to form. The energy of the superposition states must be close, there must be a coupling path between the states and other states must not couple strongly. By optimising these conditions, it may be possible to make Schrödinger cat states, useful for metrology and stable qubits.

QME4
Experimental Evidence of Spontaneous Transfer of Coherence in a Driven Degenerate Two-Level System under the Action of a Linearly or a Circularly Polarized Probe, *Luca Spani Molella[1,2], Katrin Dahl[2], Rolf-Hermann Rinkleff[1,2], Karsten Danzmann[1,2]; [1]Max-Planck-Inst. für Gravitationsphysik, Albert-Einstein-Inst., Germany, [2]Inst. für Gravitationsphysik, Leibniz Univ. Hannover, Germany.* Electromagnetically induced absorption (EIA) in a degenerate closed transition was measured under the action of a probe and a coupling laser of various polarizations giving rise to different possible N-systems or multi-level systems. While the probe shows EIA the coupling is mainly characterized by “absorption within transparency.” However, for certain lasers' intensity ranges, a switch between “absorption within transparency” and “transparency within transparency” in the coupling absorption spectra was measured for the first time.

QME5
Two Dimensional Localization of Matter Waves by Disorder, *David A. W. Hutchinson[1,2], Yvan Castin[2]; [1]Jack Dodd Ctr., Dept. of Physics, Univ. of Otago, New Zealand, [2]Lab Kastler Brossel, École Normale Supérieure, France.* The possibility of using ultracold atoms to observe localization of matter waves is now a subject of significant interest. These systems offer unprecedented control over inter-particle interactions, imposed potentials and the level of disorder as compared to their condensed matter analogues. The two-dimensional (2-D) case is of particular interest. The prevailing view has been that in the 2-D electron gas there is no metallic state, but recent experiments are suggestive of a metal-insulator transition in very dilute systems. We investigate theoretically the possibility of observing strongly localized states, corresponding to the insulating phase, in the dilute 2-D gas.

QME6
Broadband Optical Delay with Large Dynamic Range Using Atomic Dispersion, *Michael R. Vanner, Russell J. McLean, Andrei I. Sidorov, Peter Hannaford, Alexander M. Akulshin; Swinburne Univ., Australia.* We report on a tunable all-optical delay line for pulses with frequency tuned between absorption lines in hot Rb vapour. Optical pulses of 10 ns duration were delayed by more than 40 ns with reasonable transmission. The use of two isotopes allows the delay to be increased or decreased through optical pumping, permitting rapid tuning over a large fraction of the unmodified delay. We investigate the frequency and intensity range over which this delay line can be used.

QME7
Competition between Attractive and Repulsive Interactions in Two-Component BEC Trapped in an Optical Lattice, *Michal Matuszewski[1], Boris A. Malomed[2], Marek Trippenbach[1,3]; [1]Nonlinear Physics Ctr., Australian Natl. Univ., Australia, [2]School of Electrical Engineering, Faculty of Engineering, Tel-Aviv Univ., Israel, [3]Inst. of Theoretical Physics, Univ. of Warsaw, Poland.* We consider effects of inter-species attraction on two-component gap solitons in the binary BEC with intra-species repulsion, trapped in the one-dimensional optical lattice. Systematic simulations of the coupled Gross-Pitaevskii equations corroborate an assumption that, because the effective mass of solitons is negative, the inter-species attraction may split the two-component soliton. Two critical values of the lattice strength are identified. Two-species gap solitons are stable in strong lattices. In an intermediate region the soliton splits into a double-humped state with separated components. Finally, in weak lattices, the splitting generates a pair of freely moving single-species solitons.

QME8
Quantum and Thermal Decoherence in Two Weakly Coupled Bose-Einstein Condensates, *Chaohong Lee, Libin Fu, Yuri S. Kivshar; Australian Natl. Univ., Australia.* We study the coherence fluctuations in two coupled Bose condensates. We apply the two-mode approximation in the full quantum theory analysis, and so that the system obeys a two-site Bose-Hubbard Hamiltonian. The coherence fluctuations are determined by the total number of particles, charging energy, junction energy, asymmetry and temperature. For zero-temperature symmetric systems, the coherence fluctuations increase with E_C/E_J, however, the number squeezing increases with N^2E_C/E_J. For zero-temperature asymmetric systems, the coherence fluctuations are suppressed by the balance and single-atom resonance effects. The coherence fluctuations grow with temperature, and the self-trapping will cause abnormal behaviors.

QME9
Coherence of Two-Component Bose-Einstein Condensates on an Atom Chip, *Russell Anderson, Brenton V. Hall, Peter Hannaford, Andrei Sidorov; ARC Ctr. of Excellence for Quantum Atom Optics and Ctr. for Ultrafast Spectroscopy, Swinburne Univ. of Technology, Australia.* We report on progress towards experiments studying the coherence of a two-component Bose-Einstein condensate using a magnetic film atom chip. Our atom chip provides extremely low heating rates and offers advantageous conditions for increased coherence times. We currently trap 4 x 10^7 ^{87}Rb atoms in the $|F = 1, m_F = -1>$ ground state and use forced evaporative cooling towards the degeneracy. The Ramsey method of separated fields will be used to interrogate the evolution of a Bose-Einstein condensate in a superposition of the |1, -1> and |2, 1> states.

QME10
On Scattering Ground State Polar Molecules, *Chris Ticknor; Swinburne Univ., Australia.* We report a theoretical study on the nature of scattering polar molecules in the presence of an electric field in their absolute ground state. Most important is the illustration that the s-wave scattering length does not parametrize the scattering at low energies even when the electric field is non-zero. Furthermore we show that a simple semi-classical scattering cross section can be used to estimate the total cross section accurately for particular field and energy values.

QME11
Spontaneously Induced Sudden Birth of Entanglement, *Zbigniew Ficek[1], R. Tanás[2]; [1]School of Physical Sciences, Univ. of Queensland, Australia, [2]Nonlinear Optics Div., Inst. of Physics, Adam Mickiewicz Univ., Poland.* The concept of time delayed creation of entanglement by spontaneous emission is investigated. A threshold effect for the creation of entanglement is found that the initially unentangled qubits can be entangled after a finite time. This delayed creation of entanglement, that we call sudden birth of entanglement, is opposite to the currently extensively discussed sudden death of entanglement and is characteristic for transient dynamics of one-photon entangled states of the system. We determine the threshold time for the creation of entanglement and show that it is related to time the correlation between the qubits attains its maximal negative value.

QME12
Towards Production of a Dual Species Metastable Helium-Rubidium Bose-Einstein Condensate, *Lesa J. Byron, Rob G. Dall, Andrew G. Truscott; ARC Ctr. of Excellence for Quantum-Atom Optics, Australian Natl. Univ., Australia.* We present progress towards the production of the first dual species metastable Helium (He*)-^{87}Rb Bose-Einstein Condensate (BEC). The

production of a He*-Rb binary BEC would allow for studies of Penning and associative ionization, photoassociative spectroscopy and eventually for a study of bound ultracold He*Rb molecules. The production of a He*-Rb BEC will be realised by modifying the existing He* BEC experiment at the Australian National University.

QME13
Laser-Cavity Frequency Locking Using Modern Control, *Sayed Z. Hassen[1], Elanor Huntington[1], Matthew James[2], Ian R. Petersen[1]; [1]Univ. of New South Wales at the Australian Defence Force Acad., Australia, [2]Australian Natl. Univ., Australia.* This paper considers the application of Linear Quadratic Gaussian (LQG) optimal control theory to a problem of cavity locking in quantum optics. Using an equivalence between quantum LQG control and classical LQG control, this problem is reduced to a standard LQG control problem. The cavity locking problem involves controlling the error between the laser frequency and the cavity frequency. A model for the cavity system is set up and an LQG controller is synthesized. The resulting control system implemented on an experimental cavity.

QME14
CV Tripartite Entanglement from Coupled Nonlinearities, *Murray K. Olsen, Ashton S. Bradley; ARC Ctr. of Excellence for Quantum-Atom Optics, Univ. of Queensland, Australia.* We calculate the continuous variable entanglement properties of the output fields produced by systems with concurrent nonlinearities. We find that the actual criteria chosen are not important for symmetric systems but that a careful choice is necessary for asymmetric systems.

QME15
Many-Body Effects in the Dynamics of Bose-Einstein Condensates, *Thomas Ernst[1], Tobias Paul[2], Peter Schlagheck[3], Joachim Brand[1]; [1]Ctr. of Theoretical Chemistry and Physics, Inst. of Fundamental Sciences, Massey Univ. Auckland, New Zealand, [2]Lab de Physique Théorique et Modèles Statistiques, CNRS, Univ. Paris Sud, France, [3]Inst. für Theoretische Physik, Univ. Regensburg, Germany.* We study the dynamics of repulsive and attractive Bose-Einstein condensates. While previous works used the Gross-Pitaevskii equation to calculate this process, we employ a kinetic dynamics approach similar to the famous Hartree-Fock-Bogoliubov equations. Therefore we are able to take into account excitations of the condensate as well as its depletion rate. We apply it to the transport of repulsive Bose-Einstein condensates and the scattering problem of a propagating soliton on an attractive potential, where previous works showed a sharp transition from total reflection to full transmission.

QME16
Heisenberg-Limited Reference Frames Using Spin-Squeezed Atomic Ensembles, *Stephen D. Bartlett, Lisa Torlina; Univ. of Sydney, Australia.* We present an experimentally-accessible scheme to perform Heisenberg-limited alignment of a Cartesian frame using spin-squeezed atomic ensembles. This scheme involves using three distinct ensembles of spins, each polarized in one of three Cartesian directions and subsequently spin-squeezed along an orthogonal direction. Unlike previous theoretical investigations, our scheme does not require highly-entangled states of many distinguishable spins, and can make use of adaptive measurements to achieve the Heisenberg limit.

QME17
Non-Local Pair Correlations and Quasi-Crystalline Phases in a 1-D Bose Gas, *Andrew G. Sykes[1], Dimitri M. Gangardt[2], Matthew J. Davis[1], Karen V. Kheruntsyan[1]; [1]ARC Ctr. of Excellence for Quantum-Atom Optics, Univ. of Queensland, Australia, [2]Univ. of Birmingham, UK.* We calculate analytically the nonlocal pair correlation function for an interacting, uniform 1-D Bose gas at finite temperatures. In certain regimes, the pair correlation exhibits a global maximum at a finite interparticle separation, implying a quasi-crystalline structure.

QME18
The Jaynes-Cummings Model and Grassmann Phase Space Methods, *Bryan J. Dalton, Saeed Ghanbari; ARC Ctr. for Quantum-Atom Optics and Ctr. for Atom Optics and Ultrafast Spectroscopy, Swinburne Univ. of Technology, Australia.* Phase space distribution functional methods utilising c-number and Grassmann fields for bosons and fermions respectively are being developed for theoretical treatments of degenerate quantum gases with large fermionic and bosonic atom numbers. The Jaynes-Cummings model where a single mode bosonic system and a two mode fermionic system are coupled provides a simple test-bed for phase space methods involving Grassmann variables. The Fokker-Planck equation for the distribution function is shown to be equivalent to six coupled equations for c-number bosonic functions. Numerical solutions enable well-known effects such as collapses/revivals of the atomic population difference to be demonstrated.

QME19
Phase Sensitivity of a Nonlinear Matter-Wave Interferometer, *Agnieszka Gorecka[1], Chaohong Lee[1], Matthew Davis[2], Elena Ostrovskaya[1]; [1]ARC Ctr. of Excellence for Quantum-Atom Optics and Nonlinear Physics Ctr., Res. School of Physical Sciences and Engineering, Australian Natl. Univ., Australia, [2]School of Physical Sciences, Univ. of Queensland, Australia.* We present a theoretical study of the Bose-Einstein condensate (BEC) in a one-dimensional time-dependent double-well potential. As the two separate wells merge into a single well, moving nonlinear excitations (dark solitons) are formed in the condensate. The amplitude of either the soliton oscillations or the dipole oscillations in the single-well harmonic trap is sensitive to the relative phase between initially separated condensates. By employing the classical field approximation, we examine the phase sensitivity of the interferometry for different recombination rates and temperatures, and investigate the connection between the dynamics of the nonlinear excitations and the condensate heating.

QME20
Generating Nonclassical States in Atom-Optics via Self Interaction, *Simon A. Haine[1,2], M. T. Johnsson[1,3]; [1]Australian Res. Council Ctr. of Excellence for Quantum Atom Optics, Australia, [2]School of Physical Sciences, Univ. of Queensland, Australia, [3]Dept. of Physics, Australian Natl. Univ., Australia.* We propose a method for generating quantum squeezing in atom-optical systems. We show that it is possible to generate squeezed atom lasers, and Bose-Einstein condensates with squeezed occupation numbers by utilising the nonlinear atomic interactions caused by *s*-wave scatting. We develop an analytic model of the process which we compare to a detailed stochastic simulation of the system using phase space methods. Finally we show that significant squeezing can be obtained in an experimentally realistic system and suggest ways of increasing the tunability of the squeezing.

QME21
Strongly Interacting Polarized Fermi Gases, *Hui Hu[1,2], Xia-Ji Liu[1], Peter D. Drummond[1]; [1]ACQAO, Univ. of Queensland, Australia, [2]Dept. of Physics, Renmin Univ. of China, China.* Motivated by recent significant experimental development on imbalanced Fermi gases, we present a systematic study of the phase diagram and thermodynamics of the ground state and vortices in spin-polarized Fermi gases.

QME22
Characterization of the Legnaro Fr MOT, *Sergei N. Atutov[1], Roberto Calabrese[1], Lorenzo Corradi[2], Antonio Dainelli[2], Claudio de Mauro[3], Alen Khanbekyan[3], Emilio Mariotti[3], Paolo Minguzzi[4], Luigi Moi[3], Stefano Sanguinetti[4], Giulio Stancari[1], Luca Tomassetti[1]; [1]Inst. Nazionale di Fisica Nucleare, Physics Dept., Ferrara Univ., Italy, [2]Inst. Nazionale di Fisica Nucleare, Laboratori Nazionali di Legnaro, Italy, [3]Consorzio Nazionale Interuniversitario per le Scienze Fisiche Della Materia (CNISM), Physics Dept., Siena Univ., Italy, [4]Physics Dept., Pisa Univ., Italy.* The most recent results about Fr MOT in Legnaro INFN National laboratories will be presented. We have trapped both ^{210}Fr and ^{209}Fr. Continuous and pulsed regimes have been tested and the overall efficiency evaluated. Possible improvements and future applications will be discussed.

QME23
Observation of Radiation-Pressure Effects and Back-Action Cancellation in Interferometric Measurements, *Tristan Briant, Thomas Caniard, Pierre Verlot, Pierre-François Cohadon, Antoine Heidmann; Lab Kastler Brossel, Ecole Normale Supérieure, France.* We report the first experimental demonstration of a cancellation of back-action noise in ultra-sensitive interferometric measurements. Our setup is based upon a high-finesse optical cavity with movable mirrors and achieved a sensitivity of 1×10^{-20} m/√Hz. Using an intensity-modulated intracavity light beam to mimic the quantum noise of radiation-pressure we demonstrate a sensitivity improvement both in displacement and weak force measurements. Further improvements will allow to observe quantum effects of radiation pressure.

QME24
Observation of Persistent Flow of a Bose-Einstein Condensate in a Toroidal Trap, *Kristian Helmerson[1], Changhyun Ryu[1], Mikkel F. Andersen[2], Pierre Cladé[1], Vasant Natarajan[3], Anand Ramanathan[1], William D. Phillips[1]; [1]NIST, USA, [2]Univ. of Otago, New Zealand, [3]Indian Inst. of Science, India.* We have observed the persistent flow of Bose-condensed atoms in a toroidal trap. The flow persists without decay for up to 10 s, and was initiated by transferring one unit of the orbital angular momentum from Laguerre-Gaussian photons to each atom. Stable flow was only possible when the trap was multiply-connected, and was observed with a BEC fraction as small as 15%. We also created flow with two units of angular momentum, and observed its splitting into two singly-charged vortices when the trap geometry was changed from multiply- to simply-connected.

QME26
Polarization Entanglement over 100 km Optical Fiber for Quantum Key Distribution, *Michael R. Vanner[1], Hannes Hübel[2], Andreas Poppe[2], Anton Zeilinger[2,3]; [1]Ctr. for Atom Optics and Ultrafast Spectroscopy and ARC Ctr. of Excellence for Quantum Atom Optics, Swinburne Univ. of Technology, Australia, [2]Univ. of Vienna, Austria, [3]Inst. for Quantum Optics and Quantum Information, Austrian Acad. of Sciences, Austria.* We demonstrate distribution of polarization entangled photons over 100 km of optical fiber. Measurements of the two-photon visibility, without dark count subtraction, have shown that the quantum correlations (raw visibility 89%) allow secure quantum cryptography after 100 km of non-zero dispersion shifted fiber using commercially available single photon detectors. In addition, quantum tomography has revealed little degradation of entangled state indicating minimal loss in fidelity during the transmission.

QME28
Quantum Coherences and K-Way Negativities, *Naresh K. Sharma[1], S. Shelly Sharma[2]; [1]Dept. de Matematica, Univ. Estadual de Londrina, Brazil, [2]Dept. de Fisica, Univ. Estadual de Londrina, Brazil.* A characterization of N-partite quantum states, based on K-way ($2\leq K\leq N$) negativities, is proposed. For an N-partite system the fraction of K-way negativity ($2\leq K\leq N$), contributing to global negativity, is obtained. The entanglement measures for a given state ρ are identified as the fractional K-way negativities of the corresponding canonical state. Contributions to K-way negativity from different parts of the composite system are determined.

QME29
Storing Information in Nanoporous Silica through Light Controlled Rb Cluster Growth and Demolition, *Luigi Moi, Alessia Burchianti, Andrea Bogi, Carmen Marinelli, Emilio Mariotti; Dept. of Physics, Univ. of Siena, Italy.* We demonstrate that, in nanoporous glass loaded with rubidium, atomic photodesorption and confinement determine a new regime where, depending on light frequency, atoms move from pore surface to clusters and vice versa. This process modifies the optical properties of porous glass which turns blue when clusters grow up and turns back transparent when they dissolve. Therefore light works as a pencil or as an eraser and clusters work as ink. This effect allows for printing/wiping out images and for keeping memory of the light color pulse sequence for quite long time.

QME30
Photon Correlations in Two-Mode Cavity QED, *Matthias Kronenwett, Scott Parkins, Howard Carmichael; Dept. of Physics, Univ. of Auckland, New Zealand.* Photon correlation functions are presented for two-mode cavity QED with orthogonal, linearly-polarized cavity modes. The full atomic level structure is treated for an F=3 to F'=4 transition. An extremely long correlation time is identified and explained.

QME31
Guaranteed Cost Linear Quadratic Gaussian Control of Uncertain Linear Stochastic Quantum Systems, *Aj Shaiju[1], Ian R. Petersen[1], Matthew James[2]; [1]Univ. of New South Wales at the Australian Defence Force Acad., Australia, [2]Australian Natl. Univ., Australia.* In this paper, we formulate and solve a guaranteed cost control problem for a class of uncertain linear stochastic quantum systems. For these quantum systems, a connection with an associated classical (non-quantum) system is first established. The theory presented is illustrated using an example from quantum optics.

QME32
H^∞ Control of Linear Quantum Stochastic Systems, *Matthew James[1], Hendra I. Nurdin[1], Ian R. Petersen[2]; [1]Australian Natl. Univ., Australia, [2]Univ. of New South Wales at the Australian Defence Force Acad., Australia.* The purpose of this paper is to formulate and solve a H^∞ controller synthesis problem for a class of non-commutative linear stochastic systems which includes many examples of interest in quantum technology. A quantum version of standard (classical) dissipativity results are presented and from this a quantum version of the Strict Bounded Real Lemma is derived. This enables a quantum version of the two Riccati solution to the H^∞ control problem to be presented. This result leads to controllers which may be realized using purely quantum, purely classical or a mixture of quantum and classical elements.

QME33
Linear Quadratic Gaussian Control of Quantum Linear Stochastic Systems with Quantum Mechanical Controllers, *Hendra I. Nurdin[1], Matthew R. James[1], Ian R. Petersen[2]; [1]Australian Natl. Univ., Australia, [2]Univ. of New South Wales at the Australian Defence Force Acad., Australia.* We formulate a (sub-optimal) quantum Linear Quadratic Gaussian (LQG) problem for quantum linear stochastic systems where the controller itself may also be a quantum system and the plant output signal can be fully quantum. Our problem may be viewed as a

polynomial matrix programming problem and we show that by utilizing a non-linear change of variables, it can be systematically converted to a Linear Matrix Inequality (LMI) rank constrained problem. As an initial demonstration of the feasibility of this approach, we provide a fully quantum controller design example in which a numerical solution to the problem was successfully obtained.

QME34

Multipartite Entanglement of Three Trapped Ions and the Cavity Field, *S. Shelly Sharma[1], Eduardo de Almeida[1], Naresh K. Sharma[2]; [1]Dept. de Fisica, Univ. Estadual de Londrina, Brazil, [2]Dept. de Matematica, Univ. Estadual de Londrina, Brazil.* The entanglement dynamics of three trapped ion interacting with red sideband tuned single mode of a cavity field is examined. Analytical expressions for the state of three ions and the cavity field are used to obtain the global, four-way, three-way and two-way negativities. For the cavity field initially prepared in a number state, the probability of generating three ion W-state is calculated. Analytical expressions for K-way entanglement measures (K=2 to 4) are obtained and plotted as a function of time.

QME35

Seeded Parametric Downconversion for Quantum Ghost Imaging , *Stefania A. Castelletto[1], Roger Lowden[1], Robert Scholten[1], Ann Roberts[1], Ivo Degiovanni[2], Emiliano Puddu[3], Maria Bondani[4], Alessandra Andreoni[3]; [1]Univ. of Melbourne, Australia, [2]INRIM, Italy, [3]Univ. of Insubria, Italy, [4]Natl. Lab for Ultrafast and Ultraintense Optical Science, Italy.* We propose a novel source to study the role of spatial and intensity quantum correlation in ghost imaging. A seeded pseudo-thermal parametric down-conversion source exhibits correlation properties that can be tuned by changing the seed field intensity and its spatial coherence. This source can be used to explore experimental configurations so far not covered by classical and quantum ghost imaging experiments, and shows the transition from pure entangled states to mixed states in terms of visibility and resolution of the image retrieval.

•Tuesday, December 4, 2007•

QTuA • Tuesday Session I

Ballroom
8:30 a.m.–10:00 a.m.
QTuA • Tuesday Session I
Karen Kheruntsyan; ACQAO, Univ. of Queensland, Australia, Presider

QTuA1 • 8:30 a.m.
Keynote
Quantum State Generation in Many-Body Quantum Optical Systems, *Diego Porras, Christine Muschik, Inés de Vega, J. Ignacio Cirac; Max-Planck Inst., Germany.* We consider different ways of engineering quantum states of light and atoms via their interaction. First, we show that with atoms in optical lattices one may induce quantum gates between two photons. Then, I will give some procedures to create entangled states of ions and atoms in optical lattices. Those states have the property that can be mapped into photonic states by using interference, in such a way that one ends up with several entangled photons. The mapping is triggered by a laser pulse, and the emerging photons are collimated even in the absence of a cavity.

QTuA2 • 9:15 a.m.
Keynote
Spectroscopy of an ultracold Bose gas in an optical lattice, *Daniel J. Heinzen; Univ. of Texas, USA.* We measure the properties of a Bose condensate loaded into an optical lattice, using Bragg spectroscopy and photoassociation spectroscopy. Atom-molecule collisional interactions, the distribution of lattice site occupancies, and the speed of sound are determined. The speed of sound agrees remarkably well with Bogoliubov theory. We will also briefly discuss our efforts to produce a very high intensity source of ultracold atoms.

Ballroom Gallery
10:00 a.m.–10:30 a.m.
Tea Break

QTuB • Tuesday Session II

Ballroom
10:30 a.m.–12:00 p.m.
QTuB • Tuesday Session II
Peter Hannaford; Swinburne Univ. of Technology, Australia, Presider

QTuB1 • 10:30 a.m.
Invited
Quantum Degenerate Gases in Optical Lattices, *Massimo Inguscio; LENS and Dept. di Fisica, Univ. di Firenze, Italy.* Ultracold atoms in optical lattices represent a valuable resource for atom interferometry and for the quantum simulation of condensed matter systems, taking advantage of the possibility to tune interactions, adding disorder and changing quantum statistics. I will present a review of the work recently conducted at LENS in this fascinating field, discussing experiments with ultracold bosons, fermions and atomic mixtures in both periodic and disordered optical potentials, as well as the applications of a novel noninteracting ^{39}K Bose-Einstein condensate.

QTuB2 • 11:00 a.m.
Direct Observation of 2-D Condensate Formation, *Kristian Helmerson[1,2], Pierre Cladé[1,2], Changhyun Ryu[1,2], Anand Ramanathan[1,2], William D. Phillips[1,2]; [1]NIST, USA, [2]Joint Quantum Inst., Univ. of Maryland, USA.* We confine atoms in a dipole trap formed by a sheet of light, resulting in a pancake-shaped cloud. We can image the transverse spatial distribution of atoms to observe local variations in the density, including vortices and anti-vortices. Using atom interferometry, we can determine the onset of spatial coherence. By performing evaporative cooling, for varying initial atom numbers, we observe the transition from thermal, to bimodal, to quasi-condensate, to 2-D Bose-Einstein condensate.

QTuB3 • 11:20 a.m.
Astrophysics and BECs, *Craig M. Savage[1], Angela White[1], Lachlan McCalman[1], Stuart Szigeti[1], Sebastian Wuester[2]; [1]Australian Natl. Univ., Australia, [2]Univ. of Queensland, Australia.* The physics of dilute gas BECs can potentially tell us about astrophysically interesting phenomena. For example, a close analogue of black hole Hawking radiation has been predicted from supersonic transitions in BEC flows. We find that three-body loss severely limits the Hawking temperature that can be achieved in BECs, independent of the detailed implementation of the sonic horizon. Also, a candidate for the galactic halos of dark matter are BECs of the hypothetical elementary particles called axions. We discuss the contributions that theoretical and experimental quantum atom optics can make towards understanding such astrophysics.

QTuB4 • 11:40 a.m.
Continuous Faraday Measurement of a Spinor BEC, *Lincoln Turner, S. Jung, A. T. Black, E. Gomez, P. D. Lett; NIST, USA.* We report a continuous measurement of the spin state of a spinor BEC. A far off-resonant linearly polarised probe beam illuminates a sodium spinor condensate in F=1. The beam is Faraday rotated in proportion to the spin component along the beam propagation direction, and the rotation measured at the shot-noise limit with an autobalanced polarimeter. The measurement is minimally-destructive and continuous. As the condensate spin Larmor precesses in a weak magnetic bias field, the Faraday signal oscillates at the Larmor frequency, typically of order 50 kHz. We investigate this novel measurement for monitoring spin-mixing and decoherence processes in real time.

12:00 p.m.–2:30 p.m.
Lunch Break

QTuC • Tuesday Session III

Ballroom
2:30 p.m.–4:00 p.m.
QTuC • Tuesday Session III
Eugene Polzik; QUANTOP, Denmark, Presider

QTuC1 • 2:30 p.m.
Invited
Quantum Stochastic Heating of a Trapped Ion through Resonance Fluorescence, *Levente Horvath[1], Matthew J. Collett[1], Howard Carmichael[1], Robert Fisher[2]; [1]Univ. of Auckland, New Zealand, [2]Technical Univ. of Munich, Germany.* The resonant heating of a harmonically trapped ion by a standing-wave light field is described as a quantum stochastic process combining a coherent Schroedinger evolution with Bohr-Einstein quantum jumps. The dependence of the center-of-mass motion on Lamb-Dicke parameter is studied. For Lamb-Dicke parameters greater than unity we demonstrate significant departures from the diffusion process that holds in the limit of small momentum "kicks"; a strong inhibition of the heating of the ion (fluorescence) occurs. Heating rates are calculated as a Monte-Carlo average from both the full quantum stochastic process and its semi-quantum approximation.

QTuC2 • 3:00 p.m.
Trapped Ion Chain as a Neural Network: Error Resistant Quantum Computation, *Veronica Ahufinger[1,2], Marisa Pons[3], Christof Wunderlich[4], Anna Sanpera[1,5], Sibylle Braungardt[6], Aditi Sen(De)[6], Ujjwal Sen[6], Maciej Lewenstein[1,6]; [1]Inst. Catalana de Recercha i Estudis Avançcats (ICREA), Spain, [2]Grup d'Optica, Dept. de Fisica,*

Univ. Autonoma de Barcelona, Spain, [3]Univ. del País Vasco, Spain, [4]Univ. Siegen, Germany, [5]Grup de Fisica Teòrica, Dept. de Fisica, Univ. Autonoma de Barcelona, Spain, [6]ICFO, Inst. de Ciències Fotòniques, Spain. We demonstrate the possibility of realizing a neural network in a chain of trapped ions. We show that the system allows for robust distributed classical information storage and its storage capacity, which depends on the phonon spectrum of the system, can be controlled by changing the external trapping potential. Identifying the qubits with configurations of spins that echo the lowest vibrational modes of the system, we perform error resistant universal quantum information processing. Single and two-qubit gates are implemented by applying appropriate axial and transverse magnetic fields.

QTuC3 • 3:20 p.m.
Information Storage in Rubidium via Gradient Echo and EIT, *Gabriel Hétet[1], Ben Buchler[1], Magnus Hsu[1], Jevon Longdell[2], Matt Sellars[2], Hans Albert Bachor[1], Ping Koy Lam[1]; [1]ARC Ctr. of Excellence for Quantum-Atom Optics, Australian Natl. Univ., Australia, [2]Laser Physics Ctr., Res. School of Physical Science and Engineering, Australian Natl. Univ., Australia.* The aim of our work is to realize the atomic storage of continuous variable quantum information encoded in light fields. Following recent ideas, we propose a new scheme based on both Raman absorption and gradient echo and compare its efficacy with electromagnetically induced transparency (EIT)-based memories. A tuneable source of low frequency squeezing at rubidium wavelengths was built to study and compare the efficacy of the memory schemes. We will present our latest theoretical investigations and experimental observations of the coupling of squeezing to Rubidium atoms using these protocols.

QTuC4 • 3:40 p.m.
The EPR Effect and Nonlocality of a Single Photon, *Steven Jones, Howard Wiseman; Ctr. for Quantum Computer Technology and Ctr. for Quantum Dynamics, School of Science, Griffith Univ., Australia.* The EPR effect, for a bipartite pure quantum system, is that “as a consequence of two different measurements performed upon the first system, the second system may be left in states with two different wavefunctions.” In a recent work [Phys. Rev. Lett. 98, 140402 (2007)] we provided an operational definition of this effect that works also for mixed states. Here we apply this concept to a split single photon state $(|1,0\rangle+|0,1\rangle)/\sqrt{2}$. Using only homodyne detection it seems impossible to violate a Bell inequality with this state. However, it is possible to demonstrate the EPR effect, even with substantial vacuum admixture.

Ballroom Gallery
4:00 p.m.–4:30 p.m.
Tea Break

QTuD • Tuesday Session IV

Ballroom
4:30 p.m.–6:10 p.m.
QTuD • Tuesday Session IV
Elisabeth Giacobino; Lab Kastler Brossel, Univ. Pierre et Marie Curie, France, Presider

QTuD1 • 4:30 p.m.
Invited
Quantum Aspects of Frequency Combs, *Claude Fabre, N. Treps, G. De Valcarcel, G. Patera, B. Lamine; Lab Kastler Brossel, Univ. Pierre et Marie Curie, France.* We show that synchronously pumped Optical Parametric Oscillators are able to generate strongly squeezed trains of femtosecond pulses in “supermodes,” which are well defined superpositions of many modes of different frequencies. In some conditions, several supermodes can be simultaneously squeezed. In addition, we show that the use of such squeezed trains of pulses can improve time transfer between remote clocks and ranging techniques beyond the standard quantum limit provided they have an optimized temporal shape.

QTuD2 • 5:00 p.m.
Raman Schemes for Phase Sensitive Measurement and Teleportation of Massive Particles, *Ashton Bradley[1,2], Murray Olsen[1,2], Simon Haine[1,3], Joseph Hope[1,3]; [1]Australian Res. Council Ctr. of Excellence for Quantum-Atom Optics, Australia, [2]School of Physical Sciences, Univ. of Queensland, Australia, [3]Dept. of Physics, Australian Natl. Univ., Australia.* The Raman atom-laser outcoupler, which is based on optical Bose-enhancement, provides a coherent way to generate an atom laser beam from a Bose-Einstein condensate. In this theoretical work we show that a Raman atom laser incoupler, which utilises atomic Bose-enhancement, can be used to make phase sensitive quadrature measurements of an atom laser beam. An incoupler-outcoupler sequence can be used to teleport an input atom laser beam to a spatially separated location via an intermediate optical field.

QTuD3 • 5:20 p.m.
Entanglement-Free, Heisenberg-Limited Phase Measurement, *Brendon L. Higgins[1], Dominic W. Berry[2], Stephen D. Bartlett[3], Howard M. Wiseman[1], Geoff J. Pryde[1]; [1]Griffith Univ., Australia, [2]Macquarie Univ., Australia, [3]Univ. of Sydney, Australia.* 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.

QTuD4 • 5:40 p.m.
Invited
$^{171}Yb^+$ Single-Ion Optical Frequency Standards and Search for Variations of the Fine Structure Constant, *Ekkehard Peik, B. Lipphardt, H. Schnatz, I. Sherstov, B. Stein, Chr. Tamm, S. Weyers, R. Wynands; Physikalisch-Technische Bundesanstalt, Germany.* Recent results on the 688 THz Yb^+ single-ion optical frequency standard are presented. The relative uncertainty of absolute frequency measurements of the standard was reduced to 2.0×10^{-15}. We prepare to observe the electric-octupole transition of Yb^+ at 642 THz with sub-hertz resolution. Measurements of the frequency ratio between the 688 THz and 642 THz transitions in Yb^+ will permit to search for temporal variations of the fine structure constant.

Ballroom Gallery
7:00 p.m.–7:30 p.m.
Pre-Dinner Drinks

Ballroom
7:30 p.m.
Conference Dinner

•Wednesday, December 5, 2007•

QWA • Wednesday Session I

Ballroom
8:30 a.m.–10:00 a.m.
QWA • Wednesday Session I
Howard Wiseman; Griffith Univ., Australia, Presider

QWA1 • 8:30 a.m.
Keynote
Quantum Parameter Estimation with Cold Atomic Spins, *Anthony Miller, John Stockton, Magnus Hsu, Orion Crisafulli, Gopal Sarma, Luc Bouten, Andrew Silberfarb, Hideo Mabuchi; Caltech, USA.* Optical Faraday rotation of a detuned probe laser can be used to monitor the dynamic response of atomic hyperfine spins to time-varying magnetic fields, with minimal backaction. We present a modern formulation of broadband atomic magnetometry as an example of quantum parameter estimation, establishing important connections between abstract quantum measurement theory and concrete physical models. We discuss experimental challenges and progress in this area that sits at the interface of quantum information science and precision measurement.

QWA2 • 9:15 a.m.
Keynote
Mysteries of Quantum Entanglement: Why $\cos^2\alpha > \cos\alpha$ for All Values of α, *Joseph H. Eberly; Univ. of Rochester, USA.* The invention of the two-photon Clauser interferometer opened a completely new domain of photon spectroscopy. It allowed direct experimental demonstration for the first time of non-local non-realist phenomena in physics. We will describe this interferometer and analyse its application to the detection of bi-photons, and discuss other phenomena at the interface between classical and quantum physics. One of the consequences is that relaxation is not always what we were taught. Recent experiments on photons [1] and atoms [2] demonstrate the difference between local, single-particle dynamics and non-local dynamics of entangled quantum systems coupled to independent environments. Even when local environment-induced decay of a system is smoothly asymptotic, quantum entanglement may suddenly disappear. This "sudden death" constitutes yet another distinct and counterintuitive trait of entanglement, confirming earlier predictions [3,4].

Ballroom Gallery
10:00 a.m.–10:30 a.m.
Tea Break

QWB • Wednesday Session II

Ballroom
10:30 a.m.–12:00 p.m.
QWB • Wednesday Session II
Daniel J. Heinzen; Univ. of Texas, USA, Presider

QWB1 • 10:40 a.m.
Signature-Change Events, Trans-Planckian Physics and Quasi-Particle Amplification in Bose-Einstein Condensates, *Angela White[1], Silke Weinfurtner[2], Matt Visser[2], Craig Savage[1]; [1]Ctr. for Gravitational Physics, The Australian Natl. Univ., Australia, [2]Victoria Univ. of Wellington, New Zealand.* We explore signature-changing emergent geometries in a BEC; specifically analogues of signature change from Euclidean to Lorentzian regions. In our BEC-based analogue model, signature change is achieved via a change in atomic interactions from repulsive to attractive. The particle production resulting from a finite-duration Euclidean-signature event is calculated firstly in the hydrodynamic limit. A combination of trans-Planckian physics and signature change results from the inclusion of ultraviolet modes, modifying the expected particle production. We also propose using analogue signature changing events as an amplifier for analogue ”cosmological particle production” and investigate the experimental applicability of this in future BEC experiments.

QWB2 • 11:00 a.m.
Decoherence Dynamics in Interferometry with One-Dimensional Bose-Einstein Condensates, *Thorsten Schumm, Sebastian Hofferberth, Jörg Schmiedmayer; Atomic Inst. of Vienna Univ. of Technology, Austria.* We perform interferometry with one-dimensional Bose-Einstein condensates in a double well potential. Using dressed adiabatic potentials on an atomchip, we dynamically split BECs, imposing a macroscopic coherence on the system. Fluctuations of the order parameter are revealed as local shifts in the interference pattern and allow a quantization of the decoherence process with time. For the uncoupled system we ultimately recover individual phase fluctuating condensates, whereas finite tunnel coupling counteracts the decoherence and leads to an equilibrium characterized by a finite coherence length. Decoherence decay and equilibrium coherence lengths are used to determine temperature and coupling strength of the system.

QWB3 • 11:20 a.m.
Atomic Four-Wave Mixing via Condensates Collisions, *Aurelien Perrin[1], Craig Savage[2], Valentina Krachmalnicoff[1], Denis Boiron[1], Alain Aspect[1], Chris Westbrook[1], Karen Kheruntsyan[3]; [1]Lab Charles Fabry de l'Inst. d'Optique, CNRS, Univ. Paris-Sud, France, [2]ARC Ctr. of Excellence for Quantum-Atom Optics, Australian Natl. Univ., Australia, [3]ARC Ctr. of Excellence for Quantum-Atom Optics, Univ. of Queensland, Australia.* We perform first principles quantum simulations of atomic four-wave mixing via a collision of two Bose-Einstein condensates of metastable helium atoms. We analyse the collinear and back-to-back pair correlations of atoms on the s-wave scattering halo. The results provide qualitative and quantitative understanding of the recent experiments at Orsay [A. Perrin et al., arXiv: 0704.3047].

QWB4 • 11:40 a.m.
Transverse Fringes and Pattern Formation in an Atom Laser Profile, *Robert Dall[1], Lesa Byron[1], Kenneth Baldwin[1], Andrew Truscott[1], Graham Dennis[2], Mattias T. Johnsson[2], Joseph Hope[2]; [1]ARC Ctr. of Excellence for Quantum-Atom Optics, Res. School of Physical Sciences and Engineering, Australian Natl. Univ., Australia, [2]ARC Ctr. of Excellence for Quantum-Atom Optics, Dept. of Physics, Australian Natl. Univ., Australia.* Using the unique detection properties offered by metastable helium atoms we have produced high resolution images of the transverse spatial profiles of an atom laser beam. We observe transverse fringes on the beam, resulting from quantum mechanical interference between atoms that start from rest at different transverse locations within the outcoupling surface and end up at a later time with different velocities at the same transverse position. Further, for high outcoupling rates we see the emergence of structure on the beam profile, which is not predicted by the usual Gross-Pitaevskii equation.

12:00 p.m.–2:30 p.m.
Lunch Break

QWC • Wednesday Session III

Ballroom
2:30 p.m.–4:00 p.m.
QWC • Wednesday Session III
Philippe Grangier; Inst. d'Optique, France, Presider

QWC1 • 2:30 p.m.
Invited
Photon Anti-Bunching and "Hole"-Entanglement with Homodyne Detections, *Ping Koy Lam; Australian Natl. Univ., Australia.* We experimentally demonstrate a homodyne detection technique for measuring second-order coherence of quantum states of light at sideband frequencies. Our scheme is based on the original Hanbury-Brown-Twiss intensity interferometer with only homodyne detections. We show that for displaced squeezed states, strongly bunched or anti-bunched light are related to regimes of Bell's inequality violation for a Franson interferometer. For strong bunching, the entanglement is manifested by the pair detection of photons, while anti-bunching produces "hole"-entanglement.

QWC2 • 3:00 p.m.
Multi-Spatial-Mode Squeezed Light from Four-Wave Mixing in Hot Rb Vapor, *Paul D. Lett[1,2], Vincent Boyer[1], Alberto Marino[1,2], Colin McCormick[1], Neil Corzo Trejo[1], Kristen Lemons[1,3], Kevin Jones[1,3]; [1]Atomic Physics Div., NIST, USA, [2]Joint Quantum Inst., Univ. of Maryland and NIST, USA, [3]Dept. of Physics, Williams College, USA.* We demonstrate multi-spatial-mode, nondegenerate four-wave mixing in hot atomic Rb vapor. We generate images with strong intensity-difference squeezing between the amplified probe and the generated conjugate beams. Measurements to quantify the multi-mode nature of the beams will be presented. We also report on progress in improving the relative-intensity squeezing. This narrowband, squeezed light near an atomic resonance is also of interest for experiments involving atomic ensembles.

QWC3 • 3:20 p.m.
Atom Entanglement from Light Scattering on BEC's, *K. M. R. van der Stam, R. Meppelink, J. M. Vogels, Peter van der Straten; Debye Inst., Dept. of Atom Optics and Ultrafast Dynamics, Utrecht Univ., Netherlands.* Using light scattering on Bose-Einstein condensates we study the entanglement of atoms. In the light interaction with the condensate, atoms are scattered in both the forward and the 'counterintuitive' backward direction, which results in entangled atom pairs. We have enhanced the backscattering by driving the process using two frequencies and observe an equal balance between the forward and backward scattered atoms. We detected the so-called end-fire modes of the light scattering and observe under certain conditions only one end-fire mode, which enhances the entanglement. Finally, we have applied noise correlations spectroscopy to directly observe the entangled pairs.

QWC4 • 3:40 p.m.
Development of Strong and Low Frequency Squeezing, *Ben C. Buchler, Kirk McKenzie, Michael Stefszky, Sheon Chua, Malcolm B. Gray, David E. McClelland, Ping Koy Lam; Dept. of Physics, Faculty of Science, Australian Natl. Univ., Australia.* We report on the generation of squeezed states with optical parametric oscillators. Firstly, we discuss experiments aimed toward producing stronger squeezing. We characterise three different nonlinear materials (PPKTP, PPSLN and PPSLT) in terms of their nonlinearity and optical losses to evaluate their squeezing efficacy. Secondly, we present results showing the development of squeezed states at audio sideband frequencies. Squeezing in this frequency range is required for applications in interferometric gravitational wave (GW) detectors. We discuss the significance of the results in terms of potential sensitivity improvements of current and future GW detectors and also potential upgrades to our experiment.

Ballroom Gallery
4:00 p.m.–4:30 p.m.
Tea Break

QWD • Wednesday Session IV

Ballroom
4:30 p.m.–6:00 p.m.
QWD • Wednesday Session IV
Ernst Rasel; Univ. of Hannover, Germany, Presider

QWD1 • 4:30 p.m.
Invited
Schlieren Nanoscope in Atom Optics, *Jules Grucker, Jean-Christophe Karam, Valja Bocvarski, Francisco Perales, Gabriel Dutier, Jacques Baudon, Martial Ducloy; Lab de Physique des Lasers, Univ. Paris Nord, France.* One proposes the equivalent of Schlieren photography in atom interferometry. It is based on van der Waals inelastic diffraction by a material surface, in which the atom internal state (*i.e.*, Zeeman sublevel) is modified by the surface interaction. Inelastic diffraction by two close wires, or the two surfaces of a slit, leads to non-localised atom interferences, the amplitude of which is sensitive to van der Waals interactions in the nanometer range. Implementation of this atom nanoscope on cooled metastable Ar* beam will be presented.

QWD2 • 5:00 p.m.
Coherence with Ultracold Atoms at Nanofabricated Surfaces, *József Fortágh; Ctr. for Collective Quantum Phenomena, Physikalisches Inst. der Univ. Tübingen, Germany.* I am reporting about recent experiments on coherent manipulation of ultracold atoms at nanofabricated surfaces. These include the manipulation and state selective detection of single atoms as well as interferometry with Bose-Einstein condensates. Our current work focuses on the development of experimental techniques for preparing atoms at cryogenically cooled surfaces. The scientific objectives are the coupling of atoms to solid state nanodevices such as superconducting circuits. Underlying theoretical concepts and the experimental progress will be reported.

QWD3 • 5:20 p.m.
Cold Atomic Ensembles for Quantum Interfaces: New Interactions, *Marcin Kubasik, Marco Koschorreck, Mario Napolitano, Sebastián R. de Echaniz, Morgan W. Mitchell; ICFO, Inst. de Ciències Fotòniques, Spain.* Cold, trapped atomic ensembles present new opportunities for light-matter interfaces, including tomographic measurements and new interactions. The tensor polarizability can be exploited to produce interactions useful for spin squeezing, measurement of atom number, and quantum cloning of light into matter. We describe experiments in a cold ensemble of dipole-trapped ^{87}Rb to produce spin squeezing by quantum non-demolition measurement.

QWD4 • 5:40 p.m.
Linear Optical Quantum Information Processing, Imaging, and Sensing, *Hugo Cable, Sulakshana Thanvanthri, Jonathan P. Dowling; Hearne Inst. for Theoretical Physics, Louisiana State Univ., USA.* We investigate linear optical approaches to quantum information processing, clarifying how linear optics and projective measurements can be used to create designer optical nonlinearities at the few photon level.

6:00 p.m.–8:00 p.m.
Dinner Break

QWE • Wednesday Poster Session II

Ballroom Gallery
8:00 p.m.–9:30 p.m.
QWE • Wednesday Poster Session II

QWE1
Quantum Dynamics and Polarisation Squeezing of Ultrashort Pulses in Optical Fibre, *Joel F. Corney[1], Peter D. Drummond[1], Joel Heersink[2], Ruifang Dong[2], Gerd Leuchs[2], Ulrik L. Andersen[2,3]; [1]Univ. of Queensland, Australia, [2]Univ. Erlangen-Nürnberg, Germany, [3]Technical Univ. of Denmark, Denmark.* Comparing stochastic simulations and experimental measurements, we study the quantum dynamics of polarisation squeezing in optical fibres. Squeezing of -6.8 dB is measured, with Raman effects limiting squeezing for higher pulse energies and longer fibres. Depolarising GAWBS phase-noise adversely affects squeezing at low pulse energies. Third-order dispersion is also accounted for in the simulations, and this has an effect on pulses with more than the soliton energy. We theoretically determine the optimal pulse energy and fibre length for the best squeezing.

QWE2
Enhanced Kerr Nonlinearity at Low Light Intensity, *Alexander Akulshin, Andrei Sidorov, Russell McLean, Peter Hannaford; Ctr. for Atom Optics and Ultrafast Spectroscopy, Swinburne Univ. of Technology, Australia.* Both long-lived coherences and coherent population oscillations result in dramatic enhancement of a Kerr nonlinearity in atomic media at very low intensity of resonant light. We demonstrate the possibility of separating the contributions from these effects under certain experimental conditions. We report a study of the nonlinear optical properties of atomic media under a variety of experimental conditions at low light intensity, paying particular attention to self-focussing, diffraction and quasi-degenerate wave mixing.

QWE3
Macroscopic Entanglement of a Bose-Einstein Condensate on a Superconducting Atom Chip, *Mandip Singh; Ctr. for Atom Optics and Ultrafast Spectroscopy and ARC Ctr. of Excellence for Quantum-Atom Optics, Swinburne Univ. of Technology, Australia.* We present a practically implementable scheme to realise macroscopic entanglement of a Bose-Einstein condensate on a superconducting atom chip. Our proposal combines the two emerging fields of micro-manipulation of a Bose-Einstein condensate on an atom chip and quantum coherent dynamics in superconducting circuits. Our idea is based on coupling a superconductor flux loop to a Bose-Einstein condensate in a magnetic trap on an atom chip. We treat the superconductor flux loop in quantum superposition of two flux states. Our scheme also provides a platform to realise entangled atoms interferometry through a Bose-Einstein condensate on an atom chip.

QWE4
Fabrication of Atom Chips with Femtosecond Laser Ablation, *Holger Wolff, Shannon Whitlock, Martin Lowe, James Wang, Brenton V. Hall, Andrei Sidorov, Peter Hannaford; ARC Ctr. of Excellence for Quantum-Atom Optics and Ctr. for Atom Optics and Ultrafast Spectroscopy, Swinburne Univ. of Technology, Australia.* We report on the development of a new microfabrication technique for atom chips which is based on femtosecond laser ablation of thin films and allows the production of arbitrary patterns of microwires. We describe the ablation procedure and present the results of microwire quality analysis, which involves SEM imaging and magnetic field microscopy. We also discuss the designs of magnetic fields above the microwires using particular patterns of wire edges. Simulations of the magnetic fields are compared with the magnetic sensor measurements.

QWE5
Stochastic Phase-Space Methods for Fermions, *Joel F. Corney, Peter D. Drummond; ARC Ctr. of Excellence for Quantum-Atom Optics, Univ. of Queensland, Australia.* We give an overview of the Gaussian phase-space methods for fermions, focusing on the example of the Hubbard model, which describes ultracold fermions in a lattice. The phase-space methods do not suffer the sort of sign problem encountered by other quantum Monte Carlo methods, and provide an efficient means of calculating exact zero-temperature Hubbard results. However at finite temperature, there are known issues to do with the boundedness of the underlying distribution. We show how 'stochastic gauges' can be used to control the distribution tails and thereby improve the accuracy of the simulations at low temperatures.

QWE7
Necessary and Sufficient Criteria for Steering and the EPR Paradox, *Eric G. Cavalcanti[1], Chris J. Foster[1], Margaret D. Reid[1], Steve J. Jones[2], Howard M. Wiseman[2]; [1]ARC Ctr. of Excellence for Quantum-Atom Optics, School of Physical Sciences, Univ. of Queensland, Australia, [2]Ctr. for Quantum Dynamics, Griffith Univ., Australia.* We show that the correct formulation of the premises behind the EPR argument is that of a Local Hidden State model, recently introduced as a formalisation of Steering by Wiseman et al. This unifies the two concepts and allows one to define the problem of characterising the set of correlations that demonstrate the EPR paradox, providing a solid basis and extending the area of investigation introduced by M. D. Reid in 1989. In the setup of two settings and two outcomes we derive a necessary and sufficient criteria, and show that the CHSH-Bell inequality is violated only if this inequality is.

QWE8
Rotating Beam Trap for Studies of Superfluidity in BEC, *Sebastian Schnelle, L. Humbert, E. D. van Ooijen, M. J. Davis, N. R. Heckenberg, H. Rubinsztein-Dunlop; School of Physical Sciences, Univ. of Queensland, Australia.* We report on the realization of a novel rotating beam trap to investigate the superfluidity properties of Bose-Einstein condensates with different quanta of angular momentum. This has been achieved by scanning a red detuned focused beam trap using a 2-axis AOM while compensating for varying diffraction efficiencies using a synchronized AM modulation. Using this set up allows the creation of different ring diameters as well as adding different amounts of angular momentum to the Bose-Einstein condensate.

QWE9
Control of Atom Laser Coherence, *Masahiro Yanagisawa, Matthew R. James; Australian Natl. Univ., Australia.* We present a quantum control scheme in which two different feedback methods are combined to produce a stable single mode atom laser. A difficulty of producing an atom laser comes from the nonlinear effect of Bose-Einstein Condensates which is described by Gross-Pitaevskii type of equations. One feedback method is used to eliminate the nonlinear effect of atom-atom interactions. Another difficulty comes from nonlinear interactions with an optical field which is introduced to detect the BEC state for feedback. The other feedback method is applied to suppressing fluctuations due to this interaction and keeping the coherent properties of the atom laser.

QWE12
Coherent Control of the External Degrees of Freedom of Atoms and Defects in Optical Microtraps and Waveguides, *Joan Bagudà[1], Sònia Fernández-Vidal[1], Albert Benseny[1], Ramón Corbalán[1], Kai Eckert[1], Luis Roso[2], Gerhard Birkl[3], Jordi Mompart[1]; [1]Univ. Autonoma de Barcelona, Spain, [2]Univ. de Salamanca, Spain, [3]Technische Univ. Darmstadt, Germany.* We extend

the recently developed three-level atom optics (TLAO) techniques, e.g., the spatial analogue of Stimulated Raman Adiabatic Passage, to (i) the coherent control of defects, e.g., empty sites, in optical lattices and microtraps; and (ii) to the robust and efficient transport of atoms between optical waveguides.

QWE14
Twisted Photons for Quantum Applications, *Gabriel Molina-Terriza[1,2], Clara I. Osorio[1], Noelia Gonzalez[1], Yana Deyanova[1], Juan P. Torres[1,3]; [1]ICFO, Inst. de Ciencies Fotoniques, Spain, [2]Inst. Catalana de Recerca i Estudis Avançcats (ICREA), Spain, [3]Dept. of Signal Theory and Communications, Univ. Politecnica de Catalunya, Spain.* In this talk we will give an overview of the latest advances in the control of the Orbital Angular Momentum (OAM) of photons for applications in quantum information and quantum optics. The OAM of light is related with the intensity and phase spatial profiles of the beam, and it can be controlled by different means. Moreover, photons can be entangled in this degree of freedom, which is a particular case of spatial entanglement of photons.

QWE15
Subwavelength State Selective Atomic Localization via STIRAP, *Verònica Ahufinger[1,2], Jordi Mompart[2], Ramón Corbalán[2], Yurii Loiko[3,4], Carles Serrat-Jurado[3], Ramón Vilaseca[3]; [1]Inst. Catalana de Recerca i Estudis Avançcats (ICREA), Spain, [2]Grup d'Optica, Dept. de Fisica, Univ. Autònoma de Barcelona, Spain, [3]Dept. de Fisica i Enginyeria Nuclear, Univ. Politècnica de Catalunya, Spain, [4]Inst. of Molecular and Atomic Physics, Natl. Acad. of Sciences of Belarus, Belarus.* We propose a new method based on the STIRAP technique to obtain state selective atom localization below the diffraction limit. Three-level atoms in a lambda configuration interact with a travelling wave beam and a standing wave field coupled to adjacent transitions under STIRAP conditions. Atoms at the nodes of the SW do not interact with the fields and become localized in the nanoscale regime. The no interaction of the localized atoms with the fields guarantees the validity of the Raman-Nath approximation. Applications to Bose Einstein condensates, possible due to the full coherence of the STIRAP process, have been explored.

QWE16
Interaction-Induced Number Difference Squeezing in a Bose-Einstein Condensate, *Beata J. Dabrowska-Wüster[1], Sebastian Wüster[2], Matthew J. Davis[1]; [1]ARC Ctr. of Excellence for Quantum-Atom Optics, Univ. of Queensland, Australia, [2]School of Physical Sciences, Univ. of Queensland, Australia.* We study relative number squeezing of a Bose-Einstein condensate in the Bogoliubov vacuum, using the stochastic truncated Wigner method for confined, freely expanding and phase modulated condensates by determining the number difference variance between left and right *binned* number operators. We show that this variance lies below the shot-noise limit for experimentally relevant parameters.

QWE17
Spin Squeezing of Matter-Wave Gap Solitons, *Beata J. Dabrowska-Wüster, Sebastian Wüster; ARC Ctr. of Excellence for Quantum-Atom Optics, Australian Natl. Univ., Australia.* We model the quantum dynamics of a spinor Bose-Einstein condensate of ^{87}Rb in a one dimensional optical lattice. Using the truncated Wigner approach we find that for condensates with ferromagnetic interactions a stable *spin squeezed* gap soliton can be formed via a triple gap soliton interaction process.

QWE18
Estimation of Three-Dimensional Entanglement between an Atomic Ensemble and a Photon, *Ryotaro Inoue[1], Toshiya Yonehara[1], Yoko Miyamoto[2], Masato Koashi[3], Mikio Kozuma[1,4]; [1]Dept. of Physics, Tokyo Inst. of Technology, Japan, [2]Dept. of Information and Communication Engineering, Univ. of Electro-Communications, Japan, [3]Div. of Materials Physics, Graduate School of Engineering Science, Osaka Univ., Japan, [4]CREST, Japan Science and Technology Agency, Japan.* Controlling the orbital angular momentum state opens the door to the manipulation of arbitrarily large dimensional quantum state. Here we propose a new method to estimate the Schmidt number of the quantum state. The method enables us to avoid a problem appearing when we estimate the entanglement on the orbital angular momentum of photons using phase holograms. We also report the experimental results on the atoms-photon entanglement which was analyzed by the proposed method. Our experimental results show the possibility of controlling and entangling two remote massive atoms with higher dimensional basis.

QWE19
Propagation of Squeezed Vacuum Pulses inside a Cold Atomic Ensemble with Electromagnetically Induced Transparency, *Kazuhito Honda[1,2], Daisuke Akamatsu[2], Manabu Arikawa[2], Yoshihiko Yokoi[2], Keiichirou Akiba[2], Satoshi Nagatsuka[2], Akira Furusawa[3], Mikio Kozuma[1,2,4]; [1]Interactive Res. Ctr. of Science, Tokyo Inst. of Technology, Japan, [2]Dept. of Physics, Tokyo Inst. of Technology, Japan, [3]Dept. of Applied Physics, School of Engineering, Univ. of Tokyo, Japan, [4]CREST, Japan Science and Technology Agency, Japan.* We experimentally investigated propagation of squeezed vacuum pulses in a cold atomic ensemble with electromagnetically induced transparency. 930 ns of the squeezed vacuum pulse was incident on the laser cooled ^{87}Rb atoms and its propagation was analyzed using time domain method. Bandwidth of the squeezing was dramatically reduced due to the EIT and the slow propagation was clearly observed for the pulsed squeezed vacuum.

QWE20
Harmonic Entanglement from Second-Order Nonlinearity: Optimization and Interpretation, *Nicolai B. Grosse[1], Syed M. Assad[1], Moritz Mehmet[2], Thomas Symul[1], Ping Koy Lam[1]; [1]Quantum Optics Group, Australian Natl. Univ., Australia, [2]Max-Planck Inst. for Gravitational Physics, Univ. Hannover, Germany.* We theoretically investigate EPR entanglement in continuous-variable quadrature measurements between the fundamental and second-harmonic fields generated in the degenerate second-order nonlinear optical process. The parameters that optimize entanglement are found.

QWE21
Interaction Free Spectroscopy with Single Photons, *Alessandro Cerè, Florian Wolfgramm, Marta Abad García, Ana Predojevic, Zehui Zhai, Morgan W. Mitchell; ICFO, Inst. de Ciencies Fotoniques, Spain.* We discuss an interaction free measurement of the optical density of a hot sample of ^{87}Rb atoms. This system can be used as narrowband filter for light, with the filtered radiations presenting a spectrum suitable for efficient interaction with an atomic ensemble. This is useful especially together with broadband single photon sources for matching the spectral requirements of interaction with cold atoms ensembles. Experimental progress in the realization of narrowband single photon state will be presented.

QWE22
Bose-Hubbard Model for Ultracold Atoms at Finite Temperatures in Lattices, *Saeed Ghanbari[1], Tien D. Kieu[1], Joel F. Corney[2]; [1]ARC Ctr. of Excellence for Quantum Atom Optics and Ctr. for Atom Optics and Ultrafast Spectroscopy, Swinburne Univ. of Technology, Australia, [2]ARC Ctr. of Excellence for Quantum Atom Optics, Univ. of Queensland, Australia.* We simulate quantum degenerate Bose gases at finite temperatures in a grand canonical ensemble and use the Bose-Hubbard model which can describe the dynamics of ultracold bosonic atoms in optical and magnetic lattices. We study ultracold atoms

with the gauge *P*-representation in 1-D with 1, 2 (double well), 3, 7 and 11 sites and study quantum correlations and other physical quantities at different temperatures across the superfluid to Mott insulator quantum phase transition. Moreover, using a truncated number-state basis and the gauge *P*-representation, we show that the Mott lobes are not present unless the temperature is below a certain value.

QWE23
Atomic Correlations from the Dissociation of a Molecular Bose-Einstein Condensate, *Sarah L. W. Midgley, Sebastian Wüster, Matthew J. Davis, Murray K. Olsen, Karen V. Kheruntsyan; ARC Ctr. of Excellence for Quantum-Atom Optics, School of Physical Sciences, Univ. of Queensland, Australia.* The dissociation of a molecular Bose-Einstein condensate into its constituent particles is a process analogous to parametric down-conversion in optics. However, there is additional interest in the fact that the particles are massive, and may obey either bosonic or fermionic statistics. We describe a pairing mean-field theory related to the Hartree-Fock-Bogoliubov approach, and apply it to analyse the correlations present in recent experiments. We also perform calculations using stochastic phase-space methods for the bosonic case and compare the results of the two methods.

QWE24
Super-Radiant Rayleigh Scattering off a Condensate in an Optical Cavity, *Andrew J. Ferris, Ashton S. Bradley, Murray K. Olsen, Matthew J. Davis; ARC Ctr. of Excellence for Quantum-Atom Optics, School of Physical Sciences, Univ. of Queensland, Australia.* Entanglement is one of the defining features of quantum mechanics, with entangled states of the electromagnetic field being produced routinely in laboratories. At present, it is not as easy to produce entanglement between optical and atomic fields. We analyse a scheme which promises to produce these states, using superradiance and Kapitza-Dirac scattering between lasers and a Bose-Einstein condensate. We show how an optical cavity resonant with the scattered light may make the entanglement easier to measure and use for quantum information purposes.

QWE25
Shockwave Formation in a Bose-Einstein Condensate, *Erik D. van Ooijen, A. Ratnapala, C. J. Vale, M. J. Davis, N. R. Heckenberg, H. Rubinsztein-Dunlop; School of Physical Sciences, Univ. of Queensland, Australia.* New kinds of cold-atom experiments are made possible by combining magnetic traps with tightly confining optical dipole potentials. These include quantitative observations of the statics and dynamics of condensate formation driven by compression rather than cooling, as well as studies of the dynamics of quantum shock fronts in expanding condensates. We show qualitative experimental results along with comparisons with theoretical models.

QWE26
Coherence Properties of a Continuously Pumped Atom Laser at Finite Temperature, *Geoff M. Lee, Ashton S. Bradley, Matthew J. Davis; ARC Ctr. of Excellence for Quantum-Atom Optics, School of Physical Sciences, Univ. of Queensland, Australia.* A continuous wave (cw) atom laser will most likely be realised by outcoupling from a reservoir containing a Bose-Einstein condensate at finite temperature. This will mean that the correlation properties and linewidth of the cw atom laser beam will be influenced by the thermal nature of the reservoir. Here we report on simulations using the stochastic Gross-Pitaevskii formalism for finite temperature dynamics to find the steady state properties of the outcoupled beam. We determine how the linewidth and correlation length depend on the condensate size, temperature, and outcoupling properties, and determine the optimum parameters for cw atom laser operation.

QWE27
Matter-Waves in Anharmonic Periodic Potentials, *Tristram J. Alexander[1], M. Salerno[2], E. A. Ostrovskaya[1], Yu. S. Kivshar[1]; [1]Nonlinear Physics Ctr. and ARC Ctr. of Excellence for Quantum-Atom Optics, Res. School of Physical Science and Engineering, Australian Natl. Univ., Australia, [2]Dept. of Physics, Univ. of Salerno, Italy.* We demonstrate that deviations from a harmonic periodic potential may lead to dramatic changes in the band gap structure and nature of the gap solitons and Bloch waves of a Bose-Einstein condensate in a lattice. We reveal that the relative widths of the band gaps may be strongly modified even leading to closure of the higher gaps. We show that changing the shape of the potential may change the symmetry of the gap-edge Bloch waves and so affect the symmetry of the higher-gap solitons. Finally we introduce a new type of mixed-gap state existing in two different gaps simultaneously.

QWE28
Dynamical Formation of Bright Solitons in the Collapse of Bose-Einstein Condensates, *Beata J. Dabrowska-Wüster[1,2], Sebastian Wüster[2], Matthew J. Davis[1,2]; [1]ARC Ctr. of Excellence for Quantum-Atom Optics, Univ. of Queensland, Australia, [2]School of Physical Sciences, Univ. of Queensland, Australia.* We model the formation of bright atomic solitons due to collapse of Bose-Einstein condensates with attractive interactions reported by S. L. Cornish *et al.*, [*Phys. Rev. Lett.* **96** 170401 (2006)] in a realistic three dimensional situation. We show that mean-field theory does not adequately explain the experiment, while the inclusion of quantum fluctuations gives rise to bright soliton formation at the appropriate time scales. The solitons are produced either in-phase or out-of-phase and their number increases with the strength of the attractive interaction.

QWE29
Macroscopic Self Trapping in the Dynamical Tunneling of a Bose-Einstein Condensate, *Sebastian Wüster[1], Beata J. Dabrowska-Wüster[1,2], Stuart Holt[1], Matthew J. Davis[1]; [1]School of Physical Sciences, Univ. of Queensland, Australia, [2]ARC Ctr. of Excellence for Quantum-Atom Optics, Univ. of Queensland, Australia.* Dynamical tunneling is analogous to the more familiar tunneling of regular single particles between two wells, but takes place between two period-one islands in a semi-chaotic classical phase space. We study the dynamical tunneling of a BEC in a modulated anharmonic potential. We find macroscopic nonlinear self-trapping above a critical interaction strength, and derive a dynamical two mode model to explain our results.

QWE31
Investigation and Manipulation of Quantum Gas Mixtures of ^{40}K and ^{87}Rb, *Leif Humbert[1], S. Ospelkaus[2], C. Ospelkaus[3], K. Bongs[4], K. Sengstock[4]; [1]School of Physical Sciences, Univ. of Queensland, Australia, [2]JILA, Univ. of Colorado, USA, [3]NIST, USA, [4]Inst. für Laserphysik, Germany.* We have studied the interaction of an ultracold heteronuclear Fermi-Bose mixture of fermionic ^{40}K and bosonic ^{87}Rb near Feshbach resonances. In a harmonic trap we demonstrate the complete phase diagram from phase separation to collapse. We also identify a resonance as a p-wave resonance by its characteristic doublet structure.

QWE32
High Brightness Fast Electron Bunches from an Ultracold Plasma, *Simon C. Bell, David V. Sheludko, Sebastian D. Saliba, Robert Scholten; Ctr. of Excellence for Coherent X-Ray Science, Univ. of Melbourne, Australia.* An ultracold plasma is formed when neutral atoms are first laser-cooled and trapped, then ionised with a laser pulse. Because their initial temperatures are very low, electrons can be extracted to produce a beam which is orders of magnitude more intense than existing sources. We are developing the first ultracold plasma system in

Australia, to build an ultrabright electron source with future application as a compact x-ray source for coherent x-ray imaging.

QWE34
Imaging of Cold ^{85}Rb Atoms Using Electromagnetically Induced Transparency, *Sebastian D. Saliba, David V. Sheludko, Simon C. Bell, Robert Scholten; Ctr. of Excellence for Coherent X-Ray Science, Univ. of Melbourne, Australia.* Imaging cold atom samples provides interesting opportunities for studying not only the external atomic distribution, but also the internal atomic state, particularly for atoms prepared in a coherent state. We have previously developed techniques for off-resonant imaging of a cold atom cloud, without optical elements, computationally extracting the atomic column density map from a diffraction pattern (diffraction contrast imaging or DCI). We are now combining two lasers and three atomic states in a lambda-system to explore atomic coherence via two-dimensional imaging of electromagnetically induced transparency.

QWE35
Relative Intensity Squeezing Using a Novel Four-Wave Mixing System in Rubidium, *Martijn Jasperse, Robert Scholten; Ctr. of Excellence for Coherent X-Ray Science, Univ. of Melbourne, Australia.* It has been recently demonstrated (Opt. Lett. 32 p178, 2007) that relative intensity squeezed light beams can be produced by non-degenerate four-wave mixing (4WM) in rubidium vapour. Using a system based on the lambda-structure of the 5S ground state of Rb, they obtained noise reduction of -7.1 dB below the standard quantum limit. We present a new scheme using the cascade 5S-5P-5D levels of Rb, which should achieve strong relative intensity squeezing at low Fourier frequency and low (~10mW) laser power.

QWE36
Electric-Field-Induced Symmetry Breaking of Angular Momentum Distribution in Atoms, *Marcis Auzinsh; Dept. of Physics, Univ. of Latvia, Latvia.* We report the observation of alignment to orientation conversion in the 7,9 $D_{3/2}$ states of Cs in the presence of an electric field without the influence of magnetic fields or collisions. Initial alignment of angular momentum was created by two-step excitation with linearly polarized light. The appearance of transverse orientation was confirmed by the observation of circularly polarized fluorescence. We present measured signals and compare them with the results of a theoretical model based on the optical Bloch equations. The effect is odd under time reversal and should be taken into account in searches for an electron electric dipole moment.

QWE37
The Bose-Fermi Hubbard Model in the Light and Heavy Fermion Limits, *Alexander Mering, Dominik Muth, Michael Fleischhauer; Univ. of Kaiserslautern, Germany.* We discuss mixtures of bosons and spin-polarized fermions in optical lattices in the limits of heavy and light fermions. The first case is mapped to a Bose-Hubbard system with binary disorder or a super-lattice potential. Boundaries between Mott-insulating and compressible phases are determined analytically within an extended strong-coupling expansion. DMRG calculations reveal furthermore a novel phase with Bose-glass character. In the opposite limit of ultra-light fermions an effective boson Hamiltonian is derived with an oscillatory long-range interactions leading to additional phases such as compressible density-waves. We show that CDW and Luttinger-liquid phase are separated by a Bose-glass phase.

•Thursday, December 6, 2007•

QThA • Thursday Session I

Ballroom
8:30 a.m.–10:00 a.m.
QThA • Thursday Session I
Hans Albert Bachor; Australian Natl. Univ., Australia, Presider

QThA1 • 8:30 a.m.
Keynote
Quantum Atom Optics with metastable Helium, *Alain Aspect; Inst. d'Optique, France.* Thanks to a position and time resolved single atom detector, we explore quantum atom optics effects, such as the Hanbury Brown and Twiss effect, or atom pairs production by spontaneous 4-wave mixing of matter waves. We find analogies with photon quantum optics, but also differences, in particular when using ^{3}He which is a fermion.

QThA2 • 9:15 a.m.
Keynote
Quantum Atom Optics with Spin Polarized Atomic Ensembles, *Eugene Polzik; QUANTOP Ctr., Niels Bohr Inst., Copenhagen Univ., Denmark.* Optically thick spin polarized atomic ensembles have emerged as a new medium optimal for the exotic quantum state engineering via quantum interface with light. The exciting feature of this medium is that quantum atom optics can be carried out with atoms in the range of temperatures from nano-Kelvin to room temperature. Recent theoretical and experimental developments, such as light-atoms entanglement, quantum memory, quantum teleportation, and quantum nondemolition detection of strongly correlated systems will be reviewed in this talk.

Ballroom Gallery
10:00 a.m.–10:30 a.m.
Tea Break

QThB • Thursday Session II

Ballroom
10:30 a.m.–12:00 p.m.
QThB • Thursday Session II
Joel F. Corney; ARC Ctr. of Excellence for Quantum Atom Optics, Australia, Presider

QThB1 • 10:30 a.m.
Invited
Extreme Control of Molecular States: On the Way to Super Chemistry, *Christian Lisdat, Oleg Bucicov, Marcin Nowak, Sebastian Jung, Eberhard Tiemann; Inst. of Quantum Optics, Germany.* Cold SO_2 molecules are produced with a Stark decelerator consisting of 326 deceleration stages. The molecules will be used for field controlled reaction studies at low energy or for inelastic and reactive collisions experiments. For these aspects the quantum state selectivity of the decelerator is of high importance and was investigated. The possibility to steer photodissociation reactions by electric fields was explored.

QThB2 • 11:00 a.m.
Molecular BEC in a Low Power Crossed Dipole Trap, *Jurgen Fuchs, Gopi Veeravalli, Paul Dyke, Eva Kuhnle, Grainne Duffy, Chris J. Vale, Peter Hannaford, Wayne Rowlands; ARC Ctr. of Excellence for Quantum-Atom Optics, Ctr. for Atom Optics and Ultrafast Spectroscopy, Swinburne Univ. of Technology, Australia.* We create Bose-Einstein condensates of $^6Li_2$ molecules in an all-optical setup using a low power (25 W) crossed dipole trap. Our system contains a number of simplifications compared to existing setups and offers a high degree of flexibility in the trapping geometry. We will present our latest results and report on progress towards making *p*-wave Feshbach molecules.

QThB3 • 11:20 a.m.
Single Atoms on an Optical Nanofiber, *Kali P. Nayak, Fam Le Kien, Kohzo Hakuta; Univ. of Electro-Communications, Japan.* Manipulating atoms and photons is one of the key issues of modern quantum optics. Various ideas have been proposed so far in this context. Examples would include laser cooling/trapping, electromagnetically induced transparency, and cavity-QED. We propose a novel method to manipulate atoms and photons using subwavelength-diameter silica-fibers, ”optical nanofibers.”. We show how optical nanofibers can open new perspectives for manipulating atoms and photons. We explore the atom/photon interaction around a nanofiber both theoretically and experimentally. Modification of spontaneous emission, single-atom trapping without external field, collective atomic emission, and quantum interferences are experimentally demonstrated by combining the nanofibers and laser-cooled Cs-atoms.

QThB4 • 11:40 a.m.
Quantum Feedback Networks, *John Gough[1], Matthew James[2]; [1]Univ. of Wales, UK, [2]Australian Natl. Univ., Australia.* The purpose of this paper is to present general algebraic methods for describing quantum networks. These methods are motivated by new imperatives of quantum network analysis and design, in particular, feedback control. The basic tools in our methodology are a matrix representation of open quantum systems, and the concatenation and series products of two such systems. We show how these methods can be used to efficiently model open quantum systems, or networks of such systems. We also explain how quantum feedback networks can be designed using these methods.

12:00 p.m.–2:30 p.m.
Lunch Break

QThC • Thursday Session III

Ballroom
2:30 p.m.–4:00 p.m.
QThC • Thursday Session III
John D. Close; Australian Natl. Univ., Australia, Presider

QThC1 • 2:30 p.m.
Invited
Ultracold Magnesium, *Ernst Rasel; Univ. of Hannover, Germany.* We report on progress of generating ultracold atoms of magnesium. Magnesium belongs to the few elements suited for a neutral atom optical frequency standard. Its unique properties such as a very low black body radiation shift, the occurrence of fermionic and bosonic isotopes of suitable abundance, and the existence of a magic wavelength make it a very attractive candidate for future optical clocks. With our experiment, we determined for the first time the absolute frequency of the intercombination transition 31S0 → 33P1 of 24Mg with a Ramsey-Bordé interferometer, which was linked to a primary Cs Frequency standard of the PTB via a fiber femtosecond laser. Cooling ensembles of magnesium in the non-magnetic ground state to microkelvins is difficult as standard sub-Doppler cooling schemes are not applicable. We investigate novel methods to lower the temperatures of magnesium atoms. One promising method is based on a coherent two photon-process which provides higher velocity selectivity. Alternatively, standard sub-Doppler cooling schemes are applicable to the long-lived excited state, which in addition can be confined in magnetic traps.

QThC2 • 3:00 p.m.
Security of Post-Selection Based Continuous Variable Quantum Key Distribution in the Presence of Gaussian Added Noise, *Thomas Symul[1], Daniel J. Alton[1], Syed M. Assad[1], Andrew M. Lance[1], Christian Weedbrook[1,2], Timothy C. Ralph[2], Ping Koy Lam[1]; [1]Australian Natl. Univ., Australia, [2]Univ. of Queensland, Australia.* In realistic continuous variable quantum key distribution protocols, an eavesdropper may exploit the additional Gaussian noise generated during transmission to mask her presence. We present a theoretical framework for a post-selection based protocol which explicitly takes into account excess Gaussian noise. We derive a quantitative expression of the secret key rates based on the Levitin and Holevo bounds. We experimentally demonstrate that the post-selection based scheme is still secure against both individual and collective Gaussian attacks in the presence of this excess noise.

QThC3 • 3:20 p.m.
Spontaneous Vortex Formation during the Growth of a Bose-Einstein Condensate, *Matthew J. Davis[1], Ashton S. Bradley[1], Chad N. Weiler[2], Tyler W. Neely[2], David R. Scherer[2], Brian P. Anderson[2]; [1]ARC Ctr. of Excellence for Quantum-Atom Optics, Univ. of Queensland, Australia, [2]College of Optical Sciences, Univ. of Arizona, USA.* We report on experiments and simulations of the growth of a Bose-Einstein condensate in which vortices are observed to form spontaneously in a non-rotating potential. Between 10% and 50% of experiments result in between one and three unambiguous vortex cores. We simulate a temperature quench of a Bose gas through the critical point using the stochastic Gross-Pitaevskii equation and find remarkable agreement with the experimental data. Faster cooling results in a higher probability of vortex formation, and we interpret these results in light of the Kibble-Zurek scenario for the formation of topological defects in continuous phase transitions.

QThC4 • 3:40 p.m.
Quasi-Bragg Scattering of Atoms: Flexible, Magnetically Tunable Beam Splitters for Interferometry, *Karel A. H. van Leeuwen, Kenian F. E. Domen, Maarten A. H. Jansen; Eindhoven Univ. of Technology, Netherlands.* We have used a new technique to construct a clean, large-angle, coherent atomic beam splitter with an easily adjustable splitting angle. Helium atoms in the J=1 metastable state diffract from a far-detuned light field with ‘corkscrew’ polarization in the presence of a homogeneous magnetic field. Adiabatic transfer from magnetic energy to ‘transverse kinetic energy’ then allows symmetric diffraction of the incoming beam in a single, high diffraction order with a different value of M. The order is set by the value of the magnetic field. The result is a flexible, adjustable, large-angle, three-way atomic beam splitter for atom interferometry.

Ballroom Gallery
4:00 p.m.–4:30 p.m.
Tea Break

QThD • Thursday Session IV

Ballroom
4:30 p.m.–6:10 p.m.
QThD • Thursday Session IV
Kenneth G. Baldwin; Australian Natl. Univ., Australia, Presider

QThD1 • 4:30 p.m.
Invited
Temperature and Degeneracy of Ultra-cold Bosons in Optical Lattices, *P. Blair Blakie; Univ. of Otago, New Zealand.* In the past 5 years optical lattices have emerged as a versatile new tool for engineering strongly correlated states of ultra-cold atoms. In this talk we present a theory for the thermal changes that occur during lattice loading and propose a procedure for measuring the temperature of a superfluid Bose gas in an optical lattice.

QThD2 • 5:00 p.m.
Loading a Permanent Magnetic Lattice with Ultracold Atoms on an Atom Chip, *Mandip Singh, Michael Volk, Alexander Akulshin, Russell McLean, Andrei Sidorov, Peter Hannaford; Ctr. for Atom Optics and Ultrafast Spectroscopy, ARC Ctr. of Excellence for Quantum-Atom Optics, Swinburne Univ. of Technology, Australia.* We report the loading of a 1-D permanent magnetic lattice with ultracold atoms on an atom chip. Our magnetic lattice is produced by a perpendicularly magnetised film of $Gd_{10}Tb_6Fe_{80}Co_4$ deposited on a 10 µm period grooved structure. A BEC is created in a Z-wire trap about 300 µm from the surface of the chip. An atom cloud at about 5 µK is moved adiabatically towards the lattice by an appropriate bias field. We estimate that about one hundred lattice sites are loaded with atoms about 7 µm from the chip surface at a temperature of about 10 µK.

QThD3 • 5:20 p.m.
Fano Resonance and Quantum Localization of a Bose-Einstein Condensate in an Optical Lattice, *Joachim Brand; Ctr. for Theoretical Chemistry and Physics, Inst. of Fundamental Sciences, Massey Univ., New Zealand.* We consider the localization of matter waves in an optical lattice due to nonlinear interactions. We show that even below classical thresholds, localization is still possible due to quantum fluctuations or 'entanglement' between constituent bosons. Furthermore, we point out that interesting Fano resonances in the scattering of single atoms on such localized states may occur due to coherent interactions with the matter-wave field.

QThD4 • 5:40 p.m.
Invited
Strongly-Correlated Quantum Gases: Atomtronics and Rotating Optical Lattices, *Murray Holland; JILA and Dept. of Physics, Univ. of Colorado, USA.* We explore the analogy between ultracold atoms in optical lattices and electrons in crystal lattices. Of particular interest is the fractional quantum Hall effect where the analogy is with gases which are rapidly rotating. Strongly-correlated effects can be enhanced utilizing rotating optical lattices. We also consider atomtronics, where the analogy is extended to include doped semiconductor materials. Lattice "defects" achieve behaviors similar to P-type and N-type semiconductor materials. Naturally the interest is to adjoin P-type and N-type atoms lattices to produce an atom diode, and then an NPN or PNP lattice ”sandwich” to achieve bipolar transistor-like behavior for ultracold atoms.

Ballroom
6:10 p.m.–6:25 p.m.
Closing Remarks
Kenneth G. Baldwin; Australian Natl. Univ., Australia.

Key to Authors and Presiders

(**Bold** Denotes Presider or Presenting Author)