Past Seminars

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Wednesday 6th of June 2012, David Bruschi (Nottingham)
Title: The physics of boxes and entanglement resonances

Abstract: We investigate entanglement creation within a single moving cavity. We show that it is always possible to linearly increase the amount of field mode entanglement created after any arbitrary travel segment by repeating the travel segment itself. We discuss experimental feasibility and future work within the field of Relativistic Quantum Information.

Wednesday 9th of May 2012, Nicolai Friis (Nottingham)
Title: Shaking entanglement

Abstract: In the emerging field of relativistic quantum information, the past decade has revealed a number of novel kinematic effects on entanglement between observers in relative inertial motion
and between one inertial and one uniformly linearly accelerating observer. The analyses of uniform acceleration mentioned above involve several ingredients that make it difficult to compare the theoretical predictions to experimentally realizable situations. Several of these concerns have been recently addressed by studying correlations between field modes of bosonic and fermionic quantum fields confined in two cavities, one inertial and the other undergoing motion that consists of segments of inertial motion and uniform acceleration. We present these techniques in an analysis of the entanglement and the nonlocality of bosonic and fermionic quantum fields confined to cavities on world tubes that consists of inertial and uniformly accelerated segments, for small accelerations but arbitrarily long travel times. We fully characterise the emerging corrections to the initial entanglement and study how degradation effects can be avoided. We further discuss how entanglement is generated between the field modes within a single cavity due to its motion. By the equivalence principle, the results provide a model of entanglement generation by gravitational effects.

D. E. Bruschi, I. Fuentes and J. Louko, e-print arXiv:1105.1875v3[quant-ph] (2011).
N. F., A. R. Lee, D. E. Bruschi and J. Louko, Phys. Rev. D 85, 025012 (2012).
N. F., D. E. Bruschi, J. Louko, and I. Fuentes, e-print: arXiv:1201.0549v1 [quant-ph] (2012).
D. E. Bruschi, A. Dragan, A. R. Lee, I. Fuentes and J. Louko, e-print arXiv:1201.0663 [quant-ph] (2012).

Tuesday 17th of April 2012, Pablo Arrighi (Grenoble, France) Title: The physical Church-Turing thesis and the principles of quantum theory

Abstract: Notoriously, quantum computation shatters complexity theory, but is innocuous to computability theory. Yet several works have shown how quantum theory as it stands could breach the physical Church-Turing thesis. We draw a clear line as to when this is the case, in a way that is inspired by Gandy. Gandy formulates postulates about physics, such as homogeneity of space and time, bounded density and velocity of information --- and proves that the physical Church-Turing thesis is a consequence of these postulates. We provide a quantum version of the theorem. Thus this approach exhibits a formal non-trivial interplay between theoretical physics symmetries and computability assumptions.

Wednesday 21th of March 2012, Dominik Safranek (Prague, Czech Republic) Title: Free Will Experiment

Abstract: Non-locality in Quantum theory leads to some counter-intuitive phenomena. One can actually use the nonlocality to construct a device based on the delayed choice quantum eraser experiment, which could determine whether the tested person has or has not the free will. In other words, the device could possibly predict what the person is going to do before the person decides what to do. However, this device could be used for sending the information back in time, what may not be possible. At the speech the Free Will Experiment is introduced and some explanations why it may not work are offered. Still, the question if it is possible to construct such device remains open.

Tuesday 13th of March 2012, Clare Horsman (Tokyo, Japan)
Title: Surface code quantum computing by lattice surgery

Abstract: Surface codes have the highest fault-tolerant threshold of any current error correction code, and require only a fixed 2D nearest neighbour structure, making them an obvious choice for large scale designs in experimentally realistic systems. The planar version surface code uses the fewest physical qubits for a given logical error tolerance, making it the implementation of choice for small-scale achievable experiments for error correction codes. However, planar codes have previously been restricted to using transversal gates for qubit interactions, destroying the inherent 2D nearest-neighbour nature of the code. In this talk I will introduce a scheme for coupling planar qubits without transversal operations, using a technique we call "lattice surgery". This involves splitting and merging code surfaces, enabling state distribution and controlled operations to be performed without braiding. The qubit requirement for planar implementations can be further reduced by rotating the lattice used, leaving diagonal rather than straight logical operators. I will demonstrate how an encoded CNOT between two distance 3 logical states is possible with 53 physical qubits, half of that required in any other know construction in 2D.

Wednesday 8th of February 2012, Stefano Pirandola (York)
Title: Coherent-state protocols in quantum cryptography

Abstract: Continuous variable quantum key distribution is one of the most promising approaches to realize long-distance high-rate distribution of secret keys. In this seminar, we review the basics of coherent-state protocols and we analyze the potential advantages of their generalization to multi-way schemes.

Monday 6th of February 2012, Andreas Nunnenkamp (Basel, Switzerland)
Title: Nonlinear optomechanics

Abstract: In optomechanical systems mechanical degrees of freedom are coupled to modes of the electromagnetic field inside optical or microwave resonators. Possible applications include ultra-sensitive sensing of masses, forces and electromagnetic fields, transducing quantum information between different parts of a quantum network, and exploring decoherence at larger and larger mass and length scales.

In most optomechanical setups the position of the mechanical oscillator linearly modulates the cavity frequency. While the optomechanical coupling is usually much smaller than the optical line width, appreciable coupling can be achieved using a strong optical drive. Recently, the quantum ground state of mechanical motion was achieved and the zero-point motion was detected by observing an asymmetry between phonon absorption and emission.

Several optomechanics setups, using ultracold atoms in optical resonators, optomechanical crystals, or superconducting circuits, are now approaching the limit where the radiation pressure of a single photon displaces the mechanical oscillator by more than its zero-point uncertainty. In this talk I will show that this single-photon strong-coupling regime can be detected in the cavity response as well as the optical output spectrum and that the system exhibits photon-blockade physics inducing non-Gaussian states of the mechanics and non-classical states of light [PRL 107, 063602 (2011)]. I will then explain how red-sideband cooling is modified in this nonlinear regime. Using Fermi's Golden rule I calculate the transition rates induced by the optical drive. In the resolved-sideband limit I find several cooling resonances characterized by non-thermal mechanical steady-states.

Wednesday 25th of January 2012, Carl M. Bender (St. Luis, USA, and Kings College, London)
Title: Making sense of non-Hermitian Hamiltonians

Abstract: The average quantum physicist on the street believes that a quantum-mechanical Hamiltonian must be Dirac Hermitian (invariant under combined matrix transposition and complex conjugation) in order to guarantee that the energy eigenvalues are real and that time evolution is unitary. However, the Hamiltonian $H=p^2+ix^3$, which is obviously not Dirac Hermitian, has a real positive discrete spectrum and generates unitary time evolution, and thus it defines a fully consistent and physical quantum theory!

Evidently, the axiom of Dirac Hermiticity is too restrictive. While $H=p^2+ix^3$ is not Dirac Hermitian, it is PT symmetric; that is, invariant under combined space reflection P and time reversal T. The quantum mechanics defined by a PT-symmetric Hamiltonian is a complex generalization of ordinary quantum mechanics. When quantum mechanics is extended into the complex domain, new kinds of theories having strange and remarkable properties emerge. IN the past two years, some of these properties have recently been verified in laboratory experiments.

A particularly interesting PT-symmetric Hamiltonian is $H=p^2-x^4$, which contains an upside-down potential. We will discuss this potential in detail, and explain in intuitive as well as in rigorous terms why the energy levels of this potential are real, positive, and discrete.

Tuesday 17th of January 2012, Chris C. Gerry (Lehman College, The City University of New York, USA)
Title: Quantum Optical Interferometry with Photon Number Parity Measurements Abstract: I shall discuss the use of photon number parity measurements which, along with certain symmetric classes of entangled states of light, lead to Heisenberg-limited sensitivities in the detection of phase shifts via quantum optical interferometry. Heisenberg-limited

sensitivities are the best allowed by quantum mechanics with linear phase shifts. I will also show that photon number parity measurements can be used to breach the Heisenberg limit for phase shifts generated by nonlinear interactions.

Thursday 12th of January 2012, Neil Lovett (Calgary, Canada)
Title: Machine learning in Quantum Information : Phase estimation, quantum walks and quantum control Abstract: Machine learning is an artificial intelligence technique which has found success in solving many non-convex computational problems, often with better results than other methods, genetic algorithms, simulated annealing etc. I will discuss some previous work where machine learning techniques are applied to a quantum metrology problem, that of adaptive phase estimation and show that not only does this method provide improvements over classical or the best known quantum techniques, the algorithm developed is also efficient. I will then move on to discuss current research in which the same methods are applied to the problem of finding an unknown bias in the operator of a quantum walk.

Wednesday 11th of January 2012, Ed Hinds (Imperial College London)
Title: Is the electron round?
Abstract: We have made a new measurement of the electron’s electric dipole moment (EDM) using a beam of YbF molecules [1]. By measuring atto-eV energy shifts in a molecule, this experiment probes new physics at the tera-eV energy scale. According to the standard model, this EDM is de≈10-38e.cm – some eleven orders of magnitude below the current experimental limit. However, most extensions to the standard model predict much larger values, potentially accessible to measurement [2]. Hence, the search for the electron EDM is a search for physics beyond the standard model. I will describe our experimental method, our current results and their implications for particle physics. I will also note the prospects for further major improvement in sensitivity.[1] J. J. Hudson, D. M. Kara, I. J. Smallman, B. E. Sauer, M. R. Tarbutt, E. A. Hinds “Improved measurement of the shape of the electron”, Nature 473, 493 (2011). [2] E. D. Commins, Electric dipole moments of leptons, in Advances in Atomic, Molecular, and Optical Physics, Vol. 40, B. Bederson and H.Walther (Eds.), Academic Press, New York, pp. 1-56 (1999).

Thursday 5th of January 2012, James Wootton (Basel, Switzerland)
Title: A topological order parameter using anyon states
Abstract: We propose a novel topological order parameter, the anyonic topological entropy. Unlike existing quantities, which consider the state of the underlying physical medium, the anyonic topological entropy is defined using states of anyonic occupations. This makes it especially well-suited to studies of mixed states and incoherent errors, and allows it to be applied to one-dimensional topological models. Calculations are made for the thermal states of the planar code and the Majorana chain as examples of how the quantity may be used.

Friday 16th of December 2011, Katherine Brown (Baton Rouge, Louisiana)
Title: Decomposition procedures for controlled unitaries Abstract: In this talk I will introduce some work by Ralph et al. [PRA 75 022313] where qudit systems are used to replace qubits in order to create large controlled unitaires in a more efficient fashion. It is possible to adapt these results to be effective using initialised ancilla qubits. However the base gate in our sequence is a Toffoli gate, therefore the decomposition procedure is only effective when the degree of control is larger than 2. For large controlled unitaries we get a factor of two improvement over standard decomposition. We then go onto show efficient ways of making specific unitaries controlled on an another qubit in an efficient without using an ancilla. This work demonstrates improvements available in decomposition procedures which should be useful when performing large quantum computations.

Thursday 1st of December 2011, Giandomenico Palumbo (Pavia, Italy)
Title: BF Theories in Condensed Matter and in Topological Quantum Computation Abstract: The Topological Quantum Field Theories (TQFT) provide powerfull tools for the study of the quantum many-body systems. After a brief introduction of the TQFT of BF-type, I present some interisting applications of these models to Topological Insulators and Graphene. Moreover the non-Abelian BF theories, supporting anyon dynamics, are very important in the development of the Topological Quantum Computation in Condensed Matter Systems.

Wednesday 23rd of November 2011, Oscar Dahlsen (Singapore and Oxford)
Title: Unifying typical entanglement and coin tossing: on randomization in probabilistic theoriesAbstract: It is well-known that pure quantum states are typically almost maximally entangled, and thus have close to maximally mixed subsystems. We consider whether this is true for probabilistic theories more generally, and not just for quantum theory. We derive a formula for the expected purity of a subsystem in any probabilistic theory for which this quantity is well-defined. It applies to typical entanglement in pure quantum states, coin tossing in classical probability theory, and randomization in post-quantum theories; a simple generalization yields the typical entanglement in (anti)symmetric quantum subspaces. The formula is exact and simple, only containing the number of degrees of freedom and the information capacity of the respective systems. It allows us to generalize statistical physics arguments in a way which depends only on coarse properties of the underlying theory. The proof of the formula generalizes several randomization notions to general probabilistic theories. This includes a generalization of purity, contributing to the recent effort of finding appropriate generalized entropy measures.

Wednesday 16th of November 2011, Xiongfeng Ma (Waterloo, Canada)
Title: Quantum random number generator based on phase fluctuationsAbstract: Quantum random number generators (QRNGs) offer means to generate information-theoretically provable randomness in theory. In practice, quantum randomness is mixed with classical noises. In order to extract quantum randomness, one needs to quantify the randomness of the source and then apply an extractor. In this talk, I will present a QRNG design based on quantum phase fluctuations and provide a framework for evaluating the quantum randomness of a physical device by min-entropy. In data post-processing of our experiment, we apply Toeplitz-hashing extractor and Trevisan extractor for data post-processing. Two extractors yield a speed of 441 kb/s and 0.7 kb/s, respectively, and both outcomes pass the standard randomness tests. Thursday 10th of November 2011, Dan Browne (UCL, London) Title: Measurement-based Quantum Computing with a thermal state of a bi-partite HamiltonianAbstract: Measurement-based quantum computing is a promising route to scalable quantum computation, and yet the construction of suitable coherent large-scale entangled states remains a challenge. Could such states exist in a natural system, in the thermal state of a many-body quantum systems, with solely bi-partite interactions? In [1], we show that such systems can exist, and provide both a generic method for their construction, and a specific example of a Hamiltonian for a system, which would be a natural resource for MBQC, if cooled below a critical temperature.[1] Y. Li, D.E. Browne, L. C. Kwek, R. Raussendorf and T-C Wei, Phys. Rev. Lett. 107, 060501 (2011).

Wednesday 19th of October 2011, Juanjo Ripoll (Madrid, Spain)
Title: Seeing “topological order” in ultracold atomsAbstract: In a recent work, to appear in PRL, we provide a general methodology to directly measure topological order in cold atom systems, once they are released from the trap. As an application we propose the realisation of a characteristic topological model, introduced by Haldane, using optical lattices loaded with fermionic atoms in two internal states. We demonstrate that time-of-flight measurements directly reveal the topological order of the system in the form of momentum space skyrmions.

Wednesday 12th of October 2011, Thomas Philbin (St Andrews)
Title: The Casimir Effect and Macroscopic QEDAbstract: In the late 1940s significant progress was made in combining quantum mechanics with electromagnetism. The problem that was overcome (or swept under the carpet, according to Dirac and others) was that of divergences. Part of this work, due to Feynman, Schwinger and Tomonaga, had a huge influence on theoretical and experimental physics. But another contribution from these years remained largely a theoretical curiosity; this was Casimir's prediction that the (divergent) vacuum energy of quantum electromagnetism could cause measurable forces on macroscopic bodies. Beginning in the mid 1990s there has been renewed interest in the Casimir effect, led by new precision measurements verifying its existence. There is interest in finding ways of manipulating Casimir forces in the context of micro- and nano-engineering, where such forces can become significant. The theoretical foundations of the effect in the case of realistic media have also come under scrutiny. The standard theory is not based on the principles of QED and has been repeatedly criticized. This talk gives an overview of this still-developing subject and it's relation to QED.

Wednesday 3rd of August 2011, Matthew J. Hoban (UCL, London)
Title: Computation with Correlations and Processing with Post-selection

Abstract: Correlated quantum systems can be valuable resources for information processing in the quantum regime. Quantum correlations also exhibit significantly non-classical behaviour by potentially violating Bell inequalities. We establish connections between quantum computing and Bell inequalities and present insights into the very nature of quantum correlations. As a result, we take in ideas as diverse as measurement-based quantum computing and so-called loopholes in Bell inequality experiments.

Tuesday 26th of July 2011, Petr Jizba (Prague and Berlin)
Title: The emergence of Special and Doubly Special RelativityAbstract: In papers [1,2] we introduced a method for obtaining the exact Feynman propagator of a relativistic particle (for both Klein--Gordon and Dirac case) from a superstatistical average over non-relativistic single-particle paths. In this talk I show that this method could offer new insights into the currently much debated issue of emergent relativity. In particular, I will demonstrate that a Brownian motion on a short scale originates a relativistic motion on scales larger than particle's Compton wavelength. Viewed in this way, special relativity is not a primitive concept, but rather it statistically emerges when a coarse graining average over distances of order, or longer than the Compton wavelength is taken. I will also discuss the modifications necessary to accommodate in our scheme the doubly special relativistic dynamics. In this way, an unsuspected, common statistical origin of the two frameworks is brought to light. Salient issues such as generalized canonical commutation relations, connection with Feynman chessboard model, and Hausforff dimensions of corresponding path-integral trajectories will be also discussed. Further details can be found in Ref. [3].
[1] P.J. and H.Kleinert, Phys.Rev.D 82,085016 (2010). [2] P.J. and H.Kleinert, Phys.Rev.E 78,031122 (2008). [3] P.J. and F.Scardigli, arXiv:1105.3930. Thursday 21th of July 2011, Gavin Brennen (Sydney, Australie)
Title: Towards quantum computational phases of matter Abstract: The physics of strongly correlated systems such as quantum spin lattices has provided tremendous insight into the way matter can be organized. This is understood through the identification of phases of matter using scaling laws of local operators as well as non-local symmetries such as string order. In the past decade there has been a new research direction to use such states of matter as error resilient hardware for quantum information processing. I will describe some recent work involving using disordered phases of spin

lattices in 1D and 2D for measurement based quantum computing and how renormalization can be used as a physical mechanism to improve the process. I'll also explain how to use symmetry protected topological order for holonomic gates in the Haldane phase of spin-1 chains.

Wednesday 20th of July 2011, Jaesuk Hwang (Imperial College London)
Title: Quantum nanophotonics with single moleculesAbstract: At cryogenic temperature, the molecules act as simple two-level atoms with a strong electric dipole transition. They can be individually addressed and they remain trapped indefinitely in the solidified solvent. We demonstrated that a single molecule can obscure a substantial part of the light or impart a large phase shift in a free space laser beam whose cross section is comparable to the scattering cross section of the molecule [1,2]. In such a beam, we showed that the molecule behaves as a two-level quantum emitter whose nonlinear response is appreciable even at very low light intensity. This was seen through the appearance of Mollow sidebands in the fluorescence spectrum of the molecule [3]. In another proof of the large dipolar coupling we were able to observe Rabi flopping of the two-level molecule in weak light pulses, where only a few hundred photons were enough to generate a pi-pulse [3]. These advances led to a demonstration that the single molecule can act as optical nonlinear medium whose absorption coefficient can be manipulated by a control laser and can also be turned into gain when the population of the molecule is inverted [4]. We point out that high-index dielectric waveguides can also provide small mode-field areas needed for large dipolar coupling. This will enable us to create a 2-dimensional network of optical nonlinearities and single photon sources by depositing individual organic dye molecules close to optical waveguides on a photonic chip [5]. [1] G. Wrigge, I. Gerhardt, J. Hwang, G. Zumofen, V. Sandoghdar, Nature Physics 4, 60 (2008). [2] M. Pototschnig, Y. Chassgneux, J. Hwang, G. Zumofen, A. Renn, V. Sandoghdar, To appear in Phys. Rev. Lett. arXiv:1103.6048 (2011). [3] I. Gerhardt, G. Wrigge, G. Zumofen, J. Hwang, A. Renn, V. Sandoghdar, Phys. Rev. A. 79 011402(R) (2009). [4] J. Hwang, M. Pototschnig, R. Lettow, G. Zumofen, A. Renn, S. Goetzinger, V. Sandoghdar, Nature 76 460 (2009). [5] J. Hwang, E. A. Hinds, arXiv:1104.3684v1 (2011).

Wednesday 22th of June 2011, Charles Adams (Durham)
Title: Rydberg non-linear opticsAbstract: When near resonant photons enter a medium where the excited state is coupled to a highly excited Rydberg state they evolve into Rydberg polaritons and interact via long range dipole - dipole interactions. The strong interaction between photons gives rise to a large cooperative optical non-linearity [1] that could be exploited for single photon non-linear optics.
[1] J. D. Pritchard et al. Phys. Rev. Lett. 105, 193603 (2010).

Wednesday 15th of June 2011, Dara McCutcheon (UCL, London)
Title: A variational master equation technique to quantum dot Rabi rotations Abstract: In this talk I will introduce a versatile master equation approach to describe the non-equilibrium dynamics of a two-level system in contact with a bosonic environment. Unlike most master equation approaches, this technique allows one to explore a wide range of parameter regimes within a single formalism. As an experimentally relevant example, we apply this method to the study of excitonic Rabi rotations in a driven quantum dot, and compare its predictions to a numerically exact path integral approach. The variational master equation technique is able to capture effects usually considered to be non-perturbative, such as multi-phonon processes and bath-induced driving renormalisation, and can give reliable results even in regimes in which previous master equation approaches fail. [1] D.P.S McCutcheon et al, ArXiv: 1105.6015

Monday 13th of June 2011, Axel Kuhn (Oxford)
Title: Single-Photon Shaping and Storage in Cavity-QEDAbstract: We investigate the feasibility of implementing elementary light-matter interfaces for quantum networking. The combination of a deterministic single photon source based on vacuum stimulated adiabatic rapid passage [1,2], and a quantum memory is outlined [3,4]. Both systems are able to produce and process temporally shaped photonic wavepackets, and also provide a way of maintaining the indistinguishability of retrieved and original photons.
Single atoms coupled to high-finesse cavities provide a unique way to deterministically generate a stream of single photons of MHz bandwidth [1]. We report on the latest status of a strong coupling atom-cavity system based on 87Rb. Atoms are loaded into the cavity (Finesse F=80,000, L=80 μm) using an atomic fountain which gives rise to 0.5 millisecond interaction times. We demonstrate that this arrangement is capable of delivering single photons of arbitrary temporal shape, and derive analytic expressions for the required driving laser pulse [2]. Based on the successful photon generation, it is discussed how to invert the process such that a single atom absorbs a single impinging photon of arbitrary given shape with a probability close to unity. To do so, we analytically derive the shape of the driving pulse required to maintain impedance matching of the cavity to the incoming photonic wavepacket throughout its whole duration [4].
Furthermore, we report on the manipulation of atomic arrays with optical tweezers [5]. This promising new technique has the potential of handling many atoms independent from one another, and therefore might pave the way to scalable atomic arrays for quantum information processing.
[1] A. Kuhn and D. Ljunggren, “Cavity-based single-photon sources,” Contemporary Physics 51, 289 (2010)
[2] G.S. Vasilev, D. Ljunggren, and A. Kuhn, “Single-photons made-to-measure,” New Journal of Physics 12, 063024 (2010)
[3] M. Himsworth, P.B.R. Nisbet, J. Dilley, G. Langfahl-Klabes, and A. Kuhn, “EIT-based quantum memory for

single photons from cavity-QED,” Appl. Phys. B 103, 579-589 (2011)
[4] J. Dilley, P.B.R. Nisbet, B.W. Shore, and A. Kuhn, “Cavity-based single-atom quantum memory,” submitted, arXiv:1105:1699 [quant-ph]
[5] L. Brandt, C. Muldoon, T. Thiele, J. Dong, E. Brainis, and A. Kuhn, “Spatial light modulators for the manipulation of individual atoms,” Appl. Phys. B 102, 443-450 (2011) Wednesday 8th of June 2011, Arzhang Ardavan (Oxford) -- Joint seminar with Condensed Matter! Title: Quantum information processingwith electron and nuclear spin resonanceAbstract: Electron and nuclear spin systems were among the earliest proposed physical embodiments of quantum information processors. We have addressed a range of basic questions surrounding the practicalities of exploiting quantum spins as qubits. Electron spin resonance can be used to perform quantum gates with very high fidelities. We have studied the prospects for application of various candidate systems including N@C60 (a nitrogen atom encapsulated in a fullerene cage), molecular nanomagnets and magnetic defects in semiconductors. While in molecular nanomagnets magnetic nuclei in the vicinity of the electron qubit provide the dominant decoherence path, we have found that, in N@C60 and phosphrus donors in silicon, nuclear moments can provide a valuable subsidiary resource in a quantum information processor. Many of the spin manipulation techniques that we have developed with spatially localised qubits in mind may also be applied to schemes in which quantum information is distributed spatially, for example, spin-based holographic memories. Under the right circumstances, electron spin states may be manipulated using electric fields; this can offer significant architectural advantages for quantum information processors.

Wednesday 11th of May 2011, Sabrina Maniscalco (Edinburgh) Title: Sudden transition between classical and quantum decoherenceAbstract: The seminar focuses on the dynamics of quantum and classical correlations in the presence of decoherence. We have recently discovered a class of initial states for which the quantum correlations, quantified by the quantum discord, are not destroyed by decoherence for times $t < t^*$ [1]. In this initial time interval only classical correlations decay. For $t > t^*$, on the other hand, classical correlations do not change in time and only quantum correlations are lost due to the interaction with the environment. Therefore, at the transition time t^* the open system dynamics exhibits a sudden transition from classical to quantum decoherence regime.
[1] L. Mazzola, J. Piilo, and S. Maniscalco, Phys. Rev. Lett. 104, 200401 (2010). Wednesday 4th of May 2011, Igor Lesanovsky (Nottingham) Title: Many-body physics with highly excited atomsAbstract: During the past years the relatively new field of ultra cold atomic physics has produced valuable insights into the structure and dynamics of many-body quantum systems. The reason for this success story is rooted in the versatility offered by ultra cold atom systems, such as the tunability of their interactions and the advanced techniques that have been developed for their trapping and coherent manipulation [1]. At present the majority of ultra cold atoms experiments is carried out with ground state atoms. Since very recently, however, there is a growing initiative towards exploiting the unique properties of atoms in highly excited states [2]. These so-called Rydberg atoms are blessed with remarkable properties such as strong interactions and long coherence times. The interactions severely influence the excitation dynamics of dense atomic gases through a mechanism which is called the Rydberg blockade [3]: The large interaction induced energy shift makes it virtually impossible to excite two nearby atoms simultaneously to the Rydberg state, i.e. the presence of one excited atom blocks the excitation of atoms in its vicinity. I outline how this mechanism can be used to create entangled quantum states [4] and non-classical light sources. Moreover, I will talk about how a dense Rydberg gas allows to gain insights into the equilibration and thermalisation behavior of closed quantum systems [5].
[1] I. Bloch, J. Dalibard, and W. Zwerger, Rev. Mod. Phys. 80, 885 (2008)
[2] M. Saffman, T. G. Walker, and K. Molmer, Rev. Mod. Phys. 82, 2313 (2010)
[3] D. Jaksch, J. I. Cirac, P. Zoller, S. L. Rolston, R. Cote, and M. D. Lukin, Phys. Rev. Lett. 85, 2208 (2000)
[4] I. Lesanovsky, Phys. Rev. Lett. 106, 025301 (2011)
[5] I. Lesanovsky, B. Olmos, and J. P. Garrahan, Phys. Rev. Lett. 105, 100603 (2010) Wednesday 13th April 2011, Madalin Guta (Nottingham) Title: System Identification for quantum Markov chains

Abstract: Quantum Markov processes are quantum dynamical systems with a large range of applications in quantum optics and cavity QED. The paradigmatic example is that of an atom maser, in which atoms pass successively through an optical cavity, interact with the cavity field, such that the outgoing atoms carry information about the interaction.
We consider the problem of system identification for quantum Markov chains in the asymptotic set-up where the experimentalist has access to the output of the Markov chain and the number of `atoms' is large. In the special case of a one parameter model, we derive two local asymptotic normality results, the first with respect to the quantum state of the output, the second with respect to the statistics of averages of simple measurement performed on the output. In particular we provide simple estimators whose Fisher information can be optimized over different choices of measured observables. These results can be extended to multiple parameter estimation and continuous time dynamics, opening up a new area of research in quantum statistics with direct relevance for quantum engineering. Friday 1st April 2011, Kyle McEnery (Cork, Ireland) Title: Cold Quantum Gases in Toroidal Traps Abstract: The ability to create and manipulate many body quantum systems will be important to future quantum technologies. These systems must be experimentally feasible and exactly solvable. Cold quantum gases in the Tonks-Girardeau regime provide such a system. The creation of such a gas around a sub-wavelength optical fiber is investigated. It is found that a finite number of Rubidium-87 atoms can be confined to this regime. Further investigation was carried out on the manipulation of the system. This was done by examining the many body properties of the gas under rotation of the system.

Wednesday 16th of March 2011, Gregor Tanner (Nottingham)
Title: Quantum search algorithms and quantum communication on networksAbstract: Quantum search algorithms -

both for an ordered list and on an extended network - are based on propagating a well known initial quantum state into a localised target state. Grover's algorithm, one of the corner stones of modern quantum information, predicts a square root speed up of a search protocol based on wave mechanics compared to a "classical" search. I will review Grover's original work and discuss extensions of his idea to searches on networks. I will summarise the connections between quantum random walks, quantum searches and quantum graphs, and will offer a new interpretation of a quantum search in terms of avoided crossings and localised defect states.
Setting up a communication channel between two parties is in fact closely related to a two-way search. Starting from this observation, I will show that wave mechanics can be used to send signals efficiently between a sender and a receiver where neither party knows the address of the other. Possible applications in photonic crystals will be discussed.

Wednesday 9th of March 2011, Ville Lahtinen (Nordita, Sweden)
Title: Modelling interacting non-Abelian anyons with Majorana fermionsAbstract: This will be an informal black board talk without too many technical details.

Wednesday 2nd March 2011, Nick Proukakis (Newcastle)Title: Modelling Quasi-1D Bose Gases via the Stochastic Gross-Pitaevskii Equation

Abstract: Cold gas experiments now routinely produce very elongated trapped quantum degenerate systems, where the transverse degrees of freedom are largely 'frozen out'. This talk discusses a theoretical model, known as the Stochastic Gross-Pitaevskii equation, which is shown to be ideal for describing such 'quasi-condensate' systems, as revealed by the excellent agreement with numerous recent experiments; a comparison to related theories is also shown to support the usefulness of this model. Wednesday, 23rd of February 2011, Juan Jose Garcia-Ripoll (Madrid, Spain)Title: Quantum circuits for QIPC Abstract: In this talk I will provide an overview of the field of quantum circuits, which are microfabricated circuits of superconducting materials that have applications in Quantum Information and microwave Quantum Optics. After a brief description of existing superconducting qubit designs I will introduce our work, describing the technology we are introducing to reach all-optical microwave quantum computing and how this technology may have applications in other fields, such as quantum cryptography, ultrasensitive sensors, etc.

Wednesday, 16th of February 2011, Emilio Alba (Madrid, Spain)Title: Mapping the spatial distribution of entanglement in optical lattices Abstract: We study the entangled states that can be generated using two species of atoms trapped in independently movable, two-dimensional optical lattices. We show that using two sets of measurements it is possible to measure a set of entanglement witness operators distributed over arbitrarily large regions of the lattice, and use these witnesses to produce two-dimensional plots of the entanglement content of these states. We also discuss the influence of noise on the states and on the witnesses, as well as connections to ongoing experiments.

Wednesday 2nd February 2011, Paul Busch (York)Title: Quantum Fuzziness and the Quantum–Classical Contrast
Abstract: According to quantum mechanics, a fundamental fuzziness - often also called quantum uncertainty - is inherent to the properties of physical objects. In this talk I will elucidate the operational meaning of quantum fuzziness and show how it figures in attempts at (a) making room for the implementation of classical features in quantum mechanics as well as (b) representing quantum mechanics as a classical probabilistic theory. General results will be illustrated with the simplest possible type of quantum system - a qubit.

Wednesday 26th January 2011, Simon Gardiner (Durham)

Title: Rotational Sensing with Ultracold Atoms

Abstract: The possibility of carrying out precision measurements using matter-wave interferometry with a coherent source of atoms (i.e., a Bose-Einstein condensate, or BEC) has been a strong motivating factor in the experimental and theoretical study of ultracold atomic gases. Atom-atom interactions, which are typically significant, tend to cloud the signal, however. We consider theoretically the possibility of a Sagnac interferometer composed of a two-component BEC held in a toroidal trapping configuration (such as has been realized by the Phillips ultracold atoms group at the National Institute for Standards and Technology, Gaithersburg, Maryland), and show how such deleterious effects may largely be avoided, effectively through geometry.

Wednesday 19th January 2011, Sarah Al-Assam (Oxford)Title: Numerical description of 2D strongly correlated systems using correlator product states Abstract: The exact numerical description of strongly correlated many-body systems is only possible for small numbers of particles due to the exponential dependence of the size of the Hilbert space on particle number. Tensor network descriptions can be used to capture the essential properties of the ground and low-lying excited states to provide an efficient numerical description. Matrix product states have proven to be very successful in 1D, but the corresponding 2D description (PEPS) are not efficiently contractible (unless certain approximations are made), leading to a poor scaling of the computational effort with system size. Recently proposed correlator product states (CPS), or entangled plaquette states, approximate the many-body wave function as a product of scalar weights that depend on the configuration of subgroups of sites. Using this description expectation values can be efficiently sampled, and the ground state found using a stochastic minimisation technique. Although certain types of correlator product state are equivalent to MPS/PEPS, they can also provide an efficient description of certain strongly correlated states that cannot be efficiently described using MPS/PEPS such as some fractional quantum Hall states. We have applied the correlator product state description to the 2D quantum Ising model and investigated how well long-range correlations are represented, and also to the 2D Bose-Hubbard model in an artificial magnetic field in the regime where fractional quantum Hall states are predicted to occur.

Wednesday 8th December 2010, Janet Anders (UCL, London)   Title: Ancilla-driven quantum computation and Landauer's erasure principle   Abstract: I will talk about two topics: (1) An experiment-friendly method of implementing quantum computation, called Ancilla-Driven Quantum Computation (ADQC), where the computation on a static register of qubits is driven remotely with the help of a single, flying ancilla qubit that “steers” the evolution of the register [1]. (2) I will then review Landauer's erasure principle. In the last decade a number of papers and books have claimed violation of Landauer’s principle (and the 2nd law of thermodynamics) in the strongly coupled quantum regime. I will argue why these claims are erroneous and show how a consistent treatment resolves the paradox [2]. [1] J. Anders, D. K. L. Oi, E. Kashefi, D. E. Browne, E. Andersson, Phys. Rev. A 82, 020301(R) (2010); a technical discussion can be found here arXiv:0905.3354. [2] S. Hilt, S. Shabbir, J. Anders, E. Lutz, arXiv:1004.1599

Wednesday 24th November 2010, Ulf Leonhardt (St Andrews)

Title: Geometry, light, and a wee bit of magic Abstract: Many mass-produced everyday products of modern technology would appear to be completely magical to our ancestors: mobile phones, television, computers, electric light, cars, etc. Some devices that are still perceived as magical or mysterious are about to appear in the laboratory and are not so mysterious after all. For example, the first prototype of an electromagnetic cloaking device has been made at Duke university in 2006. This device makes an object invisible to microwave radiation of a single frequency and polarization. At Harvard University, first vital steps towards levitating objects on the forces of the quantum vacuum have been made. At St Andrews, we observed first indications of artificial black holes in the laboratory, using extremely short light pulses in photonic-crystal fibres. Invisibility devices, quantum forces and optical black holes have two things in common: they represent applications of Einstein's general relativity in Maxwell's electromagnetism and their practical demonstrations are made possible by modern metamaterials. I will try to elucidate the scientific principles acting behind the scenes of such "pure and applied magic".

Thursday 18th November 2010, Klaus Moelmer (Aarhus, Denmark)

Title: Collective qubits and hybrid schemes for quantum computing

Abstract: In conventional registers for quantum information processing, quantum bits are associated with individual two-level quantum systems. Separate addressing and interaction with these systems permit one-bit gates, while an interaction between systems is needed to accomplish two-bit gates. I wil review a recent proposal to implement quantum computing in collective excitation degrees of freedom in ensembles of identical quantum systems. In
this proposal one does not need to address individual particles, but one needs an interaction between all particles in the system. Such interactions exist between Rydberg excited atoms within ensembles of ten micrometer diameter and in hybrid systems where large ensembles are coupled via a resonant single mode of the quantized radiation field. We will review the main ideas of ensemble encoding and we will discuss recent experimental implementation with promising candidate systems.

Wednesday 10th November 2010, Pieter Kok (Sheffield)

Title: General optimality of the Heisenberg limit for quantum metrology

Abstract: Quantum metrology promises improved sensitivity in parameter estimation over classical procedures. However, there is an extensive debate over the question how the sensitivity scales with the resources (such as the average photon number) and number of queries that are used
in estimation procedures. Here, we reconcile the physical definition of the relevant resources used in parameter estimation with the information-theoretical scaling in terms of the query complexity of a quantum network. This leads to a completely general optimality proof of the Heisenberg limit for quantum metrology. We give an example how our proof resolves paradoxes that suggest sensitivities beyond the Heisenberg limit, and we show that the Heisenberg limit is an information-theoretic interpretation of the Margolus-Levitin bound, rather than Heisenberg's uncertainty relation.

Wednesday 29th September 2010, Matt Jones (Durham)Title: Many-body physics with cold Rydberg gases Abstract: By transiently exciting cold atoms to Rydberg states, it is possible to switch the strength of the interatomic interactions by twelve orders of magnitude. These strong, long range interactions enable the study of quantum and classical many-body physics. In this talk I will report on recent experimental results from our group in Durham that relate to both of these aspects. By coupling the cold Rydberg gas to light we have shown that the interactions can give rise to a new kind of optical non-linearity that could have applications in quantum optics. In a different approach, in a unique experiment we have used the first two-electron Rydberg gas to probe excitation transfer and the evolution of a Rydberg gas into a plasma.

Wednesday 22th September 2010, Ville Lahtinen (ETH Zurich, Switzerland)Title: Interacting anyons and gauge field driven topological phase transitions Abstract:The exact solvability of the honeycomb lattice model offers an ideal platform to study phase transitions between different topological phases. Here we show the existence of a previously undiscovered topological phase that supports chiral Abelian anyons. It appears due to a presence of a vortex lattice that we can relate to a staggering of the model's couplings. By considering the effect of coupling distortions on the low-energy theory of Dirac fermions, we show that different phase transition driving perturbations translate to different chiral gauge fields. These lead to distinct Fermi surface evolutions that characterize the phase transitions. Finally, we demonstrate how the transition can also be understood as arising due to interactions between the anyonic vortices.

Tuesday 3rd August 2010, Lauri Lehmann (Sydney, Australia)
Title: Quantum walks with anyons

Abstract: Many computational algorithms can be presented as random walks on graphs. Random walks with quantum correlations provide a speedup to the efficiency of these algorithms when the walker is a particle with conventional boson or fermion exchange statistics. This talk discusses how the algorithmic efficiency of quantum walks changes when the walker is a particle with anyonic exchange statistics. The behaviour of the walk is sensitive to the type of the walker anyon, and we seek to explain which mechanisms can void the quantum coherence. Walks on infinite lines and ring graphs are also compared and we observe peculiar differences in the decoherence mechanisms of these walks.

Wednesday 21th July 2010, Mark Everitt (Loughborough and Cairo, Egypt) Title: The correspondence principle and topological quantisation in a superconducting quantum interference device

Abstract: The recovery of classical nonlinear and chaotic dynamics from quantum systems has long been a subject of interest. In this talk we discuss the quantum to classical crossover of a superconducting quantum interference device (SQUID) ring. Such devices comprise a thick superconducting loop enclosing a Josephson weak link and are currently strong candidates for many applications in quantum technologies. The weak link brings with it a nonlinearity such that semiclassical models of this system can exhibit nonlinear and chaotic dynamics. For many similar systems an application of the correspondence principle together with the inclusion of environmental degrees of freedom through a quantum trajectories approach can be used to effectively recover classical dynamics. Here we show (i) that the standard expression of the correspondence principle is incompatible with the ring Hamiltonian and we present a more pragmatic and general expression which finds application here and (ii) that practical limitations to circuit parameters of the SQUID ring prevent arbitrarily accurate recovery of classical nonlinear dynamics.

Monday 5 July 2010, Jaewoo Joo (Calgary, Canada now QI Leeds) Title: EITA in a Delta-type superconducting system and edge-local complementation in graph states
Abstract:In my talk, I would like to present two different topics in which I am interested for recent years. The first part is that electromagnetically-induced transparency and lasing without inversion are simultaneously achieved for microwave fields by using a fluxonium superconducting circuit. The second is that the theory of edge-local complementation in graph states is of use to build concatenated logical cluster states.

Thursday 1st July 2010, Jason Ralph (Liverpool) Title: Frequency Tracking for Robust Quantum State Estimation
Abstract: We consider the problem of tracking the state of a quantum system via a continuous measurement. If the system Hamiltonian is known precisely, this merely requires integrating the appropriate stochastic master equation. However, even a small error in the assumed Hamiltonian can render this approach useless. The natural answer to this problem is to include the parameters of the Hamiltonian as part of the estimation problem, and the full Bayesian solution to this task provides a state-estimate that is robust against uncertainties. However, this approach requires considerable computational overhead. Here we consider a single qubit in which the Hamiltonian contains a single unknown parameter. We show that classical frequency estimation techniques greatly reduce the computational overhead associated with Bayesian estimation and provide accurate estimates for the qubit frequency.

Thursday 1st July 2010, Neil Oxtoby (Liverpool) Title: Probing a composite spin-boson environment
Abstract: Can correlation measurements in a probe system encode information about the environment structure in open quantum systems? Motivated by efforts in solid-state quantum computation, in a recent paper (http://stacks.iop.org/1367-2630/11/063028 or http://arxiv.org/abs/0901.4470) we considered a pair of non-interacting qubits as a controllable probe of a non-equilibrium environment of defects/impurities. The impurities are themselves quantum-coherent two-level systems (TLSs) subject to damping by independent bosonic baths (phonons, for example). Hence the nomenclature `composite spin-boson environment'. During this talk I'll present results from the aforementioned paper. I'll focus on discussing how correlation measurements in the probe system could be exploited to efficiently discriminate between different experimental preparation techniques (environments), with particular emphasis on the quantum correlations (entanglement) that build up in the probe as a result of an indirect, TLS-mediated interaction between the probe qubits. I'll also discuss the harmful effects that a spin-boson environment has on bipartite qubit state entanglement and

entangling gate performance.

Wednesday 26th May 2010, Ahsan Nazir (UCL, London)Title: Coherence and Decoherence in Quantum Dot Exciton Dynamics (subtitle: Coherent - incoherent transitions in resonant energy transfer dynamics)Abstract: In this talk, I shall explore two aspects of the interplay of quantum coherence and decoherence in quantum dot exciton dynamics. In the first part, I shall describe recent theoretical work demonstrating that the dephasing observed experimentally in single, coherently-driven quantum dots can be accurately described within a
simple weak-coupling master equation formalism [1], identifying acoustic-phonons as the dominant source of excitonic decoherence.
In the second part, I shall investigate excitonic energy transfer dynamics in a donor-acceptor (e.g. quantum dot) pair beyond the weak inter-site or system-bath coupling regimes. I identify a transition from coherent to incoherent dynamics with increasing temperature, due to multiphonon effects not captured by a standard weak system-bath
coupling treatment. The crossover temperature has a marked dependence on the degree of spatial correlation between fluctuations experienced at the two system sites. For strong correlations, this leads to the possibility of coherence surviving into a high-temperature regime [2].
[1] A. J. Ramsay et al., Phys. Rev. Lett. 104, 017402 (2010)
[2] A. Nazir, Phys. Rev. Lett. 103, 146404 (2009)

Wednesday 5th May 2010, Michael Koehl (Cambridge) Title: A trapped single ion inside a Bose-Einstein condensate Abstract: The achievement of excellent control of the motional and the internal quantum states of ultracold neutral atoms and ions has opened intriguing possibilities for quantum simulation and quantum computation. In quantum degenerate neutral atoms many-body effects have been explored with hundreds of thousands of atoms and coherent light-matter interfaces have been built. Single or few trapped ions have been employed to demonstrate universal quantum computing algorithms and to detect variations of fundamental constants in precision atomic clocks. Until now quantum gases and single trapped ions have been disconnected in experiments. Their complementarities suggest, however, that they could be advantageously combined into one hybrid system. We have explored the immersion of a single trapped ion into a Bose-Einstein condensate of neutral atoms. We demonstrate the independent control over the two systems, study the fundamental interaction processes, and observe sympathetic cooling of a single ion by immersion into a Bose-Einstein condensate [1]. Our experiment opens possibilities for continuous cooling of a quantum computer and for exploring entanglement and decoherence in hybrid quantum systems.
[1] C. Zipkes et al., Nature, in press (2010).

Monday 19th April 2010, Wim van Dam (UCSB Sanat Barbara, California) Tilte: Quantum Computing and Zeta FunctionsAbstract: A possible connection between quantum computing and Zeta functions of finite field equations is described. Inspired by the 'spectral approach' to the Riemann conjecture, the assumption is that the zeros of such Zeta functions correspond to the eigenvalues of finite dimensional unitary operators of natural quantum mechanical systems. The notion of universal, efficient quantum computation is used to model the desired quantum systems. Using eigenvalue estimation, such quantum circuits would be able to approximately count the number of solutions of finite field equations with an accuracy that does not appear to be feasible with a classical computer. For certain equations (Fermat hypersurfaces) it is show that one can indeed model their Zeta functions with efficient quantum algorithms, which gives some evidence in favor of the proposal of this talk.

Thursday 8th April 2010, Sean Barrett (Imperial College London) Title: Quantum memories still work with half their qubits missingAbstract: Building a quantum computer is one of the central challenges in modern physics. One of the main obstacles to a practical realization is that existing approaches to quantum computation seem to be rather fragile to environmental noise and other imperfections. Only a small amount of noise can render a quantum computer completely useless. In the first part of the talk I will review a promising approach to overcoming the problem of noise in quantum computers: one which might be dubbed a `software' approach, utilizing quantum error correcting codes. I will focus on stabilizer codes, in particular the surface codes introduced by Kitaev. Towards the end of the talk I will describe some recent work (performed by myself, Tom Stace and Andrew Doherty, see Phys. Rev. Lett. 102, 200501) on the effect of qubit loss on robust quantum information processing schemes. Remarkably, we have found that robust quantum storage is possible even if up to half the qubits are lost. I discuss the consequences for the prospects of quantum information processing in systems such as photonic quantum computers, optical lattices, and solid state implementations, where loss can be a dominant source of noise.

Thursday 25th March 2010, Petr Jizba (Prague) Title: Uncertainty Relation on World Crystal and its Applications to Micro Black HolesAbstract: In this talk I formulate generalized uncertainty relations in a crystal-like universe whose lattice spacing is of the order of Planck length -- "world crystal". In the particular case when energies lie near the border of the Brillouin zone, i.e., for Planckian energies, the uncertainty relation for position and momenta does not pose any lower bound on involved uncertainties. I will apply results thus obtained to micro black holes physics, where I derive a new mass-temperature relation for Schwarzschild micro black holes. In contrast to standard results based on Heisenberg and stringy uncertainty relations, obtained mass-temperature formula predicts both a finite Hawking's temperature and a zero rest-mass remnant at the end of the micro black hole evaporation. I also briefly mention some connections of the world crystal paradigm with 't Hooft's quantization and double special relativity.

Wednesday 24th March 2010, Sam Braunstein (York)
Title: Black holes as ciphers of hidden information Abstract: The black-hole information paradox has fueled a fascinating effort to reconcile the predictions of general relativity and those of quantum mechanics. Gravitational considerations teach us that black holes must trap everything that falls into them. Quantum mechanically the mass of a black hole leaks away as featureless (Hawking) radiation. However, if Hawking's analysis turned out to be accurate then the information would be irretrievably lost and a fundamental axiom of quantum mechanics, that of unitary evolution, would likewise fail. Here we show that the information about the matter that collapses to form a black hole becomes encoded into pure correlations within a tripartite quantum system, the quantum analog of a one-time pad until very late in the evaporation, provided we accept the view that the thermodynamic entropy of a black hole is due to entropy of entanglement. In this view the black hole entropy is primarily due to trans-event horizon entanglement between external modes neighboring the black hole and internal degrees of freedom of the black hole. Finally, we will show that unless the thermodynamic entropy of a black hole is primarily entropy of entanglement then the equivalence principle must fail.

Friday 19th of March 2010, Abolfazl Bayat (UCL, London)Title: Entanglement in the Kondo Spin ChainAbstract: We consider an impurity at one end of a spin chain. This model is known to realize a Kondo system and we find that a genuine entanglement measure can be used to capture the extent of the Kondo cloud. The essential scaling of the entanglement is found to be independent of the system size depending only on ratios of the sizes to the Kondo length. From a practical perspective, entanglement between the impurity and a block of spins is a useless entanglement. To convert this useless entanglement into a useful one we quench a single bond at one end of the spin chain and we show that this quickly establishes a high quality entanglement between the spins at the opposite ends of the chain. This entanglement is mediated by a Kondo cloud, attains a constant high value independent of the length for large chains, and shows thermal robustness. This quench approach paves the way
to detect the elusive Kondo cloud through the entanglement between two individual spins.

Friday 19th of March 2010, Earl Campbell (UCL, London) Title: Entanglement distillation in distributed architecturesAbstract: Low quality entanglement shared by spatially separated parties can be probabilistically converted into high quality entanglement by local operations alone by using entanglement distillation protocols. I will begin my talk by outlining the first proposed distillation protocols, and slightly later protocols that adapted these techniques to enable distillation when each location is restricted to a modest number of qubits. Such an adaptation is essential for quantum computing applications using many matter systems such as Nitrogen-Vacancy defects in diamonds or several trapped ions.
I will then summarize my contributions to the field [1,2,3] that enable quantum computing with even fewer qubits per location than was previously possible. We will see that constructing graph states, rather than aiming for a circuit-based computation, assists in this goal. I will go through the protocol of [2] in more detail, which shows how to combat photon loss noise with only 2 quits per location.   This protocol is motivated by the extreme photon loss rates typically seen in experiments, and provides a rate of entanglement production that scales linearly (rather than quadratically) with photon collection efficiency.
[1] PRA Rapid Com 76 040302(R) (2007)
[2] PRL 101 130502 (2008)
[3] In press IJQI Vol 8 (2010) arXiv:0906.1527

Monday 22th February 2010, Ferdinand Schmidt-Kaler (Ulm)Title: Single trapped ions for cavity QED experiments and quantum thermodynamics

Abstract: Superpositions of quantum logic states |0> und |1> are stored and manipulated in the electronic excitation of ions for a future quantum computer [1]. So far, we know how to deal with a single, two [2], and up to eight qubits. For a realization of a scalable quantum device we employ linear segmented micro-structured Paul-traps [3], see figure below. I report on recent progress towards quantum gate operations [4,5]. The micro trap allows novel approaches for cavity QED, in view of a link between static and flying qubits. With time dependent, including non-adiabatic changes of the trap potential we propose experimental studies of non-equilibrium thermodynamics [6], or experiments with linear ion crystals “doped” with other ion species for an investigation of novel phase transitions [7].
[1] J. I. Cirac und P. Zoller, Phys. Rev. Lett. 74, 4091(1995).
[2] F. Schmidt-Kaler et al., Nature 422, 408 (2003).
[3] S. Schulz, et al., New . Phys. 10, 045007 (2008); U. Poschinger et al, J. Phys. B 42, 154013 (2009).
[4] P. Ivanov, et al, arXiv: 0909.5397.
[5] H. Wunderlich et al, Phys. Rev. A 79, 052324 (2009).
[6] G. Huber, F. Schmidt-Kaler, S. Deffner, E. Lutz, Phys. Rev. Lett 101, 070403 (2008).
[7] P. Ivanov et al, to be published.

Wednesday 17th of February 2010, Gavin Brennen (Sydney, Australia)Title: Fault tolerant quantum computing with noisy and slow measurementsAbstract:We show that the threshold error rates of preparation and measurement for fault tolerant quantum computing can be improved considerably over prior art. By removing the dependence on measurements and feedback in quantum error correction using gadgets based on coherent feedback, one can circumvent the problem of noisy and slow measurements present in many physical systems. Applying the method to the

Bacon-Shor code, fault-tolerant universal quantum computing is achievable when gate error rates are below 2.89 x 10^{-5} and measurement and preparation error rates can be as high as 7%.

Wednesday 10th February 2010, Miguel Aguado (MPQ Garching, Germany)
Title: Topological models, Hopf algebras, and duality

Abstract: I describe a construction of a hierarchy of topological states on the lattice, starting from Kitaev's lattice quantum double construction as applied to Hopf algebras. These mathematical objects will be defined and motivated in this context. I will show how general and simple tensor network constructions stem from Hopf algebra properties, and how these lead to a direct computation of the topological entanglement entropy, and to duality results concerning Levin and Wen's more general class of topological string-net models. This is work in progress by Oliver Buerschaper, Juan Martín Mombelli, Matthias Christandl, and the speaker. Tuesday 9th February 2010, Sir Michael Atiyah (Edinburgh)

Title: Topology and quantum physics

Abstract: Classical Physics has a long and intimate relation with Geometry, going back to Galileo and Newton, in which force bends (or curves) the motion of a particle. This broad idea carries over to Maxwell’s Electromagnetism and Einstein’s General Relativity. However in the 20th century quantum mechanics altered the picture, but at the same time geometers widened their horizons by taking up topology. I will try to explain how the force- curvature link extends to a quantum-topology one. Interestingly a prime example of a topological problem is that of distinguishing knots, and Kelvin in the 1870’s suggested that knots might explain the structure of atoms. Although, with the advent of quantum mechanics, Kelvin’s theory was discarded, it was too beautiful an idea to waste. In a sense Kelvin’s basic idea has survived but applied at the subatomic level.The new understanding of the Quantum –Topology link has had a profound effect on both mathematics and theoretical physics, as I hope to indicate.

Wednesday 3rd February 2010, Jonathan Robbins (Bristol)Title: Quantum statistics on networksAbstract: We consider quantum statistics (exchange symmetry) for spinless particles on a one-dimensional network, or graph, in particular the simplest case of abelian statistics for two particles. Generalisations of anyon statistics emerge - the statistics phases can depend on where and how the particles are exchanged, and new discrete-valued phases, associated with the torsion component of the configuration space homology group, appear. Calculations are simplified by discretising the network, so that the analysis also describes the statistics of many-particle tight-binding models. This is joint work with Jonathan Harrison and Jon Keating.

Monday 25th January 2010, Radu Ionicioiu (HP, BristolTitle: From graphs to quantum states (...and hopefully back) Abstract: Given a graph G, how do we associate to it a quantum state |G>? What do we expect to be good properties of such a mapping between graphs and quantum states? Can we define new families of entangled states starting with simple mathematical objects like graphs? What about deriving properties of graphs by studying quantum states associated to them? These are a few questions which motivate the talk. Starting with a few general axioms, I will show what properties we can derive from them and what this entails for the associated quantum states. As a particular example, this construction recovers (and generalizes) the class of well-known graph states.

Wednesday 9th December 2009, Brendon Lovett (Oxford)Title: Exploring the Interplay of Different Kinds of Qubit in Solid State Systems

Abstract: A quantum computer requires qubits with many different properties. These are typically very difficult to find in a single quantum degree of freedom. In this talk, I will explore the possibility of using different qubits for different jobs. First, a nuclear spin makes a very good memory element, but an electron spin is easier to measure and manipulate. I will show that the state of a electron spin can be transferred to an nuclear spin, effectively increasing the coherence time of the electron to over one second. The limit on the nuclear spin coherence is here limited by the electron relaxation time, but I will discuss how we may overcome even this limit. Second, I will discuss how to improve the speed and fidelity of electron spin manipulation using optical excitation. For example, it is possible to exploit exciton states in quantum dots for this purpose. I will give compelling evidence that the interaction with acoustic phonons is the dominant decoherence process in this case and show how this, too, can be overcome. Though the talk will focus on theory, I will throughout use experimental data to illustrate several aspects of the ideas I discuss.

Wednesday 7th October, Sophie (Sonja) Schirmer (Cambridge) Title: Hamiltonian and Reservoir Engineering for Quantum Systems and Quantum System Identification Abstract: Starting with the basic equations describing the dynamics of quantum systems such the Schrodinger or quantum Liouville equation, I will discuss the possibilities for quantum engineering by modifying both the system Hamiltonian, and possibly the interaction with an environment (reservoir) through (coherent) control, measurements and feedback. I will discuss some principal ways of Hamiltonian engineering, especially using optimal control, including the formulation of key problems such as quantum state preparation or gate engineering as optimal control problems and algorithms to solve them. I will present some recent improvements to the algorithms and some applications such as the implementation of quantum logic gates for encoded qubits via optimal control. I will also discuss how we can utilize measurements and feedback to achieve tasks such as stabilizing quantum states in the presence of dissipative effects. Finally, I will briefly discuss the importance of quantum system identification beyond process tomography for quantum engineering. Time-permitting I may discuss some dynamic identification schemes based on Bayesian analysis of noisy 'generalized Rabi oscillation' type data.

[1] Optimal Control, Fault-tolerant gates: arXiv:0907.1635 (to appear in NJP)

[2] Lyapunov control: arXiv:0901.4544, arXiv:0901.4546 (to appear in IEEE Trans. Autom. Control) and arXiv:0906.1830 (to appear in PRA)

[3] Minimal control and spin chains: PRA 80, 030301 (2009)

[4] Reservoir engineering: arXiv:0909.1596 (submitted to PRA)

[5] System identification/Hamiltonian tomography: PRA 80, 022333 (2009)

Tuesday 14th July, Mark Everitt (Loughborough) Title: Quantum measurement with chaotic apparatus Abstract: We study a dissipative quantum mechanical model of a projective measurement process. The measurement device comprises an oscillator circuit plus environment, where the expectation value dynamics, in the correspondence limit, are either chaotic-like or periodic dependent upon the measured state of the quantum object--in this case a qubit. We demonstrate how the classical-like trajectories of a dissipative quantum system emerge in sympathy with the projection of the qubit state, providing a model of the measurement process. Furthermore, we verify that the anticipated Born rule holds for an ensemble average of measurements.

Tuesday 7th July, Damian F. Abasto (USC) Title: Fidelity analysis of quantum phase transitions Abstract: There is by now clear evidence that quantum phase transitions can be detected and analyzed using the fidelity between ground states, a simple tool borrowed from quantum information. The fidelity gives rise to a metric in the manifold of couplings of the hamiltonian, whose divergences correspond to quantum phase transitions of the underlying model. I will discuss general properties of the metric, including its scaling with system size, and focus on its applicability to analyze quantum phase transitions to topologically ordered phases.

Wednesday 8th April, Claudia Eberlein (Sussex) Title: Casimir-Polder forces between atoms and surfaces Abstract: A neutral atom near a surface experiences an attractive force because quantum fluctuations of the electromagnetic field polarize the atom as well as the surface, and these interact. The simplest example is the interaction of an atom with a plane, perfectly reflecting mirror, which was first worked out by Casimir and Polder in 1947, as a preliminary step in their calculation of the fully retarded van der Waals force between two atoms. The talk gives an easy-to-follow overview over some of the advancements in this field since. It explains the underlying physical concepts and some of the difficulties that one typically meets. It gives examples of various geometries, of the impact of material properties like dispersion and absorption. It also shows that there are many subtleties in this field and simplified models do not always work.

Wednesday 25th March, Simon Webster (Oxford)Title: Building blocks for quantum information processing with trapped ions

Abstract: Essential goals for quantum information processing are scaling up the number of qubits possible, and increasing the fidelity of operations on the qubit. Work in the Oxford ion trap group towards these goals will be presented. Firstly we are designing, fabricating and testing several multi-zone traps for increasing the number of qubits that can be manipulated. Secondly we have implemented the Uhrig pulse sequence to reduce decoherence caused by time-varying magnetic fields. Finally we have been studying high-fidelity readout using different detection methods. We have already reported high-fidelity readout for a single qubit (99.99% in 145us) using a photomultiplier, and we have now also demonstrated simultaneous readout of multiple ions using a CCD camera.

Thursday 19th March, Tim Spiller (HP, Bristol)

Title:The quantum-classical crossover (of a field mode) Abstract: There has long been interest in how fundamental quantum things give rise to the more familiar classical behavior we see every day. Using some historical examples, I argue that it is really interaction with other stuff -- some sort of environment -- that enables characteristic classical signatures to emerge from quantum systems. I give two examples of such emergent classical behaviour, for a quantum oscillator, or field mode. The first is classical dissipative chaos. The second is the transition from "collapse and revival" to continuous Rabi oscillations, as displayed by a probe qubit coupled to the field mode.

Friday 13th March, Dimitris Tsomokos (Hertfordshire) Title: Dynamical Stability of Topological Order

Abstract: Topological orders are non-symmetry breaking phases of matter, which provide a new paradigm in condensed-matter physics. Their characterization is a major open problem, although considerable progress has been made since the proposal of the topological entanglement entropy. In this talk I will examine the dynamical stability of topologically ordered quantum states. Conditions will be derived on the type of dynamical evolution that allows quantum recurrence and preservation of the initial topological order.

Wednesday 11th March, Stephen Brierley (York)   Title: Constructing mutually unbiased bases in dimension six

Abstract: The density matrix of a qudit may be reconstructed with optimal efficiency if the expectation values of a specific set of observables are known. In dimension six, the required observables only exist if it is possible to identify six mutually unbiased complex 6x 6 Hadamard matrices. In this talk I will show how to construct all vectors mutually unbiased to a given Hadamard matrix and that by repeating this calculation many times, sampling all known 6x6 Hadamard matrices, we never find more than two that are mutually unbiased. This result adds considerable support to the conjecture that no seven mutually unbiased bases exist in dimension six.

Monday 15th December, Dan Browne (University College London) Title:The computational power of multi-party correlations Abstract: One of the most striking features of quantum mechanics is the prediction of non-classical correlations. As famously noted by John Bell, measurements on spatially separated entangled states can be correlated in a ways incompatible with classical physics and, indeed, any local hidden variable model of nature.
Quantum information science aims to exploit the non-classical properties of quantum physics, and quantum correlations have proven a valuable resource - for quantum key distribution, quantum teleportation and other quantum protocols. Recently, in addition, quantum correlations have been shown to be resources for computation - indeed universal quantum computation [1]. In Raussendorf and Briegel's "one-way" computational model, single-qubit measurements on a multi- qubit "cluster state" - together with classical side processing - are sufficient to achieve the full power of quantum computation.
In this talk I will show how following John Bell's approach (studying the correlations rather than the state) one can gain new insights into the computational resource power of entangled quantum states. I will give some simple examples which illustrate this effect, including some famous non-classical correlations, and introduce Raussendorf and Briegel's cluster state model from this perspective. I will then outline how a notion of computational power for correlations can be defined, and how a hierarchy then emerges [2]. I will then describe how the new insights given by this perspective open up a new ways of studying many-body correlations, leading to new generalisations of the GHZ "paradox", the Popescu non-local box. I will then discuss the consequences of this to the parallelisation of general algorithms [3].
[1] R. Raussendorf and H.J. Briegel, A one-way quantum computer, Phys. Rev. Lett. 86, 5188 (2001).
[2] J. Anders and D.E. Browne, The computational power of correlation arXiv:0805.1002v3. (To appear in PRL)
[3] Work in progress in collaboration with Matty Hoban, Earl Campbell and Janet Anders.

Wednesday 10th December, Stefan Scheel (Imperial College London)Title: Macroscopic quantum electrodynamics -- dispersion forces and duality Abstract: In this talk I will review the basic principles of electromagnetic field quantization in the presence of dielectric background materials. As an important application, I will focus on dispersion forces such as van der Waals forces, Casimir-Polder forces, and Casimir forces and discuss the hierarchical connection between them. Special emphasis will be placed on thermal Casimir-Polder and Casimir forces and the relation to the Lifshitz theory of dispersion forces. With the advent of novel materials that show strong magnetic properties, it becomes increasingly important to understand their influence on the dynamics of atomic systems. I will show that, by invoking the priciple of duality, magnetic-magnetic type interactions can be traced back to known electric-electric type interactions. Finally, I will touch briefly upon the theory of Casimir-Polder force on moving atoms, commonly known as quantum friction.

Wednesday 3rd December, William Rubens (Imperial College London)Title: Qubits and Black HolesAbstract: We review apparent coincidences in the descriptions of certain black hole and qubits. We first look at the 3 qubit case and link that with the N=2 STU black hole, writing a dictionary between the charges of the black hole and the coefficients of the wavefunction. There are further coincidences linking a distillation protocol and the attractor mechanism. We look at a possible explanation of this consisting of identifying qubits with wrapped cycles, before going on to look at the N=8 generalisation that may be related to the three-way entanglement of seven qubits.
Friday 28th November, Mark Saunders (University of Durham)Title: Inertial sensing with cold atomsAbstract: We consider the resonant dynamics of a dilute atomic gas, falling under gravity through a periodically pulsed, sinusoidal standing-wave laser field. This atom-optical realisation of the quantum delta-kicked accelerator generalises our study into the effect of temperature upon quantum resonance and antiresonance [1].
We explore the transition between temperature extremes by investigating the evolution of the individual quasimomentum eigenstates. Tuning the acceleration experienced by the atoms reveals a rich structure of resonance phenomena [2], providing the prospect for precision measurement. [1] M. Saunders, P. L. Halkyard, K. J. Challis, and S. A. Gardiner
Manifestation of quantum resonances and antiresonances in finite-temperature dilute atomic gas,
Phys. Rev. A 76 43415 (2007).

[2] M. Saunders, P. L. Halkyard, S. A. Gardiner, and K. J. Challis,
Fractional resonances in the atom-optical delta-kicked accelerator,
arXiv:0806.3894 (2008).

Wednesday 26th November, David Tong (Cambridge)Title: Berry Phase and Supersymmetry Abstract: Non-Abelian Berry phases arise as one slowly varies the parameters of a quantum system with degenerate states. I will review this phenomenon and show how, using techniques from supersymmetry, the Berry phase can be computed for complicated quantum systems where the ground states themselves are not known. All of this will be illustrated with simple examples and pretty pictures.

Tuesday 25th November, Oscar Dahlsten (ETH Zürich)Title: Nonclassicality without entanglement enables bit commitment arXiv:0803.1264 Abstract: We investigate the existence of secure bit commitment protocols in the convex framework for probabilistic theories. The framework makes only minimal assumptions, and can be used to formalize quantum theory, classical probability theory, and a host of other possibilities. We prove that in all such theories that are locally non-classical but do not have entanglement, there exists a bit commitment protocol that is exponentially secure in the number of systems used.

Wednesday 19th November, Bob Coecke (Oxford)from 4pm, Mathematics Active Learning Lab 1 (MALL 1), Level 8 of School of Mathematics Title: TBAAbstract: TBA

Wednesday 12th November, Bahar Mehmani (Amsterdam)3-4, E C Stoner Seminar Room 8.62 Title: Non-Adiabatic cyclic evolution of a quantum system Abstract: When a quantum system adiabatically evolves in a cyclic way, its wave function acquires a phase factor, the so called Berry phase. It is a geometric phase which can be measured via interference. As a model we consider a quantum system coupled to two classical systems (work sources), where the couplings vary in a cyclic but non-adiabatic way. We investigate the corrections to the geometric phase due to the transitions to other energy levels. It is shown that in the near adiabatic regime, i.e., first order correction, the total extracted work in a cycle from the system is zero but there is a non-zero work transfer due to the non-adiabatic corrections to the geometric phase. This can be explained as the work of the geometric force exerted from the system on the sources. The second order non-adiabatic correction to the geometric phase makes it possible to extract work from the system in a cycle. The force exerted from the system on the work sources in this regime exhibits interesting features as well.

Wednesday 22nd October, Gavin Brennen (Sydney, Australia) Title: Nonlocality of Non-Abelions Abstract: Non-local correlations are a central theme in quantum mechanics and tell us that there exist states in the joint Hilbert space of two subsystems that have measurement outcomes not describable by local realism. There is another kind of non-locality arising from interactions amoung anyons which share a common topologically ordered medium. I will describe how the later concept can be understood and quantified in terms of the former via a Bell like inequality between measurements on disjoint regions of the medium.

Monday 6th October '08, Keith Burnett (University of Sheffield) Yorkshire Bank Lecture Theatre, Business School, 4-5pm Title: Quantum Fluctuations and Correlations in Cold Matter Abstract: IIt is now possible to study a wide range of many-body phenomena using evaporatively cooled atoms. Some of the most exciting developments are the new techniques for producing strongly correlated states, where quantum fluctuations dominate the behaviour of the atoms. Experimental groups around the world are working on ways to produce and probe these strongly correlated atomic assemblies. In my talk I will describe how strong quantum fluctuations arise and how they are related to correlation and entanglement in cold atom systems.

Monday 29th September '08, Konrad Banaszek (University of Torun)
Abstract: Prof. Banaszek's research concentrates on the development and characterisation of sources of non-classical radiation for quantum information processing applications. He studies the process of parametric down-conversion, in which input light spontaneously generates pairs of highly correlated photons. These photons can exhibit a specifically quantum form of correlations, called entanglement, which cannot be understood using intuitions from the classical world where the properties of an object are completely defined all at once. Applications of such photon pairs range from metrology and communication to quantum cryptography and beyond.

Wednesday 3rd September '08, David Joshua Tannor (Weizmann Institute, Israel) Title: Optimal control of laser cooling: A theory of purity increasing transformations Abstract: The powerful techniques of Optimal Control Theory (OCT), used in recent years to design laser pulse sequences to control chemical bond breaking, are applied to the problem of laser cooling in an open system. The result is a striking new mechanism in which spontaneous emission builds coherences between all the populated levels creating a pure state, only at the end of the process transferring the amplitude to the lowest energy state. This novel mechanism accelerates the cooling process by exploiting the cooling induced by spontaneous emission to all the electronic ground state levels, not just the lowest level. The mechanism suggests the calibration of cooling in terms of increasing purity of the system as measured by the quantity Tr(rho^2).The formulaton of cooling in terms of this coherence measure has an additional, interesting application: that our results carry over immediately to the problem of coherent control of quantum decoherence, suggesting both a new mechanism and fundamental limitations on the control of that process.

Thursday 22nd May '08, Ian McCulloch (University of Queensland)Title: The matrix product approach to computational many-body physics

Abstract: In recent years it has been realized that the successful Density Matrix Renormalization Group (DMRG) algorithm for one-dimensional many-body quantum groundstates, has a natural formulation as a variational calculation over the space of Matrix Product States (MPS). The MPS formulation has many advantages over the traditional approach, and I will give some examples of calculating real-time and frequency space dynamics in optical lattices, and using quantum information measures to probe quantum phase transitions. Friday 16th May '08, Martin Plenio (Imperial, London)

Title: Entanglement: From scaling laws to simulations

Abstract: I present various results on scaling laws of entanglement properties in quantum-many-body systems and explain what we can learn from them about the efficiency of certain methods for the classical description of quantum systems.
THURSDAY 1st May '08, Janet Anders (UCL, London)

Title: Measurement based classical computation

Abstract: In measurement-based computation the computation proceeds by adaptive single-qubit measurements on a multi-qubit entangled state, such as the cluster state. The adaptive measurements require a classical control computer which processes the previous measurement outcomes to determine the correct bases for the following measurement. Hence feeding the control computer with an appropriate resource state raises its computational power considerably, in the case of the cluster state it reaches quantum universality. The resources states fuelling such computational jump can in this sense be considered to possess a "computational power" themselves which is used by the control computer.

While impressive work has been done to classify entangled states that boost the power of any classical control computer to quantum universality, little is known about the reverse question. Given the simplest possible control computer, the CNOT computer, what are resources that can boost its computational power at all? Asking this way around leads naturally to the notion of measurement-based "classical computation" and I will shed light on this problem and finally derive minimal resource states needed for universal classical computation.

Reference: J. Anders and D.E. Browne, Measurement-based classical computation, on the arXiv very soon ...
WEDNESDAY 30th April '08, John Goold (Cork, Ireland)

Title: Quantum state engineering in low dimensional quantum gasesAbstract: Low -dimensional quantum gases have rapidly evolved from a being a soley theoretical concept
towards being experimentally accesible systems in the laboratories. Small-scale trapping potentials for ultracold gases have allowed the creation of degenerate fermionic or bosonic gases. Rapid experimental advances have paved the way to explore the exciting area of strongly correlated low-dimensional systems. Optical lattice techniques produce tightly confining potentials in selective directions and using Feshbach resonaces one can control and 'play with' the interaction part of the system's Hamiltonian. This presentation serves as a broad introduction to the theory of bosonic one dimensional quantum gases, described by the integrable Lieb-Liniger model. The conceptually simplistic yet instructive problem of two atoms interacting in a delta split harmonic is solved and results concerning the basic physics displayed*. I will then turn my attention to a rare example of an exactly solvable many-body problem namley the Tonks-Girardeau gas – a strongly correlated system. Through displaying calculations of one body density matrices, momentum distributions and interference simulations I will discuss interesting results concerning the spatial coherence of such a gas in a split trap**. The talk will be concluded by outlining some future plans to measure entanglement in one-dimensional quantum gases and how we might relate it to spatial coherence. References:
*.Boson pairs in a one-dimensional split trap
D. S. Murphy, J. F. McCann, J. Goold, and Th. Busch, Phys. Rev. A 76, 053616 (2007).
..Ground State Properties of a Tonks-Girardeau Gas in a Split Trap
J.Goold and Th. Busch, arXiv:0803.0846 (To appear in PRA).

THURSDAY 13th March '08, William Matthews (Bristol)

Title: PPT pure state transformations and catalysis

Abstract: In an effort to better understand the class of operations on a bipartite system which preserve positivity of partial transpose (PPT operations), we have investigated the (non-asymptotic) transformation of pure states to pure states by operations in this class. Under local operations and classical communication (LOCC) Nielsen's majorization criterion provides a necessary and sufficient condition for such a transformation. This can be used to show that under LOCC a phenomenon called catalysis can occur, where an otherwise impossible transformation can be made possible by the provision of an entangled catalyst state, which must be recovered unchanged after the transformation (hence the name). I will present some recent work where we have found a necessary condition for obtaining a given pure state from a maximally entangled state via PPT operations. This condition is conjectured to be sufficient also, and we can prove this for the case where the goal state has Schmidt rank three. We have also shown that catalysis occurs under PPT operations, and have derived a necessary and sufficient condition for PPT pure state transformations where both the initial state and the catalyst are maximally entangled.

Wed 12th March '08, Dmitry Shalashilin (Leeds)

Title: Multidimensional quantum simulations with Coupled Coherent States

Abstract: The method of Coupled Coherent States (CCS) [1-7] is a technique for direct numerical simulation of quantum many-body problems, which avoids exponential scaling of basis set with dimensionality and therefore allows exact fully quantum treatment of systems comprised of a large number of degrees of freedom. The method is based on a solution of multidimensional Schrödinger equation in the basis of trajectory guided Monte Carlo sampled coherent states. The evolution of the wave function is simulated by running an ensemble of classical trajectories of coherent states together with a system of coupled quantum equations for the coherent states amplitudes. A new feature of our approach in comparison with similar techniques [8.9] is that it uses quantum averaged potentials for running classical trajectories. This efficiently takes into account local zero point energy and results in a number of cancellations in working equations. The method is fully quantum, however, classical mechanics helps to remove quantum oscillation and to decrease coupling, which is essential for making Monte Carlo sampling work. CCS is efficient only together with importance sampling. A systematic review of various ways to sample the initial conditions of Coherent State basis set will be presented.
A number of applications to the spectroscopy of polyatomic molecules and small clusters, intramolecular vibrational energy redistribution and proton tunneling have been reported, in which a large (in the order of 10 or 20) number quantum degrees of freedom have been treated on a fully quantum level. Recently we applied the approach also to simulations of electron dynamics in strong laser field.
[1] D.V. Shalashilin, M.S. Child, J.Chem.Phys., 113, 10028, 2000.
[2] D.V. Shalashilin, M.S. Child, J.Chem.Phys., 114, 9296, 2001.
[3] D.V. Shalashilin, M.S. Child, J.Chem.Phys., 115, 5367, 2001.
[4] D.V. Shalashilin, M.S. Child, J.Chem.Phys., 119, 1961, 2003.
[5] D.V. Shalashilin, M.S. Child, D.C. Clary, J.Chem.Phys., 120, 5608, 2004.
[6] D.V. Shalashilin, M.S. Child, Chem.Phys., 304, 103, 2004.
[7] P.A.J. Sherratt, D.V. Shalashilin, M.S. Child, Chem.Phys., 322, 135 2006.
[8] M. Ben-Nun and T. J. Martinez in Adv.Chem.Phys., 121., 439, ed. I.Prigogine and S.A.Rice (John Wiley & Sons, Inc. 2002).
[9] G.A.Worth, I.Burghardt, Chem.Phys.Lett. 368, 502 (2003).

Wed 5th March '08, Alexander Klein (Oxford)

14:00, E C Stoner SR (8.90)

Title: Optical Lattices in Bose-Einstein Condensates: Polarons, Clustering, and Dephasing

Abstract: Atoms in an optical lattice are a very versatile system to investigate solid state phenomena. However, due to the nature of the trapping potential, the optical lattice does not exhibit phonons, which are an important part in condensed matter theory. We investigate the effects of a Bose-Einstein condensate (BEC) on the properties of immersed impurity atoms that are trapped in an optical lattice. We show that the impurities couple to the BEC phonons and that they are readily described in terms of polarons, i.e., atoms dressed by phonon clouds. This changes the transport properties of the atoms considerably, leading to a cross-over from coherent to diffusive. The loss of coherence is also observed in a quantum master equation approach, which gives direct access to the off-diagonal elements of the density matrix. Furthermore, the phonon coupling leads to the occurrence of a net current in a tilted optical lattice, which would otherwise be suppressed due to Bloch oscillations. Apart from these single-particle properties, the BEC also mediates an attractive off-site interaction between the impurities, which enables the formation of stable clusters. The signature of these clusters is visible in the density distribution and in time of flight expansions. FRIDAY 29th Feb '08, Richard Low (Bristol, CS)

Title: Random Quantum Circuits are Approximate 2-designs

Abstract: We ask the question: how long does it take for a random quantum circuit to approach a uniformly random

unitary? This is of physical importance because it is related to the question of entanglement growth in a randomly interacting system. It is of algorithmic interest because constructing uniformly random unitaries is exponentially hard in the number of qubits but for many purposes only pseudo random unitaries are required. We partially answer the question by considering the convergence of the moments of the distribution and we prove tight bounds for the first and second moments for a large class of random circuits. As a corollary of our main result, we improve previous bounds on the convergence rate of random walks on the Cliord group. This is joint work with Aram Harrow.

Wed 27th Feb '08, Tim Freegarde (Southampton)

Title: New optical methods of cooling and manipulating atoms and molecules

Abstract: The remarkable recent advances that have exploited laser cooling to generate ultracold and quantum coherent atoms have been limited to just a small handful of atomic elements. Broader application to other atoms and to molecules will require optical cooling schemes that are more tolerant of, and less reliant upon, the spontaneous emission that conventionally accompanies each useful photon impulse.
I shall describe a number of such schemes, some now being investigated experimentally, that use optical modulators and nanostructured surfaces to generate temporally modulated scattering forces and spatially varying dipole forces respectively. The design and underlying principles of these practical mechanisms, of potential application to a wide range of atomic and molecular species, link them to phenomena as disparate as quantum computation and the Casimir-Polder effect.
I shall also outline how the macroscopic pumps, vacuum chambers, atomic sources and optics that comprise current experimental apparatus can be miniaturized into an integrated, self-contained chip-scale device.

Wed 13th Feb '08, Jens Eisert (Imperial College London)

Title: The computational power of quantum states, or: Novel schemes for measurement-based quantum computation

Abstract: We establish a framework which allows one to construct a plethora of novel schemes for measurement-based quantum computation, based on local measurements on entangled resource states. The technique further develops tools from many-body physics - based on finitely correlated or projected entangled pair states - to go beyond the cluster-state based one-way computer. This work hence constitutes an instance where a quantum information problem - how to realize quantum computation - was approached using tools from many-body theory and not vice versa.
We identify resource states that are in several ways quite radically different from the cluster state. Notably, we find a great flexibility in the properties of the universal resource states: They may for example exhibit non-vanishing long-range correlation functions or be locally arbitrarily close to a pure state. Certain ground states server as universal resources. We discuss variants of Kitaev's toric code states, which are states with non-trivial topological properties, as universal resources, and contrast this with situations where they can be efficiently classically simulated. This framework opens up a way of thinking of tailoring resource states to specific physical systems.
[1] D. Gross and J. Eisert, Phys. Rev. Lett. 98, 220503 (2007).
[2] D. Gross, J. Eisert, N. Schuch, and D. Perez-Garcia, Phys. Rev. A 76, 052315 (2007).
[3] D. Gross and J. Eisert, in preparation (2008).

Thursday 7th Feb '08, Luigi Amico (Catania, Italy)

Title: Entanglement in many body systems

Abstract: The recent interest in aspects common to quantum information and condensed matter has prompted a prosperous activity at the border of these disciplines that were far distant until few years ago. Numerous interesting questions have been addressed so far. Here I review the properties of the entanglement in many-body systems. I will be discussing the zero and finite temperature properties of entanglement, by focusing on spin lattice models. Both bipartite and multipartite entanglement will be considered. At equilibrium we emphasize on how entanglement is connected to the phase diagram of the underlying model. The behavior of entanglement can be related, via certain witnesses, to thermodynamic quantities thus offering interesting possibilities for an experimental test. Out of equilibrium entangled states can be generated and manipulated by means of many-body Hamiltonians.

Fri 25th Jan '08, David Hutchinson (Otago, New Zealand; Paris, France)

Title: Effects of Disorder in Ultra-cold, dilute gases

Abstract: The possibility of using ultracold atoms to observe strong localization of matter waves is now a subject of both theoretical and experimental interest. These systems offer unprecedented control over inter-particle interactions, imposed potentials and the level of disorder in the system as compared to their condensed matter analogues. The two-dimensional (2D) case is of particular interest. The prevailing view has been that in the 2D 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, review the experimental position in the field in the dilute 2D gas and discuss potential future experiments.

Wed 23th Jan '08, Pepijn Pinkse (MPQ Garching, Germany)

Title:Cavity Quantum Electrodynamics and Cold Polar Molecules

Abstract:A single atom coupled to a single mode of the optical field represents an archetype of matter-light interaction and is a textbook example of cavity-quantum electrodynamics (cavity QED). In the cavity, the matter-light interaction is enhanced to the extent that a single neutral atom can change the transmission of the cavity completely, allowing fast and non-destructive single-atom detection. Simultaneously, a single photon can saturate an atomic transition many times. Hence single quanta of light and matter interact strongly, forming a new quantum entity. As a consequence, light forces are altered by the presence of the cavity. These forces can be exploited to tame the motion of the atoms interacting with the cavity field, allowing single atoms to be trapped in the cavity. These forces can be used to cool down the motion of the atom. We were able to demonstrate “cavity cooling” for the first time. This dissipative cooling method, remarkably, does not rely on spontaneous emission. Hence it can, in principle, be used for particles lacking closed transitions, such as molecules.

The second part of this talk reports about experiments with cold polar molecules, which have raised interest in various research fields such as chemistry, metrology, molecular physics and quantum information processing. Velocity filtering of polar molecules is introduced as a technique to produce a beam of cold polar molecules. The beam is guided by exploiting the Stark shift of the polar molecules in electrostatic or in switched electric fields. Building on the developed techniques, it was possible to demonstrate trapping of neutral molecules and atoms in purely electric traps. Whereas the motional temperature of the molecules in the trap can be below 1 K, the internal motion of the molecules is hotter, because many rotational states contribute to the flux. In order to measure their distribution, an optical method is developed confirming theoretical predictions. We expect to narrow down the state distribution by a technique in which molecules are cooled by a cryogenic helium buffer gas. Finally, cavity cooling is investigated theoretically for further cooling the external as well as the internal motion of the molecules, coming full circle to cavity QED.

Thur 17th Jan '08, Susana Huelga (Hertfordshire)

Title:Stochastic Resonance effects in composite systems

Abstract:I will discuss the phenomenon of stochastic resonance (SR), a paradigm of the counter intuitive effects noise may have, in driven coupled quantum systems. I will construct dynamical and information theoretic measures of the system's response that exhibit a non-monotonic behaviour as a function of the noise strength and analyze the relation between lack of monotonicity in the response and the presence of quantum correlations and identify parameter regimes where the breakdown of a linear response can be linked to the presence of entanglement. I will also show that a chain of coupled spin systems can exhibit an array-enhanced response, where the sensitivity of a single resonator is enhanced as a result of nearest-neighbour coupling. These results enlarge the domain where SR effects exist and should be observable in a variety of qubit realizations, such as arrays of superconducting qubits.

Wed 12th Dec '07, Erika Anderson (Strathclyde)

Title: Efficient realisation of generalised quantum measurements

Abstract: Generalised quantum measurements (POMs or POVMs), which go beyond standard von Neumann projective measurements, are an essential part of many protocols in quantum information science, including state identification, state estimation and quantum cryptography. It is therefore important to find efficient means of experimentally implementing these non-trivial measurement schemes. The "standard" realisation of a generalised measurement requires an ancillary quantum system, sometimes with many dimensions, and quantum operations coupling the original system plus the ancilla. Recently, a method of performing generalised measurements using repeated projective measurements was proposed [1]. It was shown that an arbitrary generalised quantum measurement could be realised by adding a single auxiliary state to the original system and performing successive projective measurements on this enlarged system. I will explain the method and give a possible experimental implementation using photons or atomic qubits. A potential drawback with the method is the number of iterations required to complete the measurement. We have therefore investigated a way to reduce the number of projective measurements required, leading to a "binary search tree" of measurements. This latter way of realising generalised quantum measurements could be used e.g. for probing the state of a cavity field by sending an atom through it and measuring the atom.

[1] Realization of positive-operator-valued measures by projective measurements without introducing ancillary dimensions, Guoming Wang and Mingsheng Ying, quant-ph/0608235.

Wed 28th Nov '07, Myungshik Kim (Belfast)

Title: Addition and subtraction of a single photon

Abstract: A photon is the unit of light particles. We now have technology to add and subtract a single photon in a light field. In this talk, we review the foundations of addition and subtraction of a photon before we show how to implement such the operations. We then show an interesting result of non-commutativity between photon subtraction and addition. We show how these techniques can be used for quantum-state engineering of light fields.

Tue 20th Nov '07, Elisabeth Rieper (Braunschweig)

Title: Do npt bound entangled states exist?

Abstract: It is known that positive partial transpose (ppt) bipartite entangled states are not distillable, that means there exist no local operations on these states such that the resulting output state is maximally entangled. Therefore the amount of entanglement of ppt states is bounded. It is an open conjecture that negative partial transpose (npt) states exist. In the talk, I will give a short introduction to the key concepts like the ppt criterion, entanglement distillation and bound entanglement. Then I will present an example of a distillation protocol designed to study the destillation properties of a class of highly symmetric states, called Werner states, which are supposed to be npt bound entanglement for a certain parameter range.

FRIDAY 16th Nov '07, Damien Markham (Paris)

Title: Graph States for Quantum Secret Sharing

Abstract: We show that graph states are an excellent resource for both classical and quantum secret sharing for either classical or quantum channels between players and with or without eavesdropping, in the cases that either the threshold condition for secret sharing is that all~n players collaborate or in the special cases that at least three collaborate for a total number of players being either $n=4$ or $n=5$. Our graph state approach unifies disparate quantum secret sharing schemes in certain cases and provides an elegance insofar as the secret sharing capabilities emerge naturally from a few properties of the associated graphs, which we prove here.

Wed 14th Nov '07, Mete Atature (Cambridge)

Title: Quantum Optics with Quantum Dot Spins

Abstract: Self-assembled semiconductor quantum dots (QDs) have atom-like properties such as discrete energy levels coupled by optical transitions, and their coherence properties can be revealed in quantum-optics experiments. Further, these transitions are governed by spin-dependent optical selection rules. This opens an access channel to single spins in a quantum dot via lasers. This has been the driving motivation for the development of numerous proposals for quantum information processing with quantum spins and cavity quantum electrodynamics (QED). However, QDs are not isolated systems and can also interact strongly with a spin (nuclei) and a charge (electrons) reservoir of the solid-state environment leading to a rich source of interaction mechanisms. Consequently, identifying the regimes of these mechanisms is crucial for achieving a level of control in solid-state-based systems similar to that of atoms. I will provide a highlight of recent progress on all-optical control of single and coupled quantum dot spins along with the current research directions in coherent light-matter interactions.

Tue 6th Nov '07, Joost Slingerland (Dublin)

Title: Interferometry with non-Abelian anyons

Abstract: After a short introduction to topological phases and their application to topologically protected quantum computation, I will talk about proposed interferometric experiments in fractional quantum Hall systems which should provide strong evidence for the presence of quasiparticles with non-Abelian exchange statistics in those systems. Anyonic interferometry will also allow for measurement of the topological charges of clusters anyons, an important ingredient in topological quantum computers. I will describe this measurement process and the decoherence of

topological charge which results from it.

Wed 31th Oct '07, Karoline Wiesner (Bristol)

Title: Intrinsic quantum computation

Abstract: How are computing, information creation, and dynamics related? A contemporary view of these three historical threads is that they are not so disparate. I will show that a synthesis leads to methods to analyze how quantum processes store and manipulate information - what we refer to as "intrinsic quantum computation". I will introduce ways to measure information storage in quantum dynamics, using a recently introduced computation-theoretic model that accounts for measurement effects. The first, the entropy rate, quantifies the amount of inherent randomness in a process. The second, the excess entropy, quantifies the shared information between a quantum process's past and its future.

Wed 24th Oct '07, Sofyan Iblisdir (Barcelona)

Title: The toric code at finite temperature

Abstract: The toric code is a two-dimensional spin model defined on a lattice. This model has a spectrum that is both rich and simple: it features anyonic excitations and is exactly solvable. It has also attracted much attention as a candidate for a quantum memory. In the first part of the talk, the main properties of this model will be reviewed. Then, we will introduce the concept of topological entropy of entanglement, and show how it can be used to study the robustness of the model in presence of temperature.

Wed 17th Oct '07, Michael Trupke (London)

Title: Towards QIP on atom chips

Fri 27th July '07, Colin Benjamin (Marseille)Title:Controllable pi junction in a Josephson quantum-dot device with molecular spin

Abstract: We consider a model for a single molecule with a large frozen spin sandwiched in between two BCS superconductors at equilibrium, and show that this system has a π junction behavior at low temperature. The π shift can be reversed by varying the other parameters of the system, e.g., temperature or the position of the quantum dot level, implying a controllable π junction with novel application as a Josephson current switch. We show that the mechanism leading to the π shift can be explained simply in terms of the contributions of the Andreev bound states and of the continuum of states above the superconducting gap. The free energy for certain configuration of parameters shows a bistable nature, which is a necessary pre-condition for achievement of a qubit.

Thurs 26th July '07, Roger Colbeck (Cambridge)Title:Expanding a Private Random String with Untrusted Quantum Devices

Abstract: In cryptography, it is common to assume that each party trusts completely the operation of their devices. In this talk, we will consider what is achievable if this assumption is dropped. Instead, we assume that all quantum devices must be sourced from a potentially malicious supplier. I will describe a protocol for expansion of an initial private random string, under any attack by the supplier consistent with the laws of quantum theory. Security is ensured by verifying the violation of a Bell-like quantity.

5th July '07, Giovanni Mazzarrella

Title: Atomic physics, quantum phase transitions, and statiscal mechanics in ptical lattices.

Abstract: In this talk, I am displaying some reults about bosonic atomic gases rapped by external magnetic potentials and confined in one-dimensional eriodical geometries.

First, I am showing how the external trapping potentials affects the phase diagram of bosonic atoms in one-dimensional optical lattices. In articular, I am introducing a generalized Bose-Hubbard Hamiltonian ncluding the structure of the energy levels of the trapping potential, and I am showing that these levels are in general populated both at finite and zero temperature. Finally, I am characterizing the properties of the superfluid transition, by stressing that the excited levels of the external potential take part to the superfluid phase.

Second, I am deriving an Extended Bose Hubbard (EBH) model by developing a systematic expansion of the Hamiltonian of the system in powers of the lattice parameters, by identifying the dominant terms up to the nearest-neighbor interactions and nearest-neighbor hoppings conditioned by the on-site occupation numbers. I am displaying the phase diagrams of the system both at zero and at finite temperature, by stressing that at zero temperature a dual strucuture characterizes the Mott insulating regime. Finally, I am commenting that in the EBH model, a zero temperature quantum phase transition to pair superfluidity is, in principle, possible, but it is completely suppressed at the lowest order of the above expansion.

29th June '07, Prof. Dr. Dr. h.c. Klaas Bergmann, (Fachbereich Physik der Universität Kaiserslautern - Germany) Title: Controlled preparation and detection of coherent superpositions of degenerate quantum states

Abstract: After the discussion of some basis features of the STIRAP-method, it will be explained how the technique can be used to generate a controlled superposition of degenerate quantum states with freely chosen relative amplitudes and phases. Furthermore, methods suitable for experimentally determining amplitudes and phase of such a coherent superposition, will be presented.

30th May '07, Karl Tordrup, (Aarhus, Denmark and Leeds).Title:Quantum Computing with Rare-Earth-Ion-Doped CrystalsAbstract: We present an implementation of Quantum Computing using rare-earth-ion-doped solids. In this realisation, qubits are encoded in hyperfine levels of the rare-earth-ion dopants and may be addressed via electronic excited states using optical fields. Due to large broadening of the optical transitions, different qubits may be defined as ensembles of ions with almost identical transition frequencies. We will demonstrate how frequency-chirped pulses may be used in tandem with phase-compensating pulses to overcome inhomogeneities in the ensembles when performing single-qubit rotations. Furthermore, by making use of the dipole blockade effect to control qubit interactions we can implement a fully entangling controlled phase gate.

25th May '07, Giovanni Vacanti, (Palermo, Italy).

Title: Entanglement generation in optomechanical system by means of radiation pressure

Abstract: We present a scheme for generating entanglement between two micromechanical oscillators which have never interacted with each other by using an entanglement swapping protocol. The system under study is a Michelson-Morley interferometer in which the mirror at the end of each arm is a tiny cantilever able to oscillate around its equilibrium position. Each cantilever is coupled to a field mode of the corresponding cavity via radiation pressure. Entanglement between the two cantilevers can be generated through a measurement on the output of the interferometer. Both the unitary and the non-unitary evolution cases are investigated.

Thursday 24th May '07, Elica Kioseva, (Sofia, Bulgaria).

Title: Physical realization of coupled Hilbert-space mirrors for quantum-state engineering

Abstract: Manipulation of superpositions of discrete quantum states has a mathematical counterpart in the motion of a unit-length statevector in an N-dimensional Hilbert space. Any such statevector motion can be regarded as a succession of two-dimensional rotations. But the desired statevector change can also be treated as a succession of reflections, the generalization of Householder transformations. In multidimensional Hilbert space such reflection sequences offer more efficient procedures for statevector manipulation than do sequences of rotations. We here show how such reflections can be designed for a system with two degenerate levels -- a generalization of the traditional two-state atom -- that allows the construction of propagators for angular momentum states. We use the Morris-Shore transformation to express the propagator in terms of Morris-Shore basis states and Cayley-Klein parameters, which allows us to connect properties of laser pulses to Hilbert-space motion. Under suitable conditions on the couplings and the common detuning, the propagators within each set of degenerate states represent products of generalized Householder reflections, with orthogonal vectors. We propose physical realizations of this novel geometrical object with resonant, near-resonant and far-off-resonant laser pulses. We give several examples of implementations in real atoms or molecules.

Wednesday 23rd May '07, Clare Hewitt-Horsmann, (University College London, UK).Title: Explaining the quantum speed-up using a many-worlds interpretation,
or: How to build a classical computer

Abstract: Quantum computers can do many things that classical computers cannot, but no-one really knows why. In this talk I will present a physical picture of quantum computing, based on a type of many-worlds interpretation of quantum mechanics. In this picture the speed-up of quantum vs classical computation can be explained in a surprising way. The picture also gives us a new understanding of how quantum and classical resources are interchangable, and puts classical computation and communication protocols in their rightful places as subsets of their quantum counterparts.

Monday 14th May '07, Michael Fleischauer (Technical University of Kaiserslautern)

Title: Light induced Abelian and non-Abelian gauge potentials for ultra-cold atoms

Wednesday 6th December '06, Janet Anders (National University of Singapore)

Title: Thermal entanglement in a harmonic chain

Abstract: In my talk I want to summarise the knowledge we have about the entanglement of linear chains in thermal equilibrium states. Such a chain can be, for instance, a line of traps each holding a single ion. The ions shall couple harmonically to their nearest neighbours only. To reach conclusions about the entanglement in the chain, I will shortly review the diagonalisation of the Hamiltonian into phonon modes, discuss the possible phonon spectra and their dependence on the trapping potentials, explain a little bit about continuous variable states as opposed to qubit states and find violation of uncertainty relations if we treat an upcoming Goldstone boson in a wrong manner. I will show you that entanglement exists between nearest neighbours if the temperature is tuned below a certain critical temperature which varies with the trapping potential. At the end of this journey I want to discuss with you about the physical interpretation of this critical temperature and talk a bit of the establishment of Long Range Order in 3D. I hope to learn from you what system is experimentally available or desirable and how we could swap entanglement.

Wednesday 29th November '06, Charles H.-T. Wang (University of Aberdeen, King's College, UK)

Title: Probing quantum gravity using matter wave interferometry

Abstract: One of the biggest unsolved problems in physics is the unification of quantum mechanics and general relativity. The lack of experimental guidance has made the issue extremely evasive, though various attempts have been made to relate the loss of matter wave coherence to quantum spacetime fluctuations. We present a new approach to the gravitational decoherence near the Planck scale, made possible by the recently discovered conformal structure of canonical gravity. This leads to a gravitational analogue of Brownian motion whose correlation length is given by the Planck length up to a scaling factor. With input from recent matter wave experiments, we show the minimum value of this factor to be well within the expected range for quantum gravity theories. This suggests that the sensitivities of advanced matter wave interferometers may be approaching the fundamental level due to quantum spacetime fluctuations, and that investigating Planck scale physics using matter wave interferometry may become a reality in the near future. Ref: C. Wang, R. Bingham, T. Mendonca 2006, Class. Quantum Grav. 23 L59-L65

Friday 24th November '06, Akimasa Miyake (University of Innsbruck, Austria)

Title: Universal entanglement resources for measurement-based quantum computation

Abstract: I talk about which entanglement resources allow universal measurement-based quantum computation via LOCC, i.e., in an extended framework of the one-way quantum computation endowed with the cluster states. We introduce several entanglement criteria which should be satisfied for any universal resource, and show new examples of universal resources, including encoded resources which may make physical implementations easier. The talk is based on Phys. Rev. Lett. 97, 150504 (2006), and our recent progress on the topic.

Thursday 23rd November '06, Rob Spekkens (University of Cambridge, UK)

Title: Quantum coherence: fact or fiction?

Abstract: A controversy that has arisen many times over in disparate contexts is whether quantum coherences between eigenstates of additively conserved quantities are fact or fiction. I present a pedagogical introduction to the debate in the form of a hypothetical dialogue between proponents from each of the two camps: a factist and a fictionist. It is argued that a resolution of the debate can be achieved by recognizing that quantum states do not only contain information about the intrinsic properties of a system but about its extrinsic properties as well, that is, about its relation to other systems external to it. Specifically, the coherent quantum state of the factist is the appropriate description of the relation of the system to one reference frame, while the incoherent quantum state of the fictionist is the appropriate description of the relation of the system to another, uncorrelated, reference frame. The two views are alternative but equally valid paradigms of description. This conclusion has implications for a variety of conceptual puzzles including whether synchronized clocks and aligned Cartesian frames are a source of entanglement (generally, they are not), whether a single particle can exhibit Bell correlations (it can), and whether it is possible to lift superselection rules (it is, and we propose an experiment to demonstrate this for atom number).

Wednesday 8th November '06, Stefan Eriksson (Imperial College London, UK) Title: Atom Chips Abstract: I will describe our work on atom chips at the Centre for Cold Matter at Imperial College. Atom chips allow trapping, manipulation and detection of ultra-cold neutral atoms near microstructured surfaces. Complex atomic circuits can be integrated on an atom chip using techniques derived from conventional electronic microchip fabrication. Because the trapped atoms interact weakly with the environment coherence times of prepared states can be exceedingly long. These properties make atom chips ideal for novel quantum physics experiments. Many of the well known experiments with ultra-cold atoms such as the production of Bose and Fermi degenerate gases have recently also been realised on atom chips. These achievements are the first steps towards miniaturisation of atom optics and the creation of small quantum devices based on neutral atoms. The tight confinement of atoms in the chip-traps together with tailored internal state dependent potentials opens up entirely new avenues to explore. Experiments pursued in our group include single mode matter wave guiding and atom interferometry, and the production quantum gases in low dimensions. We are also investigating scenarios to scale up the number of traps on the chip as well as ways of integrating arrays of micro-traps with micro-optics for single atom detection. The high finesse and small mode volume of our atom chip microcavities enables cavity-QED experiments with possible applications to quantum information processing.

Wednesday 1st November '06, Bruno Sanguinetti (QI, Leeds) Title: Measuring the state of the Micromaser cavity fieldAbstract: The Micromaser is an experiment where microwave photons are kept inside a cavity, which isolates them from the environment by virtue of its high quality factor and low temperature. We can then interact with the field inside the cavity in a controlled way by passing single atoms trough the cavity. This scheme provides a quantum system that is very well understood and can be used as the basis for a wealth of quantum mechanical experiments, which depend on creating and measuring particular quantum states. After a quick introduction to the Micromaser I will talk about the method that will be used to measure the state of the cavity field, illustrating with a quantum Monte Carlo simulation.
Wednesday 25th October '06, Ben Varco (QI, Leeds)Abstract: Research involving the basic tools of quantum information – qubits and quantum memory - is teaching us more about the nature of quantum mechanical interactions than we have ever known. However as the nature of the interactions between quantum space time and matter are becoming better defined, we have recently shown that in fact quantum information experiments can also teach us about the nature of quantum gravity. The next generation of experiments that search for the theory of everything could well be table top quantum information experiments. I will talk about some experiments that we are doing in this area. Wednesday 18th October '06, Matthew Leifer (Perimeter Institute, Canada) Title: Cloning and broadcasting in generalized probabilistic theoriesAbstract: Motivated by the question of what lies behind the information processing abilities of quantum theory, several authors, including Barrett and Spekkens, have begun to investigate information theoretic phenomena in more general probabilistic frameworks. Others, such as Hardy and d'Ariano, have proposed novel axiomatizations of quantum theory that operate within similar frameworks. Barrett's framework is essentially the finite dimensional special case of a much older framework first proposed by Mackey in the 1950s, and later developed by Ludwig, Foulis and Randall, Bugajski, Holevo and others. This framework supports states from which "super-quantum" correlations may be obtained, which violate Bell inequalities to a larger extent than allowed by quantum theory, without permitting signaling. In this talk, I will give generic analogs of the no-cloning and no-broadcasting theorems that apply to all theories within this framework. The proof of the no-broadcasting theorem thus obtained is conceptually simpler than any of the proofs for the purely quantum case available to date. This talk is based on joint work with Howard Barnum, Jon Barrett and Alex Wilce.
Wednesday 11th October '06, William Hall (University of York, UK)Title: Compatibility of subsystem states and convex geometry Abstract: The subsystem compatibility problem, which concerns the question of whether a set of subsystem states of a multipartite quantum system are compatible with a state of the entire system, has received much study. Here we attack the problem from a new angle, utilising the ideas of convexity that have been successfully employed against the separability problem. Analogously to an entanglement witness, we introduce the idea of a compatibility witness. We also consider the use of convex programming techniques, and we show that the compatibility problem can be solved numerically and efficiently using these techniques. Finally, we will see how these techniques can be used to gain some analytical insights about the problem. Monday 25th September '06, Johannes Kofler (University of Vienna, Austria) Title: Classical world because of quantum phyicsAbstract: We present a novel theoretical approach to macroscopic realism and classical physics within quantum theory and which is conceptually different from the decoherence program. It puts the stress on the limits of observability of quantum effects of macroscopic objects, i.e., on the required precision of our measurement apparatuses such that quantum effects can still be observed. First, we demonstrate that for unrestricted measurement accuracy a violation of macrorealism is possible for arbitrary large systems. Then we show that, given the restriction of coarse-grained measurement resolution, not only macrorealism becomes valid but even the classical (Newtonian) laws emerge out of a quantum (Schrordinger) time evolution and the projection postulate. Classical physics can thus be seen as implied by quantum mechanics under the restriction of fuzzy measurements." Thursday 14th September '06, Damian Markham, (University of Tokyo, Japan) Title: "Multiparty Entanglement in Quantum Information"Abstract: I will give an overview of various recent results we have on multipartite entanglement, and how genuine multiparty entanglement may be used in quantum information processing in a way beyond bipartite

entanglement. Recently we have been able to quantify entanglement for many interesting classes of multiparty pure and mixed states, including cluster states useful for quantum computation and error correction. These methods are intimately related to entanglement witnesses, which have recently allowed bounds to these quantities to be measured in experiment. This connection also allows us to give general conditions for entanglement for any thermal states, with possilbe applications for investigations of entanglement in manybody large quantum systems. We have also been able to show that these quantities can have an operational meaning in terms of LOCC information access, allowing many possible new applications to QIT. Monday 15th May '06, Professor Sam Braunstein, (University of York, UK).Title: "Bob and the black hole: a one-sided perspective"Abstract: Relevant Paper: "gr-qc/0603046" Tuesday 9th May '06, Professor Andrew Briggs, (Professor of Nanomaterials, Director of the Quantum Information Processing IRC, Department of Materials University of Oxford). Title: "Spin qubits in carbon nanomaterials"Abstract: Of the many schemes proposed for quantum computing, most of those in the solid state use nanostructures in which there are well-defined states with long coherence times. Candidates include a variety of carbon nanomaterials, in which the qubit can be embodied in excitons or electric charge or spin. It may be that more than one of these should be used, and a recent scheme uses excitons to control the interaction between single electron spins in adjacent regions of quantum confinement. Such schemes can also be applied to compound semiconductor nanomaterials. The endohedral fullerenes are a versatile family of molecular materials, whose electron spin distributions are becoming well characterized and understood, and whose chemistry can be controlled. Endohedral fullerenes have been demonstrated to have spin coherence times of up to 0.25 ms. The electron spin in N@C60 can be manipulated with exquisite precision, using pulse sequences borrowed from NMR. A qubit on the nuclear spin can be manipulated with a fast phase gate, and can be decoupled from the environment by trapping it in closed cycles on the Block sphere. Molecularly self-assembling materials offer the potential of reproducibility without requiring individual tuning. One-dimensional arrays can be formed in single-walled carbon nanotubes; these can provide both structural support and controlled interactions, and their electronic structure can be externally modulate. The challenge of addressing large numbers of qubits in such tiny structures may seem insuperable, but that may not be necessary. Schemes that use global addressing of classes of qubits simultaneously have been demonstrated theoretically to be adequate for universal quantum computing. It is still too early to say which, if any, of the competing technologies will eventually be used to build a quantum computer, and there is plenty of scope for evaluating the properties of carbon nanomaterials. 2nd May '06, Bruce W. Shore (Visiting Scientist, Technical University of Kaiserslautern).Title: Coherent Manipulation of Atomic ExcitationAbstract: Lasers have become ubiquitous devices, not only in mechanisms that surround us in our daily lives but also as essential laboratory tools throughout the disciplines of physical and biological sciences. For many of these purposes it is only the near-monochromatic properties, or the directional properties, that are used. But the coherence properties -- not envisioned by laser pioneers -- have become increasingly valuable. I will discuss laser coherence as it is used for producing, in individual atoms or molecules, various manipulations of the internal structures that, according to quantum theory, underly the properties of such microscopic entities. Whereas the first exploitation of coherence aimed simply to produce excitation of preselected quantum states (a technique of interest in studies of chemical reaction dynamics and analytical chemistry), more recent interest has centered on creating coherent superpositions -- a purely quantum mechanical notion that has application in such newly emerging technologies as quantum information processing. 26th April '06, Sir Peter Knight (Imperial College London, UK).Title: Quantum Optics and the 2005 Nobel Prizes. 29th March '06, William D. Phillips, (NIST Gaithersburg, Distinguished Professor, University of Maryland, 1997 Nobel Laureate in Physics).Title: Atom optics with Bose-Einstein condensates 22nd March '06, Dr Marcelo Terra Cunha (QIS, University of Leeds).Title: On Entangled Fermions and on Geometric Phase TransitionsAbstract: In this seminar I plan to talk on two themes. The first is about how to extract entanglement by taking a pair of fermions from a Fermi sea, and also the role of symmetry in this process. The second, which we call a Geometric Phase Transition, is related to singular behaviours of entanglement quantifiers when a quantum state of a composed system varies smoothly. 15th March '06, Mahboubeh Asgari-Targhi (University College London, UK).Title: Braid Theory and Its Application.Abstract: Braid theory is a relatively young field with many opportunities for discovey and exploration for mathematicians. In my talk, I shall first describe the braid theory, then I shall discuss as how it can be employed to model topologically complex systems such as magnetic fields in the solar corona and the DNA cells. 8th March '06, Prof. Ian Lawrie, (University of Leeds, UK).Title: Phase Transitions In The Early Universe And Elsewhere.Abstract: We currently have no abstract for this talk. For Prof. Lawrie's website please click here. 1st March '06, Ho Tsang Ng, (University of Oxford, UK).Title: 'Optical Josephson junction'Abstract: Recently, Saba et. al [Science, vol 307, 1945 (2005)] have demonstrated how to determine the relative phase between two separate Bose-Einstein condensates (BEC's) using the Bragg scattering. It opens the possibility to design the Josephson devices of two separate systems. In this talk, I will introduce the model and derive the effective Hamiltonian of an ``optical Josephson junction'' (OJJ) based on this technology. I will discuss the potential applications of this OJJ such as precision measurement, entanglement generation and qubit circuits. 22nd February '06, Chris Timpson, (University of Leeds, UK).Title:`Two views on quantum information theory'Abstract: In this talk two views on the nature of quantum information will be contrasted. The 'substance' view takes quantum information to be part of the contents of the world, the aim of quantum information theory being the study of the behaviour of this novel sort of entity; the 'deflationary' view, by contrast, insists that the term 'information' is an abstract noun and hence does not refer to an entity or a substance. I will argue in favour of the deflationary view. If time allows, we will close with some remarks on the potential significance of quantum information theory for our understanding of quantum mechanics. 15th February '06, Pieter Kok, (Oxford University, UK). Title: Linear optical quantum computing, a review.Abstract: Linear optics with photon counting is a prominent candidate fopractical quantum computing. The protocol by Knill, Laflamme and Milburn [Nature 409, 46 (2001)] explicitly demonstrates that efficient scalable quantum computing with single photons, linear optical elements, and projective measurements is possible. Subsequently, several improvements on this protocol have started to bridge the gap between theoretical scalability and practical implementation. We review the original theory and its improvements, and we give a few examples of experimental two-qubit gates. We discuss the use of realistic components, the errors they induce in the computation, and how they can be corrected.There will be another related seminar in School of Philosophy (Leeds) as following; Wednesday 15 February 2006 at 3.15 pm Dr Harvey Brown (University of Oxford) 'Space-time Geometry: Its Meaning and Explanatory Role'.Meetings will be held in the School of Philosophy, Baines Wing Room G36, at 3.15pm. Tea will be served at 3 pm in the same room. 9th February '06, Matt Jones, (Orsay, France). Title: “Quantum Optics and Quantum Information with Optically Trapped Single Atoms”Abstract: I will describe our work in the Quantum Optics Group at Orsay on trapping and manipulating single rubidium atoms in a sub-micron sized trap, formed at the waist of a tightly focused laser beam. Arrays of these traps can be used to make an array of single atom qubits for use in quantum information experiments. In our recent work, we have shown that we can use the single trapped atom as a high quality source of triggered single photons. I will also present our latest experiments in which we use these techniques to demonstrate two-photon interference between single photons spontaneously emitted by different atoms. This is an important step towards the conditional generation of atom-atom entanglement using photon detection. 1st February '06, Aires Ferreira, (University of Leeds, UK). Aires has just arrived here in Leeds and has kindly agreed to give a talk about his work based upon an experiment taking place in Vienna. The experiment is intended to investigate the entanglement between two mirrors...

25th January '06, Andrew Fisher, (UCL, London). Andrew is a professor in the condensed matter group at UCL and his group forms part of the new London Centre of Nanotechnology. Visit his website for more about his research interests. This seminar will take place in collaboration with the condensed matter group in our department. 12th December '05, Erik Sjoqvist, (University of Upsala, Sweden).Title: Quantum Holonomy Open PathsAbstract: Non-Abelian quantum holonomies, i.e., unitary state changes solely induced by geometric properties of a quantum system, have been much under focus in the physics community as generalizations of the Abelian Berry phase. Apart from being a general phenomenon displayed in various subfields of quantum physics, the use of holonomies has lately been suggested as a robust technique to obtain quantum gates; the building blocks of quantum computers. Non-Abelian holonomies are usually associated with cyclic changes of quantum systems, but here we consider a generalization to noncyclic evolutions. We argue that this open-path holonomy can be used to construct quantum gates. We also show that a structure of partially defined holonomies emerges from the open-path holonomy. This structure has no counterpart in the Abelian setting. We illustrate the general ideas using an example that may be accessible to tests in various physical systems. 6th December '05, Bill Munro, (HP Labs Bristol).Title: Qubus Computation: Quantum Computation by CommunicationAbstract: We discuss a new approach to scalable quantum computing---a ``qubus computer --- which realises qubit measurement and quantum gates through interacting qubits with a quantum communication bus mode. The qubits could be ``static'' matter qubits or ``flying'' optical qubits, but the scheme we focus on here is particularly suited to matter qubits. There is no requirement for direct interaction between the qubits. Universal two-qubit quantum gates may be effected by schemes which involve measurement of the bus mode, or by schemes where the bus disentangles automatically and no measurement is needed. In effect, the approach integrates together qubit degrees of freedom for computation with quantum continuous variables for communication and interaction.

Tuesday 14th July, Mark Everitt (Loughborough) Title: Quantum measurement with chaotic apparatus   Abstract: We study a dissipative quantum mechanical model of a projective measurement process. The measurement device comprises an oscillator circuit plus environment, where the expectation value dynamics, in the correspondence limit, are either chaotic-like or periodic dependent upon the measured state of the quantum object--in this case a qubit. We demonstrate how the classical-like trajectories of a dissipative quantum system emerge in sympathy with the projection of the qubit state, providing a model of the measurement process. Furthermore, we verify that the anticipated Born rule holds for an ensemble average of measurements.

Tuesday 7th July, Damian F. Abasto (USC) Title: Fidelity analysis of quantum phase transitions Abstract: There is by now clear evidence that quantum phase transitions can be detected and analyzed using the fidelity between ground states, a simple tool borrowed from quantum information. The fidelity gives rise to a metric in the manifold of couplings of the hamiltonian, whose divergences correspond to quantum phase transitions of the underlying model. I will discuss general properties of the metric, including its scaling with system size, and focus on its applicability to analyze quantum phase transitions to topologically ordered phases.

Wednesday 8th April, Claudia Eberlein (Sussex)   Title: Casimir-Polder forces between atoms and surfaces Abstract: A neutral atom near a surface experiences an attractive force because quantum fluctuations of the electromagnetic field polarize the atom as well as the surface, and these interact. The simplest example is the interaction of an atom with a plane, perfectly reflecting mirror, which was first worked out by Casimir and Polder in 1947, as a preliminary step in their calculation of the fully retarded van der Waals force between two atoms. The talk gives an easy-to-follow overview over some of the advancements in this field since. It explains the underlying physical concepts and some of the difficulties that one typically meets. It gives examples of various geometries, of the impact of material properties like dispersion and absorption. It also shows that there are many subtleties in this field and simplified models do not always work.

Wednesday 25th March, Simon Webster (Oxford)Title: Building blocks for quantum information processing with trapped ions

Abstract: Essential goals for quantum information processing are scaling up the number of qubits possible, and increasing the fidelity of operations on the qubit. Work in the Oxford ion trap group towards these goals will be presented. Firstly we are designing, fabricating and testing several multi-zone traps for increasing the number of qubits that can be manipulated. Secondly we have implemented the Uhrig pulse sequence to reduce decoherence caused by time-varying magnetic fields. Finally we have been studying high-fidelity readout using different detection methods. We have already reported high-fidelity readout for a single qubit (99.99% in 145us) using a photomultiplier, and we have now also demonstrated simultaneous readout of multiple ions using a CCD camera.

Thursday 19th March, Tim Spiller (HP, Bristol)

Title:The quantum-classical crossover (of a field mode) Abstract: There has long been interest in how fundamental quantum things give rise to the more familiar classical behavior we see every day. Using some historical examples, I argue that it is really interaction with other stuff -- some sort of environment -- that enables characteristic classical signatures to emerge from quantum systems. I give two examples of such emergent classical behaviour, for a quantum oscillator, or field mode. The first is classical dissipative chaos. The second is the transition from "collapse and revival" to continuous Rabi oscillations, as displayed by a probe qubit coupled to the field mode.

Friday 13th March, Dimitris Tsomokos (Hertfordshire) Title: Dynamical Stability of Topological Order

Abstract: Topological orders are non-symmetry breaking phases of matter, which provide a new paradigm in condensed-matter physics. Their characterization is a major open problem, although considerable progress has been made since the proposal of the topological entanglement entropy. In this talk I will examine the dynamical stability of topologically ordered quantum states. Conditions will be derived on the type of dynamical evolution that allows quantum recurrence and preservation of the initial topological order.

Wednesday 11th March, Stephen Brierley (York)   Title: Constructing mutually unbiased bases in dimension six

Abstract: The density matrix of a qudit may be reconstructed with optimal efficiency if the expectation values of a specific set of observables are known. In dimension six, the required observables only exist if it is possible to identify six mutually unbiased complex 6x 6 Hadamard matrices. In this talk I will show how to construct all vectors mutually unbiased to a given Hadamard matrix and that by repeating this calculation many times, sampling all known 6x6 Hadamard matrices, we never find more than two that are mutually unbiased. This result adds considerable support to the conjecture that no seven mutually unbiased bases exist in dimension six.

Monday 15th December, Dan Browne (University College London) Title:The computational power of multi-party correlations Abstract: One of the most striking features of quantum mechanics is the prediction of non-classical correlations. As famously noted by John Bell, measurements on spatially separated entangled states can be correlated in a ways incompatible with classical physics and, indeed, any local hidden variable model of nature.
Quantum information science aims to exploit the non-classical properties of quantum physics, and quantum correlations have proven a valuable resource - for quantum key distribution, quantum teleportation and other quantum protocols. Recently, in addition,   quantum correlations have been shown to be resources for computation - indeed universal quantum computation [1]. In Raussendorf and Briegel's "one-way" computational model, single-qubit measurements on a multi- qubit "cluster state" - together with classical side processing - are sufficient to achieve the full power of quantum computation.
In this talk I will show how following John Bell's approach (studying the correlations rather than the state) one can gain new insights into the computational resource power of entangled quantum states. I will give some simple examples which illustrate this effect, including some famous non-classical correlations, and introduce Raussendorf and Briegel's cluster state model from this perspective. I will then outline how a notion of computational power for correlations can be defined, and how a hierarchy then emerges [2]. I will then describe how the new insights given by this perspective open up a new ways of studying many-body correlations, leading to new generalisations of the GHZ "paradox", the Popescu non-local box. I will then discuss the consequences of this to the parallelisation of general algorithms [3].
[1] R. Raussendorf and H.J. Briegel, A one-way quantum computer, Phys. Rev. Lett. 86, 5188 (2001).
[2] J. Anders and D.E. Browne, The computational power of correlation   arXiv:0805.1002v3. (To appear in PRL)
[3] Work in progress in collaboration with Matty Hoban, Earl Campbell and Janet Anders.

Wednesday 10th December, Stefan Scheel (Imperial College London)Title: Macroscopic quantum electrodynamics -- dispersion forces and duality Abstract: In this talk I will review the basic principles of electromagnetic field quantization in the presence of dielectric background materials. As an important application, I will focus on dispersion forces such as van der Waals forces, Casimir-Polder forces, and Casimir forces and discuss the hierarchical connection between them. Special emphasis will be placed on thermal Casimir-Polder and Casimir forces and the relation to the Lifshitz theory of dispersion forces. With the advent of novel materials that show strong magnetic properties, it becomes increasingly important to understand their influence on the dynamics of atomic systems. I will show that, by invoking the priciple of duality, magnetic-magnetic type interactions can be traced back to known electric-electric type interactions. Finally, I will touch briefly upon the theory of Casimir-Polder force on moving atoms, commonly known as quantum friction.

Wednesday 3rd December, William Rubens (Imperial College London)Title: Qubits and Black HolesAbstract: We review apparent coincidences in the descriptions of certain black hole and qubits. We first look at the 3 qubit case and link that with the N=2 STU black hole, writing a dictionary between the charges of the black hole and the coefficients of the wavefunction. There are further coincidences linking a distillation protocol and the attractor mechanism. We look at a possible explanation of this consisting of identifying qubits with wrapped cycles, before going on to look at the N=8 generalisation that may be related to the three-way entanglement of seven qubits.
Friday 28th November, Mark Saunders (University of Durham)Title: Inertial sensing with cold atomsAbstract: We consider the resonant dynamics of a dilute atomic gas, falling under gravity through a periodically pulsed, sinusoidal standing-wave laser field. This atom-optical realisation of the quantum delta-kicked accelerator generalises our study into the effect of temperature upon quantum resonance and antiresonance [1].
We explore the transition between temperature extremes by investigating the evolution of the individual quasimomentum eigenstates. Tuning the acceleration experienced by the atoms reveals a rich structure of resonance phenomena [2], providing the prospect for precision measurement. [1] M. Saunders, P. L. Halkyard, K. J. Challis, and S. A. Gardiner
Manifestation of quantum resonances and antiresonances in finite-temperature dilute atomic gas,
Phys. Rev. A 76 43415 (2007).

[2] M. Saunders, P. L. Halkyard, S. A. Gardiner, and K. J. Challis,
Fractional resonances in the atom-optical delta-kicked accelerator,
arXiv:0806.3894 (2008).

Wednesday 26th November, David Tong (Cambridge)Title: Berry Phase and Supersymmetry Abstract: Non-Abelian Berry phases arise as one slowly varies the parameters of a quantum system with degenerate states. I will review this phenomenon and show how, using techniques from supersymmetry, the Berry phase can be computed for complicated quantum systems where the ground states themselves are not known. All of this will be illustrated with simple examples and pretty pictures.

Tuesday 25th November, Oscar Dahlsten (ETH Zürich)Title: Nonclassicality without entanglement enables bit commitment arXiv:0803.1264 Abstract: We investigate the existence of secure bit commitment protocols in the convex framework for probabilistic theories. The framework makes only minimal assumptions, and can be used to formalize quantum theory, classical probability theory, and a host of other possibilities. We prove that in all such theories that are locally non-classical but do not have entanglement, there exists a bit commitment protocol that is exponentially secure in the number of systems used.

Wednesday 19th November, Bob Coecke (Oxford)from 4pm, Mathematics Active Learning Lab 1 (MALL 1), Level 8 of School of Mathematics Title: TBAAbstract: TBA

Wednesday 12th November, Bahar Mehmani (Amsterdam)3-4, E C Stoner Seminar Room 8.62 Title: Non-Adiabatic cyclic evolution of a quantum system Abstract: When a quantum system adiabatically evolves in a cyclic way, its wave function acquires a phase factor, the so called Berry phase. It is a geometric phase which can be measured via interference. As a model we consider a quantum system coupled to two classical systems (work sources), where the couplings vary in a cyclic but non-adiabatic way. We investigate the corrections to the geometric phase due to the transitions to other energy levels. It is shown that in the near adiabatic regime, i.e., first order correction, the total extracted work in a cycle from the system is zero but there is a non-zero work transfer due to the non-adiabatic corrections to the geometric phase. This can be explained as the work of the geometric force exerted from the system on the sources. The second order non-adiabatic correction to the geometric phase makes it possible to extract work from the system in a cycle. The force exerted from the system on the work sources in this regime exhibits interesting features as well.

Wednesday 22nd October, Gavin Brennen (Sydney, Australia) Title: Nonlocality of Non-Abelions Abstract: Non-local correlations are a central theme in quantum mechanics and tell us that there exist states in the joint Hilbert space of two subsystems that have measurement outcomes not describable by local realism. There is another kind of non-locality arising from interactions amoung anyons which share a common topologically ordered medium. I will describe how the later concept can be understood and quantified in terms of the former via a Bell like inequality between measurements on disjoint regions of the medium.

Monday 6th October '08, Keith Burnett (University of Sheffield) Yorkshire Bank Lecture Theatre, Business School, 4-5pm Title: Quantum Fluctuations and Correlations in Cold Matter Abstract: IIt is now possible to study a wide range of many-body phenomena using evaporatively cooled atoms. Some of the most exciting developments are the new techniques for producing strongly correlated states, where quantum fluctuations dominate the behaviour of the atoms. Experimental groups around the world are working on ways to produce and probe these strongly correlated atomic assemblies. In my talk I will describe how strong quantum fluctuations arise and how they are related to correlation and entanglement in cold atom systems.

Monday 29th September '08, Konrad Banaszek (University of Torun)
Abstract: Prof. Banaszek's research concentrates on the development and characterisation of sources of non-classical radiation for quantum information processing applications. He studies the process of parametric down-conversion, in which input light spontaneously generates pairs of highly correlated photons. These photons can exhibit a specifically quantum form of correlations, called entanglement, which cannot be understood using intuitions from the classical world where the properties of an object are completely defined all at once. Applications of such photon pairs range from metrology and communication to quantum cryptography and beyond.

Wednesday 3rd September '08, David Joshua Tannor (Weizmann Institute, Israel) Title: Optimal control of laser cooling: A theory of purity increasing transformations Abstract: The powerful techniques of Optimal Control Theory (OCT), used in recent years to design laser pulse sequences to control chemical bond breaking, are applied to the problem of laser cooling in an open system. The result is a striking new mechanism in which spontaneous emission builds coherences between all the populated levels creating a pure state, only at the end of the process transferring the amplitude to the lowest energy state. This novel mechanism accelerates the cooling process by exploiting the cooling induced by spontaneous emission to all the electronic ground state levels, not just the lowest level. The mechanism suggests the calibration of cooling in terms of increasing purity of the system as measured by the quantity Tr(rho^2).The formulaton of cooling in terms of this coherence measure has an additional, interesting application: that our results carry over immediately to the problem of coherent control of quantum decoherence, suggesting both a new mechanism and fundamental limitations on the control of that process.

Thursday 22nd May '08, Ian McCulloch (University of Queensland)Title: The matrix product approach to computational many-body physics

Abstract: In recent years it has been realized that the successful Density Matrix Renormalization Group (DMRG) algorithm for one-dimensional many-body quantum groundstates, has a natural formulation as a variational calculation over the space of Matrix Product States (MPS). The MPS formulation has many advantages over the traditional approach, and I will give some examples of calculating real-time and frequency space dynamics in optical lattices, and using quantum information measures to probe quantum phase transitions. Friday 16th May '08, Martin Plenio (Imperial, London)

Title: Entanglement: From scaling laws to simulations

Abstract: I present various results on scaling laws of entanglement properties in quantum-many-body systems and explain what we can learn from them about the efficiency of certain methods for the classical description of quantum systems.
THURSDAY 1st May '08, Janet Anders (UCL, London)

Title: Measurement based classical computation

Abstract: In measurement-based computation the computation proceeds by adaptive single-qubit measurements on a multi-qubit entangled state, such as the cluster state. The adaptive measurements require a classical control computer which processes the previous measurement outcomes to determine the correct bases for the following measurement. Hence feeding the control computer with an appropriate resource state raises its computational power considerably, in the case of the cluster state it reaches quantum universality. The resources states fuelling such computational jump can in this sense be considered to possess a "computational power" themselves which is used by the control computer.

While impressive work has been done to classify entangled states that boost the power of any classical control computer to quantum universality, little is known about the reverse question. Given the simplest possible control computer, the CNOT computer, what are resources that can boost its computational power at all? Asking this way around leads naturally to the notion of measurement-based "classical computation" and I will shed light on this problem and finally derive minimal resource states needed for universal classical computation.

Reference: J. Anders and D.E. Browne, Measurement-based classical computation, on the arXiv very soon ...
WEDNESDAY 30th April '08, John Goold (Cork, Ireland)

Title: Quantum state engineering in low dimensional quantum gasesAbstract: Low -dimensional quantum gases have

rapidly evolved from a being a soley theoretical concept
towards being experimentally accesible systems in the laboratories. Small-scale trapping potentials for ultracold gases have allowed the creation of degenerate fermionic or bosonic gases. Rapid experimental advances have paved the way to explore the exciting area of strongly correlated low-dimensional systems. Optical lattice techniques produce tightly confining potentials in selective directions and using Feshbach resonaces one can control and 'play with' the interaction part of the system's Hamiltonian. This presentation serves as a broad introduction to the theory of bosonic one dimensional quantum gases, described by the integrable Lieb-Liniger model. The conceptually simplistic yet instructive problem of two atoms interacting in a delta split harmonic is solved and results concerning the basic physics displayed*. I will then turn my attention to a rare example of an exactly solvable many-body problem namley the Tonks-Girardeau gas – a strongly correlated system. Through displaying calculations of one body density matrices, momentum distributions and interference simulations I will discuss interesting results concerning the spatial coherence of such a gas in a split trap**. The talk will be concluded by outlining some future plans to measure entanglement in one-dimensional quantum gases and how we might relate it to spatial coherence. References:

*.Boson pairs in a one-dimensional split trap
D. S. Murphy, J. F. McCann, J. Goold, and Th. Busch, Phys. Rev. A 76, 053616 (2007).
..Ground State Properties of a Tonks-Girardeau Gas in a Split Trap
J.Goold and Th. Busch, arXiv:0803.0846 (To appear in PRA).

THURSDAY 13th March '08, William Matthews (Bristol)

Title: PPT pure state transformations and catalysis

Abstract: In an effort to better understand the class of operations on a bipartite system which preserve positivity of partial transpose (PPT operations), we have investigated the (non-asymptotic) transformation of pure states to pure states by operations in this class. Under local operations and classical communication (LOCC) Nielsen's majorization criterion provides a necessary and sufficient condition for such a transformation. This can be used to show that under LOCC a phenomenon called catalysis can occur, where an otherwise impossible transformation can be made possible by the provision of an entangled catalyst state, which must be recovered unchanged after the transformation (hence the name). I will present some recent work where we have found a necessary condition for obtaining a given pure state from a maximally entangled state via PPT operations. This condition is conjectured to be sufficient also, and we can prove this for the case where the goal state has Schmidt rank three. We have also shown that catalysis occurs under PPT operations, and have derived a necessary and sufficient condition for PPT pure state transformations where both the initial state and the catalyst are maximally entangled.

Wed 12th March '08, Dmitry Shalashilin (Leeds)

Title: Multidimensional quantum simulations with Coupled Coherent States

Abstract: The method of Coupled Coherent States (CCS) [1-7] is a technique for direct numerical simulation of quantum many-body problems, which avoids exponential scaling of basis set with dimensionality and therefore allows exact fully quantum treatment of systems comprised of a large number of degrees of freedom. The method is based on a solution of multidimensional Schrödinger equation in the basis of trajectory guided Monte Carlo sampled coherent states. The evolution of the wave function is simulated by running an ensemble of classical trajectories of coherent states together with a system of coupled quantum equations for the coherent states amplitudes. A new feature of our approach in comparison with similar techniques [8.9] is that it uses quantum averaged potentials for running classical trajectories. This efficiently takes into account local zero point energy and results in a number of cancellations in working equations. The method is fully quantum, however, classical mechanics helps to remove quantum oscillation and to decrease coupling, which is essential for making Monte Carlo sampling work. CCS is efficient only together with importance sampling. A systematic review of various ways to sample the initial conditions of Coherent State basis set will be presented.
A number of applications to the spectroscopy of polyatomic molecules and small clusters, intramolecular vibrational energy redistribution and proton tunneling have been reported, in which a large (in the order of 10 or 20) number quantum degrees of freedom have been treated on a fully quantum level. Recently we applied the approach also to simulations of electron dynamics in strong laser field.

[1] D.V. Shalashilin, M.S. Child, J.Chem.Phys., 113, 10028, 2000.
[2] D.V. Shalashilin, M.S. Child, J.Chem.Phys., 114, 9296, 2001.
[3] D.V. Shalashilin, M.S. Child, J.Chem.Phys., 115, 5367, 2001.
[4] D.V. Shalashilin, M.S. Child, J.Chem.Phys., 119, 1961, 2003.
[5] D.V. Shalashilin, M.S. Child, D.C. Clary, J.Chem.Phys., 120, 5608, 2004.
[6] D.V. Shalashilin, M.S. Child, Chem.Phys., 304, 103, 2004.
[7] P.A.J. Sherratt, D.V. Shalashilin, M.S. Child, Chem.Phys., 322, 135 2006.
[8] M. Ben-Nun and T. J. Martinez in Adv.Chem.Phys., 121., 439, ed. I.Prigogine and S.A.Rice (John Wiley & Sons, Inc.

2002).
[9] G.A.Worth, I.Burghardt, Chem.Phys.Lett. 368, 502 (2003).

Wed 5th March '08, Alexander Klein (Oxford)

14:00, E C Stoner SR (8.90)

Title: Optical Lattices in Bose-Einstein Condensates: Polarons, Clustering, and Dephasing

Abstract: Atoms in an optical lattice are a very versatile system to investigate solid state phenomena. However, due to the nature of the trapping potential, the optical lattice does not exhibit phonons, which are an important part in condensed matter theory. We investigate the effects of a Bose-Einstein condensate (BEC) on the properties of immersed impurity atoms that are trapped in an optical lattice. We show that the impurities couple to the BEC phonons and that they are readily described in terms of polarons, i.e., atoms dressed by phonon clouds. This changes the transport properties of the atoms considerably, leading to a cross-over from coherent to diffusive. The loss of coherence is also observed in a quantum master equation approach, which gives direct access to the off-diagonal elements of the density matrix. Furthermore, the phonon coupling leads to the occurrence of a net current in a tilted optical lattice, which would otherwise be suppressed due to Bloch oscillations. Apart from these single-particle properties, the BEC also mediates an attractive off-site interaction between the impurities, which enables the formation of stable clusters. The signature of these clusters is visible in the density distribution and in time of flight expansions. FRIDAY 29th Feb '08, Richard Low (Bristol, CS)

Title: Random Quantum Circuits are Approximate 2-designs

Abstract: We ask the question: how long does it take for a random quantum circuit to approach a uniformly random unitary? This is of physical importance because it is related to the question of entanglement growth in a randomly interacting system. It is of algorithmic interest because constructing uniformly random unitaries is exponentially hard in the number of qubits but for many purposes only pseudo random unitaries are required. We partially answer the question by considering the convergence of the moments of the distribution and we prove tight bounds for the first and second moments for a large class of random circuits. As a corollary of our main result, we improve previous bounds on the convergence rate of random walks on the Cliord group. This is joint work with Aram Harrow.

Wed 27th Feb '08, Tim Freegarde (Southampton)

Title: New optical methods of cooling and manipulating atoms and molecules

Abstract: The remarkable recent advances that have exploited laser cooling to generate ultracold and quantum coherent atoms have been limited to just a small handful of atomic elements. Broader application to other atoms and to molecules will require optical cooling schemes that are more tolerant of, and less reliant upon, the spontaneous emission that conventionally accompanies each useful photon impulse.
I shall describe a number of such schemes, some now being investigated experimentally, that use optical modulators and nanostructured surfaces to generate temporally modulated scattering forces and spatially varying dipole forces respectively. The design and underlying principles of these practical mechanisms, of potential application to a wide range of atomic and molecular species, link them to phenomena as disparate as quantum computation and the Casimir-Polder effect.
I shall also outline how the macroscopic pumps, vacuum chambers, atomic sources and optics that comprise current experimental apparatus can be miniaturized into an integrated, self-contained chip-scale device.

Wed 13th Feb '08, Jens Eisert (Imperial College London)

Title: The computational power of quantum states, or: Novel schemes for measurement-based quantum computation

Abstract: We establish a framework which allows one to construct a plethora of novel schemes for measurement-based quantum computation, based on local measurements on entangled resource states. The technique further develops tools from many-body physics - based on finitely correlated or projected entangled pair states - to go beyond the cluster-state based one-way computer. This work hence constitutes an instance where a quantum information problem - how to realize quantum computation - was approached using tools from many-body theory and not vice versa.
We identify resource states that are in several ways quite radically different from the cluster state. Notably, we find a great flexibility in the properties of the universal resource states: They may for example exhibit non-vanishing long-range correlation functions or be locally arbitrarily close to a pure state. Certain ground states server as universal resources. We discuss variants of Kitaev's toric code states, which are states with non-trivial topological properties, as universal resources, and contrast this with situations where they can be efficiently classically simulated. This framework opens up a way of thinking of tailoring resource states to specific physical systems.

[1] D. Gross and J. Eisert, Phys. Rev. Lett. 98, 220503 (2007).
[2] D. Gross, J. Eisert, N. Schuch, and D. Perez-Garcia, Phys. Rev. A 76, 052315 (2007).
[3] D. Gross and J. Eisert, in preparation (2008).

Thursday 7th Feb '08, Luigi Amico (Catania, Italy)

Title: Entanglement in many body systems

Abstract: The recent interest in aspects common to quantum information and condensed matter has prompted a prosperous activity at the border of these disciplines that were far distant until few years ago. Numerous interesting questions have been addressed so far. Here I review the properties of the entanglement in many-body systems. I will be discussing the zero and finite temperature properties of entanglement, by focusing on spin lattice models. Both bipartite and multipartite entanglement will be considered. At equilibrium we emphasize on how entanglement is connected to the phase diagram of the underlying model. The behavior of entanglement can be related, via certain witnesses, to thermodynamic quantities thus offering interesting possibilities for an experimental test. Out of equilibrium entangled states can be generated and manipulated by means of many-body Hamiltonians.

Fri 25th Jan '08, David Hutchinson (Otago, New Zealand; Paris, France)

Title: Effects of Disorder in Ultra-cold, dilute gases

Abstract: The possibility of using ultracold atoms to observe strong localization of matter waves is now a subject of both theoretical and experimental interest. These systems offer unprecedented control over inter-particle interactions, imposed potentials and the level of disorder in the system as compared to their condensed matter analogues. The two-dimensional (2D) case is of particular interest. The prevailing view has been that in the 2D 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, review the experimental position in the field in the dilute 2D gas and discuss potential future experiments.

Wed 23th Jan '08, Pepijn Pinkse (MPQ Garching, Germany)

Title:Cavity Quantum Electrodynamics and Cold Polar Molecules

Abstract:A single atom coupled to a single mode of the optical field represents an archetype of matter-light interaction and is a textbook example of cavity-quantum electrodynamics (cavity QED). In the cavity, the matter-light interaction is enhanced to the extent that a single neutral atom can change the transmission of the cavity completely, allowing fast and non-destructive single-atom detection. Simultaneously, a single photon can saturate an atomic transition many times. Hence single quanta of light and matter interact strongly, forming a new quantum entity. As a consequence, light forces are altered by the presence of the cavity. These forces can be exploited to tame the motion of the atoms interacting with the cavity field, allowing single atoms to be trapped in the cavity. These forces can be used to cool down the motion of the atom. We were able to demonstrate “cavity cooling” for the first time. This dissipative cooling method, remarkably, does not rely on spontaneous emission. Hence it can, in principle, be used for particles lacking closed transitions, such as molecules.

The second part of this talk reports about experiments with cold polar molecules, which have raised interest in various research fields such as chemistry, metrology, molecular physics and quantum information processing. Velocity filtering of polar molecules is introduced as a technique to produce a beam of cold polar molecules. The beam is guided by exploiting the Stark shift of the polar molecules in electrostatic or in switched electric fields. Building on the developed techniques, it was possible to demonstrate trapping of neutral molecules and atoms in purely electric traps. Whereas the motional temperature of the molecules in the trap can be below 1 K, the internal motion of the molecules is hotter, because many rotational states contribute to the flux. In order to measure their distribution, an optical method is developed confirming theoretical predictions. We expect to narrow down the state distribution by a technique in which molecules are cooled by a cryogenic helium buffer gas. Finally, cavity cooling is investigated theoretically for further cooling the external as well as the internal motion of the molecules, coming full circle to cavity QED.

Thur 17th Jan '08, Susana Huelga (Hertfordshire)

Title:Stochastic Resonance effects in composite systems

Abstract:I will discuss the phenomenon of stochastic resonance (SR), a paradigm of the counter intuitive effects noise may have, in driven coupled quantum systems. I will construct dynamical and information theoretic measures of the system's response that exhibit a non-monotonic behaviour as a function of the noise strength and analyze the relation between lack of monotonicity in the response and the presence of quantum correlations and identify parameter regimes where the breakdown of a linear response can be linked to the presence of entanglement. I will also show that a chain of coupled spin systems can exhibit an array-enhanced response, where the sensitivity of a single resonator is enhanced as a result of nearest-neighbour coupling. These results enlarge the domain where SR effects exist and should be observable in a variety of qubit realizations, such as arrays of superconducting qubits.

Wed 12th Dec '07, Erika Anderson (Strathclyde)

Title: Efficient realisation of generalised quantum measurements

Abstract: Generalised quantum measurements (POMs or POVMs), which go beyond standard von Neumann projective measurements, are an essential part of many protocols in quantum information science, including state identification, state estimation and quantum cryptography. It is therefore important to find efficient means of experimentally implementing these non-trivial measurement schemes. The "standard" realisation of a generalised measurement requires an ancillary quantum system, sometimes with many dimensions, and quantum operations coupling the original system plus the ancilla. Recently, a method of performing generalised measurements using repeated projective measurements was proposed [1]. It was shown that an arbitrary generalised quantum measurement could be realised by adding a single auxiliary state to the original system and performing successive projective measurements on this enlarged system. I will explain the method and give a possible experimental implementation using photons or atomic qubits. A potential drawback with the method is the number of iterations required to complete the measurement. We have therefore investigated a way to reduce the number of projective measurements required, leading to a "binary search tree" of measurements. This latter way of realising generalised quantum measurements could be used e.g. for probing the state of a cavity field by sending an atom through it and measuring the atom.

[1] Realization of positive-operator-valued measures by projective measurements without introducing ancillary dimensions, Guoming Wang and Mingsheng Ying, quant-ph/0608235.

Wed 28th Nov '07, Myungshik Kim (Belfast)

Title: Addition and subtraction of a single photon

Abstract: A photon is the unit of light particles. We now have technology to add and subtract a single photon in a light field. In this talk, we review the foundations of addition and subtraction of a photon before we show how to implement such the operations. We then show an interesting result of non-commutativity between photon subtraction and addition. We show how these techniques can be used for quantum-state engineering of light fields.

Tue 20th Nov '07, Elisabeth Rieper (Braunschweig)

Title: Do npt bound entangled states exist?

Abstract: It is known that positive partial transpose (ppt) bipartite entangled states are not distillable, that means there exist no local operations on these states such that the resulting output state is maximally entangled. Therefore the amount of entanglement of ppt states is bounded. It is an open conjecture that negative partial transpose (npt) states exist. In the talk, I will give a short introduction to the key concepts like the ppt criterion, entanglement distillation and bound entanglement. Then I will present an example of a distillation protocol designed to study the destillation properties of a class of highly symmetric states, called Werner states, which are supposed to be npt bound entanglement for a certain parameter range.

FRIDAY 16th Nov '07, Damien Markham (Paris)

Title: Graph States for Quantum Secret Sharing

Abstract: We show that graph states are an excellent resource for both classical and quantum secret sharing for either classical or quantum channels between players and with or without eavesdropping, in the cases that either the threshold condition for secret sharing is that all~n players collaborate or in the special cases that at least three collaborate for a total number of players being either $n=4$ or $n=5$. Our graph state approach unifies disparate quantum secret sharing schemes in certain cases and provides an elegance insofar as the secret sharing capabilities emerge naturally from a few properties of the associated graphs, which we prove here.

Wed 14th Nov '07, Mete Atature (Cambridge)

Title: Quantum Optics with Quantum Dot Spins

Abstract: Self-assembled semiconductor quantum dots (QDs) have atom-like properties such as discrete energy levels coupled by optical transitions, and their coherence properties can be revealed in quantum-optics experiments. Further, these transitions are governed by spin-dependent optical selection rules. This opens an access channel to single spins in a quantum dot via lasers. This has been the driving motivation for the development of numerous proposals for quantum information processing with quantum spins and cavity quantum electrodynamics (QED). However, QDs are not isolated systems and can also interact strongly with a spin (nuclei) and a charge (electrons) reservoir of the solid-state environment leading to a rich source of interaction mechanisms. Consequently, identifying the regimes of these mechanisms is crucial for achieving a level of control in solid-state-based systems similar to that of atoms. I will provide a highlight of recent progress on all-optical control of single and coupled quantum dot spins along with the current research directions in coherent light-matter interactions.

Tue 6th Nov '07, Joost Slingerland (Dublin)

Title: Interferometry with non-Abelian anyons

Abstract: After a short introduction to topological phases and their application to topologically protected quantum computation, I will talk about proposed interferometric experiments in fractional quantum Hall systems which should provide strong evidence for the presence of quasiparticles with non-Abelian exchange statistics in those systems. Anyonic interferometry will also allow for measurement of the topological charges of clusters anyons, an important ingredient in topological quantum computers. I will describe this measurement process and the decoherence of topological charge which results from it.

Wed 31th Oct '07, Karoline Wiesner (Bristol)

Title: Intrinsic quantum computation

Abstract: How are computing, information creation, and dynamics related? A contemporary view of these three historical threads is that they are not so disparate. I will show that a synthesis leads to methods to analyze how quantum processes store and manipulate information - what we refer to as "intrinsic quantum computation". I will introduce ways to measure information storage in quantum dynamics, using a recently introduced computation-theoretic model that accounts for measurement effects. The first, the entropy rate, quantifies the amount of inherent randomness in a process. The second, the excess entropy, quantifies the shared information between a quantum process's past and its future.

Wed 24th Oct '07, Sofyan Iblisdir (Barcelona)

Title: The toric code at finite temperature

Abstract: The toric code is a two-dimensional spin model defined on a lattice. This model has a spectrum that is both rich and simple: it features anyonic excitations and is exactly solvable. It has also attracted much attention as a candidate for a quantum memory. In the first part of the talk, the main properties of this model will be reviewed. Then, we will introduce the concept of topological entropy of entanglement, and show how it can be used to study the robustness of the model in presence of temperature.

Wed 17th Oct '07, Michael Trupke (London)

Title: Towards QIP on atom chips

Fri 27th July '07, Colin Benjamin (Marseille)Title:Controllable pi junction in a Josephson quantum-dot device with molecular spin

Abstract: We consider a model for a single molecule with a large frozen spin sandwiched in between two BCS superconductors at equilibrium, and show that this system has a π junction behavior at low temperature. The π shift can be reversed by varying the other parameters of the system, e.g., temperature or the position of the quantum dot level, implying a controllable π junction with novel application as a Josephson current switch. We show that the mechanism leading to the π shift can be explained simply in terms of the contributions of the Andreev bound states and of the continuum of states above the superconducting gap. The free energy for certain configuration of parameters shows a bistable nature, which is a necessary pre-condition for achievement of a qubit.

Thurs 26th July '07, Roger Colbeck (Cambridge)Title:Expanding a Private Random String with Untrusted Quantum Devices

Abstract: In cryptography, it is common to assume that each party trusts completely the operation of their devices. In this talk, we will consider what is achievable if this assumption is dropped. Instead, we assume that all quantum devices must be sourced from a potentially malicious supplier. I will describe a protocol for expansion of an initial private random string, under any attack by the supplier consistent with the laws of quantum theory. Security is ensured by verifying the violation of a Bell-like quantity.

5th July '07, Giovanni Mazzarrella

Title: Atomic physics, quantum phase transitions, and statiscal mechanics in ptical lattices.

Abstract: In this talk, I am displaying some reults about bosonic atomic gases rapped by external magnetic potentials and confined in one-dimensional eriodical geometries.

First, I am showing how the external trapping potentials affects the phase diagram of bosonic atoms in one-dimensional optical lattices. In articular, I am introducing a generalized Bose-Hubbard Hamiltonian ncluding the structure of the energy levels of the trapping potential, and I am showing that these levels are in general populated both at finite and zero temperature. Finally, I am characterizing the properties of the superfluid transition, by stressing that the excited levels of the external potential take part to the superfluid phase.

Second, I am deriving an Extended Bose Hubbard (EBH) model by developing a systematic expansion of the Hamiltonian of the system in powers of the lattice parameters, by identifying the dominant terms up to the nearest-neighbor interactions and nearest-neighbor hoppings conditioned by the on-site occupation numbers. I am displaying the phase diagrams of the system both at zero and at finite temperature, by stressing that at zero temperature a dual strucucture characterizes the Mott insulating regime. Finally, I am commenting that in the EBH model, a zero temperature quantum phase transition to pair superfluidity is, in principle, possible, but it is completely suppressed at the lowest order of the above expansion.

29th June '07, Prof. Dr. Dr. h.c. Klaas Bergmann, (Fachbereich Physik der Universität Kaiserslautern - Germany) Title: Controlled preparation and detection of coherent superpositions of degenerate quantum states

Abstract: After the discussion of some basis features of the STIRAP-method, it will be explained how the technique can be used to generate a controlled superposition of degenerate quantum states with freely chosen relative amplitudes and phases. Furthermore, methods suitable for experimentally determining amplitudes and phase of such a coherent superposition, will be presented.

30th May '07, Karl Tordrup, (Aarhus, Denmark and Leeds).Title:Quantum Computing with Rare-Earth-Ion-Doped CrystalsAbstract: We present an implementation of Quantum Computing using rare-earth-ion-doped solids. In this realisation, qubits are encoded in hyperfine levels of the rare-earth-ion dopants and may be addressed via electronic excited states using optical fields. Due to large broadening of the optical transitions, different qubits may be defined as ensembles of ions with almost identical transition frequencies. We will demonstrate how frequency-chirped pulses may be used in tandem with phase-compensating pulses to overcome inhomogeneities in the ensembles when performing single-qubit rotations. Furthermore, by making use of the dipole blockade effect to control qubit interactions we can implement a fully entangling controlled phase gate.

25th May '07, Giovanni Vacanti, (Palermo, Italy).

Title: Entanglement generation in optomechanical system by means of radiation pressure

Abstract: We present a scheme for generating entanglement between two micromechanical oscillators which have never interacted with each other by using an entanglement swapping protocol. The system under study is a Michelson-Morley interferometer in which the mirror at the end of each arm is a tiny cantilever able to oscillate around its equilibrium position. Each cantilever is coupled to a field mode of the corresponding cavity via radiation pressure. Entanglement between the two cantilevers can be generated through a measurement on the output of the interferometer. Both the unitary and the non-unitary evolution cases are investigated.

Thursday 24th May '07, Elica Kioseva, (Sofia, Bulgaria).

Title: Physical realization of coupled Hilbert-space mirrors for quantum-state engineering

Abstract: Manipulation of superpositions of discrete quantum states has a mathematical counterpart in the motion of a unit-length statevector in an N-dimensional Hilbert space. Any such statevector motion can be regarded as a succession of two-dimensional rotations. But the desired statevector change can also be treated as a succession of reflections, the generalization of Householder transformations. In multidimensional Hilbert space such reflection sequences offer more efficient procedures for statevector manipulation than do sequences of rotations. We here show how such reflections can be designed for a system with two degenerate levels -- a generalization of the traditional two-state atom -- that allows the construction of propagators for angular momentum states. We use the Morris-Shore transformation to express the propagator in terms of Morris-Shore basis states and Cayley-Klein parameters, which allows us to connect properties of laser pulses to Hilbert-space motion. Under suitable conditions on the couplings and the common detuning, the propagators within each set of degenerate states represent products of generalized Householder reflections, with orthogonal vectors. We propose physical realizations of this novel geometrical object with resonant, near-resonant and far-off-resonant laser pulses. We give several examples of implementations in real atoms or molecules.

Wednesday 23rd May '07, Clare Hewitt-Horsmann, (University College London, UK).Title: Explaining the quantum speed-up using a many-worlds interpretation,
or: How to build a classical computer

Abstract: Quantum computers can do many things that classical computers cannot, but no-one really knows why. In this talk I will present a physical picture of quantum computing, based on a type of many-worlds interpretation of quantum mechanics. In this picture the speed-up of quantum vs classical computation can be explained in a surprising way. The picture also gives us a new understanding of how quantum and classical resources are interchangable, and puts classical computation and communication protocols in their rightful places as subsets of their quantum counterparts.

Monday 14th May '07, Michael Fleischauer (Technical University of Kaiserslautern)

Title: Light induced Abelian and non-Abelian gauge potentials for ultra-cold atoms

Wednesday 6th December '06, Janet Anders (National University of Singapore)

Title: Thermal entanglement in a harmonic chain

Abstract: In my talk I want to summarise the knowledge we have about the entanglement of linear chains in thermal equilibrium states. Such a chain can be, for instance, a line of traps each holding a single ion. The ions shall couple harmonically to their nearest neighbours only. To reach conclusions about the entanglement in the chain, I will shortly review the diagonalisation of the Hamiltonian into phonon modes, discuss the possible phonon spectra and their dependence on the trapping potentials, explain a little bit about continuous variable states as opposed to qubit states and find violation of uncertainty relations if we treat an upcoming Goldstone boson in a wrong manner. I will show you that entanglement exists between nearest neighbours if the temperature is tuned below a certain critical temperature which varies with the trapping potential. At the end of this journey I want to discuss with you about the physical interpretation of this critical temperature and talk a bit of the establishment of Long Range Order in 3D. I hope to learn from you what system is experimentally available or desirable and how we could swap entanglement.

Wednesday 29th November '06, Charles H.-T. Wang (University of Aberdeen, King's College, UK)

Title: Probing quantum gravity using matter wave interferometry

Abstract: One of the biggest unsolved problems in physics is the unification of quantum mechanics and general relativity. The lack of experimental guidance has made the issue extremely evasive, though various attempts have been made to relate the loss of matter wave coherence to quantum spacetime fluctuations. We present a new approach to the gravitational decoherence near the Planck scale, made possible by the recently discovered conformal structure of canonical gravity. This leads to a gravitational analogue of Brownian motion whose correlation length is given by the Planck length up to a scaling factor. With input from recent matter wave experiments, we show the minimum value of this factor to be well within the expected range for quantum gravity theories. This suggests that the sensitivities of advanced matter wave interferometers may be approaching the fundamental level due to quantum spacetime fluctuations, and that investigating Planck scale physics using matter wave interferometry may become a reality in the near future. Ref: C.

Wang, R. Bingham, T. Mendonca 2006, Class. Quantum Grav. 23 L59-L65

Friday 24th November '06, Akimasa Miyake (University of Innsbruck, Austria)

Title: Universal entanglement resources for measurement-based quantum computation

Abstract: I talk about which entanglement resources allow universal measurement-based quantum computation via LOCC, i.e., in an extended framework of the one-way quantum computation endowed with the cluster states. We introduce several entanglement criteria which should be satisfied for any universal resource, and show new examples of universal resources, including encoded resources which may make physical implementations easier. The talk is based on Phys. Rev. Lett. 97, 150504 (2006), and our recent progress on the topic.

Thursday 23rd November '06, Rob Spekkens (University of Cambridge, UK)

Title: Quantum coherence: fact or fiction?

Abstract: A controversy that has arisen many times over in disparate contexts is whether quantum coherences between eigenstates of additively conserved quantities are fact or fiction. I present a pedagogical introduction to the debate in the form of a hypothetical dialogue between proponents from each of the two camps: a factist and a fictionist. It is argued that a resolution of the debate can be achieved by recognizing that quantum states do not only contain information about the intrinsic properties of a system but about its extrinsic properties as well, that is, about its relation to other systems external to it. Specifically, the coherent quantum state of the factist is the appropriate description of the relation of the system to one reference frame, while the incoherent quantum state of the fictionist is the appropriate description of the relation of the system to another, uncorrelated, reference frame. The two views are alternative but equally valid paradigms of description. This conclusion has implications for a variety of conceptual puzzles including whether synchronized clocks and aligned Cartesian frames are a source of entanglement (generally, they are not), whether a single particle can exhibit Bell correlations (it can), and whether it is possible to lift superselection rules (it is, and we propose an experiment to demonstrate this for atom number).

Wednesday 8th November '06, Stefan Eriksson (Imperial College London, UK) Title: Atom Chips Abstract: I will describe our work on atom chips at the Centre for Cold Matter at Imperial College. Atom chips allow trapping, manipulation and detection of ultra-cold neutral atoms near microstructured surfaces. Complex atomic circuits can be integrated on an atom chip using techniques derived from conventional electronic microchip fabrication. Because the trapped atoms interact weakly with the environment coherence times of prepared states can be exceedingly long. These properties make atom chips ideal for novel quantum physics experiments. Many of the well known experiments with ultra-cold atoms such as the production of Bose and Fermi degenerate gases have recently also been realised on atom chips. These achievements are the first steps towards miniaturisation of atom optics and the creation of small quantum devices based on neutral atoms. The tight confinement of atoms in the chip-traps together with tailored internal state dependent potentials opens up entirely new avenues to explore. Experiments pursued in our group include single mode matter wave guiding and atom interferometry, and the production quantum gases in low dimensions. We are also investigating scenarios to scale up the number of traps on the chip as well as ways of integrating arrays of micro-traps with micro-optics for single atom detection. The high finesse and small mode volume of our atom chip microcavities enables cavity-QED experiments with possible applications to quantum information processing.

Wednesday 1st November '06, Bruno Sanguinetti (QI, Leeds) Title: Measuring the state of the Micromaser cavity fieldAbstract: The Micromaser is an experiment where microwave photons are kept inside a cavity, which isolates them from the environment by virtue of its high quality factor and low temperature. We can then interact with the field inside the cavity in a controlled way by passing single atoms trough the cavity. This scheme provides a quantum system that is very well understood and can be used as the basis for a wealth of quantum mechanical experiments, which depend on creating and measuring particular quantum states. After a quick introduction to the Micromaser I will talk about the method that will be used to measure the state of the cavity field, illustrating with a quantum Monte Carlo simulation.
 Wednesday 25th October '06, Ben Varco (QI, Leeds)Abstract: Research involving the basic tools of quantum information – qubits and quantum memory - is teaching us more about the nature of quantum mechanical interactions than we have ever known. However as the nature of the interactions between quantum space time and matter are becoming better defined, we have recently shown that in fact quantum information experiments can also teach us about the nature of quantum gravity. The next generation of experiments that search for the theory of everything could well be table top quantum information experiments. I will talk about some experiments that we are doing in this area.

Wednesday 18th October '06, Matthew Leifer (Perimeter Institute, Canada) Title: Cloning and broadcasting in generalized probabilistic theoriesAbstract: Motivated by the question of what lies behind the information processing abilities of quantum theory, several authors, including Barrett and Spekkens, have begun to investigate information theoretic phenomena in more general probabilistic frameworks. Others, such as Hardy and d'Ariano, have proposed novel axiomatizations of quantum theory that operate within similar frameworks. Barrett's framework is essentially the finite dimensional special case of a much older framework first proposed by Mackey in the 1950s, and later developed by Ludwig, Foulis and Randall, Bugajski, Holevo and others. This framework supports states from which "super-quantum" correlations may be obtained, which violate Bell inequalities to a larger extent than allowed by quantum theory, without permitting signaling. In this talk, I will give generic analogs of the no-cloning and no-broadcasting theorems that apply to all theories within this framework. The proof of the no-broadcasting theorem thus obtained is conceptually simpler than any of the proofs for the purely quantum case available to date. This talk is based on joint work with Howard Barnum, Jon Barrett and Alex Wilce.

Wednesday 11th October '06, William Hall (University of York, UK)Title: Compatibility of subsystem states and convex geometry Abstract: The subsystem compatibility problem, which concerns the question of whether a set of subsystem states of a multipartite quantum system are compatible with a state of the entire system, has received much study. Here we attack the problem from a new angle, utilising the ideas of convexity that have been successfully employed against the separability problem. Analogously to an entanglement witness, we introduce the idea of a compatibility witness. We also consider the use of convex programming techniques, and we show that the compatibility problem can be solved numerically and efficiently using these techniques. Finally, we will see how these techniques can be used to gain some analytical insights about the problem.

Monday 25th September '06, Johannes Kofler (University of Vienna, Austria) Title: Classical world because of quantum phyicsAbstract: We present a novel theoretical approach to macroscopic realism and classical physics within quantum theory and which is conceptually different from the decoherence program. It puts the stress on the limits of observability of quantum effects of macroscopic objects, i.e., on the required precision of our measurement apparatuses such that quantum effects can still be observed. First, we demonstrate that for unrestricted measurement accuracy a violation of macrorealism is possible for arbitrary large systems. Then we show that, given the restriction of coarse-grained measurement resolution, not only macrorealism becomes valid but even the classical (Newtonian) laws emerge out of a quantum (Schrordinger) time evolution and the projection postulate. Classical physics can thus be seen as implied by quantum mechanics under the restriction of fuzzy measurements."

Thursday 14th September '06, Damian Markham, (University of Tokyo, Japan) Title: "Multiparty Entanglement in Quantum Information"Abstract: I will give an overview of various recent results we have on multipartite entanglement, and how genuine multiparty entanglement may be used in quantum information processing in a way beyond bipartite entanglement. Recently we have been able to quantify entanglement for many interesting classes of multiparty pure and mixed states, including cluster states useful for quantum computation and error correction. These methods are intimately related to entanglement witnesses, which have recently allowed bounds to these quantities to be measured in experiment. This connection also allows us to give general conditions for entanglement for any thermal states, with possilbe applications for investigations of entanglement in manybody large quantum systems. We have also been able to show that these quantities can have an operational meaning in terms of LOCC information access, allowing many possible new applications to QIT.

Monday 15th May '06, Professor Sam Braunstein, (University of York, UK).Title: "Bob and the black hole: a one-sided perspective"Abstract: Relevant Paper: "gr-qc/0603046"

Tuesday 9th May '06, Professor Andrew Briggs, (Professor of Nanomaterials, Director of the Quantum Information Processing IRC, Department of Materials University of Oxford). Title: "Spin qubits in carbon nanomaterials"Abstract: Of the many schemes proposed for quantum computing, most of those in the solid state use nanostructures in which there are well-defined states with long coherence times. Candidates include a variety of carbon nanomaterials, in which the qubit can be embodied in excitons or electric charge or spin. It may be that more than one of these should be used, and a recent scheme uses excitons to control the interaction between single electron spins in adjacent regions of quantum confinement. Such schemes can also be applied to compound semiconductor nanomaterials. The endohedral fullerenes are a versatile family of molecular materials, whose electron spin distributions are becoming well characterized and understood, and whose chemistry can be controlled. Endohedral fullerenes have been demonstrated to have spin coherence times of up to 0.25 ms. The electron spin in N@C60 can be manipulated with exquisite precision, using pulse sequences borrowed from NMR. A qubit on the nuclear spin can be manipulated with a fast phase gate, and can be decoupled from the environment by trapping it in closed cycles on the Block sphere. Molecularly self-assembling materials offer the potential of reproducibility without requiring individual tuning. One-dimensional arrays can be formed in single-walled carbon nanotubes; these can provide both structural support and controlled interactions, and their electronic structure can be externally modulate. The challenge of addressing large numbers of qubits in such tiny structures may seem insuperable, but that may not be necessary. Schemes that use global addressing of classes of qubits simultaneously have been demonstrated theoretically to be adequate for universal quantum computing. It is still too early to say which, if any, of the competing technologies will eventually be used to build a quantum computer, and there is plenty of scope for evaluating the properties of carbon nanomaterials.

2nd May '06, Bruce W. Shore (Visiting Scientist, Technical University of Kaiserslautern).Title: Coherent Manipulation of Atomic ExcitationAbstract: Lasers have become ubiquitous devices, not only in mechanisms that surround us in our daily lives but also as essential laboratory tools throughout the disciplines of physical and biological sciences. For many of these purposes it is only the near-monochromatic properties, or the directional properties, that are used. But the coherence properties -- not envisioned by laser pioneers -- have become increasingly valuable. I will discuss laser coherence as it is used for producing, in individual atoms or molecules, various manipulations of the internal structures that, according to quantum theory, underly the properties of such microscopic entities. Whereas the first exploitation of coherence aimed simply to produce excitation of preselected quantum states (a technique of interest in studies of chemical reaction dynamics and analytical chemistry), more recent interest has centered on creating coherent superpositions -- a purely quantum mechanical notion that has application in such newly emerging technologies as quantum information processing.

26th April '06, Sir Peter Knight (Imperial College London, UK).Title: Quantum Optics and the 2005 Nobel Prizes.

29th March '06, William D. Phillips, (NIST Gaithersburg, Distinguished Professor, University of Maryland, 1997 Nobel Laureate in Physics).Title: Atom optics with Bose-Einstein condensates 22nd March '06, Dr Marcelo Terra Cunha (QIS, University of Leeds).Title: On Entangled Fermions and on Geometric Phase TransitionsAbstract: In this seminar I plan to talk on two themes. The first is about how to extract entanglement by taking a pair of fermions from a Fermi sea, and also the role of symmetry in this process. The second, which we call a Geometric Phase Transition, is related to singular behaviours of entanglement quantifiers when a quantum state of a composed system varies smoothly.

15th March '06, Mahboubeh Asgari-Targhi (University College London, UK).Title: Braid Theory and Its Application.Abstract: Braid theory is a relatively young field with many opportunities for discovey and exploration for mathematicians. In my talk, I shall first describe the braid theory, then I shall discuss as how it can be employed to model topologically complex systems such as magnetic fields in the solar corona and the DNA cells.

8th March '06, Prof. Ian Lawrie, (University of Leeds, UK).Title: Phase Transitions In The Early Universe And Elsewhere.Abstract: We currently have no abstract for this talk. For Prof. Lawrie's website please click here.

1st March '06, Ho Tsang Ng, (University of Oxford, UK).Title: 'Optical Josephson junction'Abstract: Recently, Saba et. al [Science, vol 307, 1945 (2005)] have demonstrated how to determine the relative phase between two separate Bose-Einstein condensates (BEC's) using the Bragg scattering. It opens the possibility to design the Josephson devices of two separate systems. In this talk, I will introduce the model and derive the effective Hamiltonian of an ``optical Josephson junction'' (OJJ) based on this technology. I will discuss the potential applications of this OJJ such as precision measurement, entanglement generation and qubit circuits.

22nd February '06, Chris Timpson, (University of Leeds, UK).Title:`Two views on quantum information theory'Abstract: In this talk two views on the nature of quantum information will be contrasted. The 'substance' view takes quantum information to be part of the contents of the world, the aim of quantum information theory being the study of the behaviour of this novel sort of entity; the 'deflationary' view, by contrast, insists that the term 'information' is an abstract noun and hence does not refer to an entity or a substance. I will argue in favour of the deflationary view. If time allows, we will close with some remarks on the potential significance of quantum information theory for our understanding of quantum mechanics.

15th February '06, Pieter Kok, (Oxford University, UK). Title: Linear optical quantum computing, a review.Abstract: Linear optics with photon counting is a prominent candidate fopractical quantum computing. The protocol by Knill, Laflamme and Milburn [Nature 409, 46 (2001)] explicitly demonstrates that efficient scalable quantum computing with single photons, linear optical elements, and projective measurements is possible. Subsequently, several improvements on this protocol have started to bridge the gap between theoretical scalability and practical implementation. We review the original theory and its improvements, and we give a few examples of experimental two-qubit gates. We discuss the use of realistic components, the errors they induce in the computation, and how they can be corrected.There will be another related seminar in School of Philosophy (Leeds) as following; Wednesday 15 February 2006 at 3.15 pm Dr Harvey Brown (University of Oxford) 'Space-time Geometry: Its Meaning and Explanatory Role'.

9th February '06, Matt Jones, (Orsay, France). Title: “Quantum Optics and Quantum Information with Optically Trapped Single Atoms”Abstract: I will describe our work in the Quantum Optics Group at Orsay on trapping and manipulating single rubidium atoms in a sub-micron sized trap, formed at the waist of a tightly focused laser beam. Arrays of these traps can be used to make an array of single atom qubits for use in quantum information experiments. In our recent work, we have shown that we can use the single trapped atom as a high quality source of triggered single photons. I will also present our latest experiments in which we use these techniques to demonstrate two-photon interference between single photons spontaneously emitted by different atoms. This is an important step towards the conditional generation of atom-atom entanglement using photon detection.

1st February '06, Aires Ferreira, (University of Leeds, UK). Aires has just arrived here in Leeds and has kindly agreed to give a talk about his work based upon an experiment taking place in Vienna. The experiment is intended to investigate the entanglement between two mirrors...

25th January '06, Andrew Fisher, (UCL, London). Andrew is a professor in the condensed matter group at UCL and his group forms part of the new London Centre of Nanotechnology. Visit his website for more about his research interests. This seminar will take place in collaboration with the condensed matter group in our department.

12th December '05, Erik Sjoqvist (University of Upsala, Sweden)Title: Quantum Holonomy Open PathsAbstract: Non-Abelian quantum holonomies, i.e., unitary state changes solely induced by geometric properties of a quantum system, have been much under focus in the physics community as generalizations of the Abelian Berry phase. Apart from being a general phenomenon displayed in various subfields of quantum physics, the use of holonomies has lately been suggested as a robust technique to obtain quantum gates; the building blocks of quantum computers. Non-Abelian holonomies are usually associated with cyclic changes of quantum systems, but here we consider a generalization to noncyclic evolutions. We argue that this open-path holonomy can be used to construct quantum gates. We also show that a structure of partially defined holonomies emerges from the open-path holonomy. This structure has no counterpart in the Abelian setting. We illustrate the general ideas using an example that may be accessible to tests in various physical systems.

6th December '05, Bill Munro (HP Labs Bristol)Title: Qubus Computation: Quantum Computation by CommunicationAbstract: We discuss a new approach to scalable quantum computing---a ``qubus computer --- which realises qubit measurement and quantum gates through interacting qubits with a quantum communication bus mode. The qubits could be ``static'' matter qubits or ``flying'' optical qubits, but the scheme we focus on here is particularly suited to matter qubits. There is no requirement for direct interaction between the qubits. Universal two-qubit quantum gates may be effected by schemes which involve measurement of the bus mode, or by schemes where the bus disentangles automatically and no measurement is needed. In effect, the approach integrates together qubit degrees of freedom for computation with quantum continuous variables for communication and interaction.