Wednesday

9:40 - 10:20
Samuel Braunstein

Quantum information describes black hole evaporation

10:20 - 10:40
Hamed Mohammady

Weak ensemble measurements in magnetic resonance spectroscopy

In many experimental situations, such as traditional magnetic resonance spectroscopy, the means of probing the system of interest is not the standard strong measurement of a POVM, whereby different measurement outcomes can be distinguished from one another. Here, the only available information is given by the expectation value of an observable. I will give a brief description of how this is a result of carrying out the POVM weakly on an ensemble of identical systems.

10:40 - 11:00
Matthew James Edmonds

An interacting gauge theory for ultracold quantum gases

Over the last two decades Ultracold atomic gases have formed the basis for a plethora of theoretical and experimental investigations of matter at the nano Kelvin temperature regime. Condensates formed from either bosonic or fermionic matter offer a large degree of experimental control, and as such it is now possible to perform quantum simulations of various physical scenarios envisaged in other condensed matter systems, such as spin-orbit coupling, quantum magnetism and even relativistic effects. Here, we will discuss how one can create artificial gauge fields for an ensemble of Ultracold atoms. Until now, all such gauge potentials have been static. We will show how to induce a U(1) dynamical gauge field,such that there is an effective back action between the gauge field and the matter field. We will then go on to construct the one-dimensional solutions for such a system which comprises unique topological states. By performing the appropriate gauge transformation, the one-dimensional many-body equation of motion can be shown to feature a current nonlinearity. The resulting non-linear equation of motion can be solved exactly to yield chiral Solitons [3], as well as critical particle numbers required for the onset of rotation of a condensate in a ring geometry [4].

[1] J. Dalibard et al., Rev. Mod. Phys. 83, 1523 (2011).
[2] Y.J. Lin et al., Nature 471 83 (2011)
[3] U. Aglietti., et al, Phys. Rev. Lett. 77, 4406 (1996).
[4] M. J. Edmonds et al., in preparation (2012)

11:20 - 11: 40
Bobby Antonio

Comparing adiabatic cluster state quantum computation to measurement based quantum computation

If you take measurement based quantum computation (MBQC) and replace measurements with adiabatic transformations, you get adiabatic cluster-state computation (ACSQC). This model of quantum computation is interesting in that it lies somewhere between adiabatic computation and MBQC, and we look into what properties of MBQC are inherited by ACSQC. In particular we look at what order of operations the computation can be done in, and whether Clifford operations have the same properties in both models. We find that the allowed ordering of operations in ACSQC is very different to MBQC, and that some Clifford operations take longer to perform than any other operations.

11:40 - 12:00
Mercedes Gimeno-Segovia

Building an optical quantum computer

A quantum computer is a machine that would exploit the non-classical features of quantum systems, such as entanglement and superposition, and take advantage of the complexity of the many-particle quantum wavefunction to solve a computational problem. It will certainly not replace the classical computers sitting on our desks but will open the possibilities of performing computations we wouldn't be able to do otherwise. There are several models for quantum computation and different technologies in which a quantum computer could be implemented. The focus of this talk will be on the combination of the computation model of measurement-based quantum computation with on-chip photonic systems. The advantage of cluster state computation is that the entire resource with all its non-classical features is prepared offline, so that the computation is done by single-qubit measurements reducing the risk of the computation going wrong. Photonic systems are very promising as the technology for the implementation of this model as they have low-noise properties and high speed transmission. I will review photonic cluster state computation before addressing the difficulties of the design of a full scale optical quantum computer.

12:00 - 12:20
Pawel Mazurek

Towards hyperfine coupling induced decay of quantum correlations in silicon quantum dots

The main mechanism of spin decoherence for electrons in quantum dots (QDs) is hyperfine interaction (in the case of non-zero nuclear spin materials) [1]. The "box-model" [2, 3], where one assumes hyperfine interaction values to be the same for all the nuclei, gives the exact analytical solution. We performed the exact calculations of correlations decay in a system of two electrons in QDs, exploiting recently introduced analytical upper bounds for geometric discord [4].

[1] W. A. Coish and D. Loss, Phys. Rev. B 70, 195340 (2004).
[2] Ł. Cywiǹski, Acta Phys. Pol. A 119, 576 (2011)
[3] W. A. Coish, E. A. Yuzbashyan, B. L. Altshuler, and D. Loss, J. Appl. Phys. **101**, 081715 (2007).
[4] A. Miranowicz, P. Horodecki, R. W. Chhajlany, J. Tuziemski, and J. Sperling, arXiv:1209.2698

12:20 - 12:40
Anna Przysiezna

Orbital-effects in strongly interacting Fermi-Fermi mixtures

Ground-state properties of Fermi-Fermi mixtures in the presence of optical lattices are investigated. We show that in a strongly attractive regime interaction-induced inter-orbital tunneling becomes important. New term describing such a process must be added to the Hubbard model which leads to significant changes in a ground-state phase diagram in comparison to results based on the standard Hubbard Hamiltonian. We describe different states arising from this effect.

14:00 - 14:20
Bjorn Bernston

PT-Symmetric and Pseudo-Hermitian Quantum Mechanics

The Hermiticity condition in quantum mechanics guarantees the reality of the eigenvalue spectrum and unitary dynamics and provides a positive-definite inner product on the Hilbert space. While Hermiticity guarantees a Hamiltonian has these desirable properties, it is not a necessary condition for their existence. Researchers have shown that systems with an antilinear parity-time (PT) symmetry, and more generally pseudo-Hermitian systems, admit a Hilbert space structure that defines a consistent quantum theory. This has been exploited to construct models with extraordinary properties, including a Hamiltonian density for electroweak interactions that does not require the Higgs mechanism and a conformal gravity Hamiltonian that provides theoretical results consistent with experimental observations of dark matter. In this talk, I will introduce the principles of PT-symmetry using a simple classical-mechanical experiment before considering a few theoretical models. In particular, I will emphasize the connection between PT-symmetric and integrable systems, detailing some of my recent work on superintegrable systems. Lastly, I will discuss how pseudo-Hermiticity generalizes PT symmetry to any antilinear symmetry of the Hamiltonian.

14:20 - 14:40
Claudia Benedetti

Time-evolution of quantum correlations under different classical noises

In the framework of quantum information processing, it is of great interest to investigate how different kinds of noise can affect the dynamics of quantum correlations. In particular, we will focus on the time evolution of entanglement and quantum discord in a two-qubit system subjected to a classical noise. We consider an initial Bell state of two non-interacting qubits and we mimic the classical noise by randomizing the transition amplitudes between the two states of each single-qubit subsystem. We evaluate the effect of independent environments acting on each qubit individually as well as the effect of a common bath acting on the two-qubit system. The time-evolution of quantum correlations is analyzed by means of analytical and numerical techniques. The dynamics is governed by a stochastic Hamiltonian, which leads to a stochastic evolution of the quantum states. In particular, we calculate the two-qubit density matrix as an average over a large number of density matrices each associated to a specific value of the random parameter. We analyze the effects of static and time-dependent $\frac{1}{f^\alpha}$ noise, both representatives of non-Markovian environments. Quantum correlations can decay either monotonically in time or with a damped oscillating behaviour depending on the kind of noise considered.

14:40 - 15:00
Luis Correa

Performance of realistic minimal self-contained quantum refrigerators

A class of minimal self-contained quantum thermal machines has been recently studied [1-3], being essentially the only ones that can achieve Carnot efficiency. In this work we focus on minimal refrigerators consisting of three qubits in contact with equilibrium reservoirs, and fully solve the problem, taking into account the finite interaction between the qubits. We then study the coefficient of performance at maximum cooling power, finding a tight and simple upper bound in terms of Carnot efficiency. We also investigate the possible role played by the quantumness of these machines in the optimality of their performance.

[1] N. Linden, S. Popescu and P. Skrzypczyk, Phys. Rev. Lett. 105, 130401 (2010)
[2] P. Skrzypczyk, N. Brunner, N. Linden and S. Popescu, J. Phys. A: Math. Theor. 44, 492002 (2011)
[3] N. Brunner, N. Linden, S. Popescu and P. Skrzypczyk, Phys. Rev. E 85, 051117 (2012)

15:00 - 15:20
Sara Di Martino

Multi-partite entanglement: an algebraic approach

Entanglement plays an important role especially in the field of quantum information and communication. Nevertheless detection and classification of entanglement in multipartite systems are unsolved problems up to date. We introduce a simple algebraic approach to the study of multipartite entanglement for pure states, together with a class of suitable functionals able to detect entanglement. On this basis, we reproduce some known results. Indeed, by investigating the properties of the introduced functionals, it is shown that a subset of such class is strictly connected to the purity. Moreover, we provide a direct and basic solution to the problem of the simultaneous maximization of three appropriate functionals for three-qubit states, confirming that the simultaneous maximization of the entanglement for all possible bipartitions is compatible only with the structure of GHZ-states.

15:20 - 15:40
Merlijn van Horssen

Phase transitions in open quantum systems

We study the occurrence of phase transitions open quantum systems in terms of ensembles of their trajectories (the thermodynamics of trajectories approach). For an open quantum system, phase transitions in this sense are related to spectral properties of the generator of the dynamics. In particular, we consider the behaviour of the atom maser (for which we obtain a connection to large deviations theory) and the open three-level system.

15:40 - 16:00
Sammy Ragy

Quantum correlations in intensity interferometry with optical light

The first example of intensity interferometry with optical light was the (somewhat) famed Hanbury Brown Twiss experiment performed in the late 1950s. The results of this experiment were controversial and caused some consternation among physicists of the time, in particular because a classical explanation was claimed for the phenomenon. This was well before the theoretical foundations of quantum optics were solidified by Sudarshan and Glauber in the early 1960s and it was a counter-intuitive result that in the low-photon regime where one expects quantum effects to dominate it is *still* possible to explain the results of such an experiment classically. We illustrate that the reason for this is because the definition of classicality used at the time is insufficient to capture the quantum signature in the system.

Thursday

9:40 - 10:00
Andrea Cadarso-Rebolledo

Entanglement in a quantum spin chain under fractional magnetization or long-range interactions

Entanglement plays a central role in many-body quantum systems as it can be used to understand the structure of the quantum states that appear in nature. Based on the theory of Matrix Product States, we can give precise statements and complete analytical proofs of the following claim: a large fractionalization in the magnetization or the need of long range interactions imply large entanglement in the state of a quantum spin chain. This is a joint work in progress with David Prez-Garca (UCM), Mikel Sanz (MPQ), Michael W. Wolf (TUM) and J. Ignacio Cirac (MPQ).

10:00 - 10:20
Dan McNulty

Mutually Unbiased Bases in Composite Dimensions

Two orthonormal bases are mutually unbiased (MU) if the inner products across all their elements have equal magnitude. In quantum mechanics, these bases represent observables that are maximally non-commuting, i.e. complementary. Mutually unbiased bases have a number of interesting applications, e.g. they allow one to optimally reconstruct quantum states and they can be used to establish secure methods of quantum key distribution. It is known that in a Hilbert space of dimension N which is a prime power, there exists a complete set of N +1 MU bases. However, when N is a non-prime-power, i.e. N = 6, 10, 12 . . . , the question of whether a complete set of N + 1 MU bases exists remains open. In the simplest unsolved case, N = 6, it is conjectured that there are only three MU bases. In this talk I will summarise what we know about MU bases in dimension six and review all progress, using numerical, computer algebraic and analytic results, supporting the conjecture that no more than three MU bases exist. In particular, I will highlight some recent work on MU bases consisting entirely of separable states, in which strong analytic results have been found.

10:20 - 10:40
Fabio Deelan Cunden

Typicality of random pure states

In the last years many researchers have studied the typical properties of random pure states, i.e. unit vectors drawn at random from the Hilbert space. This subject has attracted attention in several directions, and many important results have been achieved. The paradigmatic example which has been intensively investigated is the ensemble of random pure states induced by the Haar measure on unitary operators. This ensemble, being the maximally symmetric one, implements in a natural way the case of minimal knowledge on quantum states. For this reason, the unitarily invariant ensemble is also known as unbiased ensemble.

10:40 - 11:00
Jan Tuziemski

On some aspects of general private states and selected quantum channels with private key

In this talk we will present a novel property for general private states, namely the invariance of distillable key under rotations around private axis in Devetak-Winter protocol. Its application to the problem of searching optimal measurement basis for a given private state will be demonstrated. We will also provide results concerning estimation of the quantum capacity of the quantum channel isomorphic to the experimentally realized [Dobek et al. Phys. Rev. Lett. 106, 030501] private bit and related private bits as well as estimation of the private capacity with the help of the specified protocol, which performs the secret key distillation from a quantum state.

11:20 - 11:40
Marcin Markiewicz

Simulating Local Quantum Measurements with Constant Average Communication Cost

It is known since Bell that quantum mechanics of multipartite systems predicts correlations of measurement outcomes that cannot be reconstructed using only locally computable real functions without any communication between separate parties. In this work we investigate properties of Quantum Mechanics from the point of view of some communication tasks. We adapt here a Communication Complexity scenario. We consider a problem, in which two parties (Alice and Bob) share some random resource. As an input, Alice and Bob obtain some parametrization of a local binary (with two distinct outputs) projective measurements and a global shared state. Their task is to produce binary outcomes, which statistics is equivalent to statistics of real quantum measurements.

In this contribution we propose a protocol, which perfectly solves this task, with constant average number of two-way communicated bits required. Our protocol is based on the idea, that the problem can be resolved, if we are able to simulate joint probabilities of quantum measurements conditioned on local outputs.

11:40 - 12:00
Anna Szymusiak

Entropy of group covariant POVM

Which ensembles of initial states are optimal for a given POVM measurement? This problem of quantum communication can be expressed in mathematical terms as follows: we are looking for ensembles that maximize mutual information between themselves and the POVM measurement outcomes. For a group covariant measurement this can be restated equivalently as finding pure initial states that minimize the entropy of the measurement output. Due to the non-polynomial form of the minimized function, an analytical solution of the problem apparently seems difficult to obtain. The method applied involves using the Hermite polynomial interpolation and some properties of group invariant polynomials. The single qubit case with a highly symmetric rank-one group covariant POVM is investigated in details.

12:00 - 12:40
Nilanjana Datta

Quantum rate distortion, reverse Shannon theorems and source-channel separation

Friday

09:40 - 10:20
Karoline Wiesner

Occam's quantum razor: how quantum mechanics can reduce the complexity of classical models

10:20 - 10:40
David Bruschi

Towards relativistic quantum technologies

In the past few years, the field of Relativistic Quantum Information has gained attention from the scientific community. Research in the field is aimed towards understanding how gravity and relativity affect entanglement and quantum information tasks. Recently, attention was given towards the possible implementations of the predictions of the theory in experimental settings. We discuss the role of localized devices and their ability to store, extract and manipulate entanglement of global or local fields. We discuss future directions and applications.

10:40 - 11:00
Hugo Ferreira

Quantum effects on Warped AdS3 Black Holes in 3D Topologically Massive Gravity

3D gravity allows us to study aspects of General Relativity and quantum gravity in a simpler technical setting which retains much of the conceptual complexity of the 4D version. However, pure Einstein gravity has no local degrees of freedom in 3D. Topologically Massive Gravity is a deformation of pure Einstein gravity which adds a gravitational Chern-Simons term and includes propagating gravitons. For many years several attempts at finding a stable vacuum solution for this theory were made and it has been recently established that the Anti-de Sitter (AdS3) solution is unstable for almost all values of the coupling constant of the Chern-Simons term. Warped AdS3 solutions are recent candidates for a stable vacuum solution. In this talk I first classically describe these solutions and the black hole spacetimes one can obtain from them. In addition, I describe scalar field perturbations on these black hole backgrounds and progress towards determining the renormalized stress energy tensor for the Hartle-Hawking vacuum state.

11:20 - 11:40
Nicolai Friis

Shaking Entanglement

We present an analysis of the entanglement generation between modes of quantum fields in non- uniformly moving cavities. In our fully relativistic model the cavities can undergo generic travel scenarios, where the cavity trajectories are composed of segments of inertial motion and uniform acceleration. We show how bipartite and genuine multipartite correlations are being generated and compare the striking differences between fermionic and bosonic particle statistics in this effect. Our results provide fundamental insights into the structure of Bogoliubov transformations and suggest strong links between quantum information, quantum fields in curved spacetimes and gravitational analogues by way of the equivalence principle

11:40 - 12:00
Paul Knott

Relative position localisation of particles due to entanglement

Macroscopic objects behave classically even though the underlying structure is quantum mechanical. An interpretation of why this happens was devised that uses a robust form of entanglement to explain relative position localisation. This interpretation will be illustrated by describing a thought experiment in which the relative positions of two particles become highly localised due to photon scattering. An experimental signature of this process was devised allowing the theory to be tested. We have extended this to include details about the rate of the localisation and we present precision requirements that are achievable with current experiments. We also extend the scheme from its initial one dimensional proof of principle to the more real world scenario of three-dimensional measurement-induced relative position localisation, which as in the one dimensional case, adds strength to the status of relative over absolute position within physics.

12:00 - 12:20
Antony Lee

Unruh-DeWitt detectors with spatial profiles

We investigate how non-point-like Unruh-DeWitt detectors couple to a quantum field while undergoing uniform acceleration. The aim of this work is to develop a model of detector-field interaction which allows single mode interaction and does not violate the causality structure of spacetime.

12:20 - 12:40
Sara Tavares

Observables in 2d Yang Mills

Yang Mills theory in two dimensions has been the target of intensive study in the last twenty years due to its almost topological nature. I will expose a systematic approach to its quantization and introduce a framework to deal with exact calculations of expectation values of operators (observables).

14:00 - 14:20
Michele Avalle

Entropy flow of Quantum Cellular Automata

Quantum Cellular Automata (QCA) can be described as a set of quantum subsystems ("cells") on a d-dimensional lattice (typically infinite or periodic) evolving in discrete time-steps according to a certain transition rule. This rule has to be local (information cannot be trasmitted faster than some fixed number of cells per time-step) and translationally invariant (it acts the same everywhere). Because of this "physics-like" kind of structure and their inherent parallelism, QCA can be versatile and interesting models for quantum computation and quantum simulation. Despite the idea of generalizing the classical notion of cellular automata to the quantum regime dates back to the famous Feynman's seminal lecture of 1982, the theory underlying QCA remained in some way unsatisfactory until recent years due to the lack of an exhaustive axiomatic definition of these systems and to the consequent overabundance of competing definitions they have been given during the years. In this talk I will review the recent results that led to obtain both an axiomatic and a constructive definition of (reversible) QCA and that also showed that all the non-axiomatic definitions are actually equivalent.

14:20 - 14:40
Tanapat Deesuwan

The Second Law of Thermodynamics, Jarzynski Equality, and Beyond

I will review the second law of thermodynamics and introduce the Jarzynski equality in classical and quantum regime which can be considered a generalisation of the second law. Interestingly, Jarzynski equality can be extended to include of a Maxwell demon. I will then talk about the experimental scheme that we designed to test Jarzynski equality in the classical regime, and in the quantum regime in the future.

14:40 - 15:00
Andre Ranchin

Introduction to Categorical Quantum Mechanics

Despite its indisputable historical success and importance, the Hilbert space formalism is flawed in several respects. The mathematical theory of categories provides a more general framework to study quantum mechanics as one theory in a larger space of hypothetical generalized process theories. This talk will briefly introduce the Categorical Quantum Mechanics approach of Abramsky and Coecke with a particular focus on the treatment of complementary observables within this framework.

15:00 - 15:20
Davide Girolami

Quantum Uncertainty on single observables

Physicists investigate Nature by making measurements and predicting their outcomes. The Heisenberg principle states that measurements of complementary observables carry an inherent uncertainty which is independent of technical deficiencies of the measurement apparatus or incomplete knowledge of the state of the system. Here we show that quantum mechanics predicts that even a single observable can be intrinsically uncertain on its own. This quantum signature into the rationale of the measurement process witnesses quantum correlations shared by the system under scrutiny, affects the statistical accuracy of experimental data analysis and states superselection rules to the measurability of quantum observables. The interplay between uncertainties due to quantum correlations and noncommutitavity of observables can be exploited to improve the efficiency of protocols for quantum metrology tasks, establishing the minimum quantum enhancement in parameter estimation with noisy probes.