**Physics Post Graduate Conference**

**Thursday 23rd August 2018**

**Carnegie Room**

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| **Time** | **Student** | **Primary Supervisor** |
| **09:15-09:30** | **Tomohiro Hashizume** | **Daley** |
|  | **Title:** Dynamical Properties of Isolated Spin Chain with Exotic Long-Range Interactions  **Abstract:** The classical kinetic theory predicts a drop of milk injected into a cup of coffee spreads in the time scale proportional to the power of 2/d of the number of particles in a coffee cup. When an electric charge is injected to a black hole, the time scale for which the charge density to spread over the entire Schwarzschild surface scales logarithmically with Schwarzschild radius. This implies that nature allows the super ballistic transport of information. '  In 2018, a quantum spin chain with interactions which decays/increases algebraically but only allowed with sites separated by the integer powers of 2 is realized. Motivated by the experiment, we investigated the dynamical properties of the chain to seek for such super ballistic behaviors. Also, we compared the chain to a chain with interactions in a different number system, which may explain such a super ballistic transport, to seek connections between them. The ballistic transport is observed for power law increasing interactions. Also a significant difference in the dynamical behaviors is found despite the similarity in the energy spectra of the two models. |  |
| **09:30 – 09:45** | **Boy Panjaitan** | **Chen** |
|  | **Title:** Study of Protein Encapsulated Gold Nanoclusters by experimental and simulation work  **Abstract:** Protein encapsulated gold nanoclusters (AuNCs) owe much attention in the field of medical due to their excellent fluorescent properties. Glucose Binding Protein (GBP) and glucose molecule have a unique interaction. It will be good if GBP encapsulated gold nanoclusters can be utilised for detection of diabetes, a chronic disease indicated with higher level of glucose in human body. However, synthesize of gold nanoclusters in GBP is not possible due to the absence of cysteine residue in GBP. In this conference I will report our study on nucleation of gold nanoclusters inside native GBP and mutant GBP using Molecular Dynamic (MD) simulation. Due to the great application of Gold Nanorods (GNRs), interaction of AuNCs with GNRs will also be presented.  . |  |

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| **09:45 – 10:00** | **David McLellan** | | **Robb** |
|  | **Title:** Modelling Cooperative Effects with Cold Atom Clouds  **Abstract:** Cooperative effects in light matter interaction break the model of mean field optics in terms of expected measurable outputs.  Code based on the established Coupled Dipole Model is used as a mechanism for evaluating in our case superradiant outputs based on atomic cloud geometry and incident radiation.  Signature effects of cooperative behaviour have been replicated successfully with our code and the intention is to couple atomic forces into the existing code.  This code will be used to look for and expand on unconventional cold atom models comparable to astrophysical phenomena such as photon bubbles and attractive forces from blackbody radiation. | |  |
| **10:00– 10:15** | **Paul Janin** | | **Griffin** |
|  | **Title:** MEMS photonic devices for atom and ion traps  **Abstract:** This project aims to design, characterise, and implement photonic microelectromechanical systems (MEMS) for beam steering and shaping applications, specifically for integration in atom and ion traps for quantum information processing. This talk presents two types of devices : a varifocal mirror, and multiple designs for high frequency tilting mirrors, to enable 3D beam steering. The design process of both devices is explained, and the characterisation results of the varifocal mirror are examined ; this includes the fabrication process and actuation perspectives. | |  |
| **10:15 – 10:30** | **Stuart Flannigan** | | **Daley** |
|  | **Title**: Transport Properties of Many-Body Systems with Quantum Simulators  **Abstract:** We investigate how to use ultra-cold atoms confined in an optical lattice in order to experimentally simulate quantum transport through interesting one-dimensional geometries. Using these experimental systems we can accurately create non-trivial lattice geometries and set up out-of-equilibirum scenarios in a highly controllable and perfectly disorder free environment. We work on benchmarking the experiment, so that we are sure that the system is simulating the correct physical properties and we also investigate how to exploit the unique quantum behaviour to improve the efficiency of information transfer in future quantum electronic devices. | |  |
| **Coffee Break 10:30-11:00** | | | |
| **11:00 – 11:15** | **Milan Adelt** | | **Chen** |
|  | **Title:** Synthesis of noble metal nanostructures for metal-enhanced fluorescence in biomedicine.  **Abstract:** Weak fluorescence signal is often a drawback of fluorescence-based biomedical techniques. These conditions can be improved by combining noble metal nanostructures with fluorophores. Due to the ability of noble metals to support surface plasmon resonance, fluorescence signal can be greatly enhanced through mechanism termed metal-enhanced fluorescence (MEF). We explore applications of gold nanorods (GNRs) for development of plasmonic nanostructures with potential use as MEF-based fluorescence amplifiers in biomedicine. We utilize GNRs and site-selectively functionalize their surface with silica and poly(ethylene glycol) methyl ether disulfide and thiol to synthetize dye-doped core-shell GNRs and side-by-side oriented GNRs assemblies. | |  |
| **11:15-11:30** | **Hao Yang (Jack )** | | **Jeffers** |
|  | **Title:** Quantum Radar  **Abstract:** There has been considerable interest in creating a “quantum radar”, where entangled states of light and their non-classical correlations are exploited to improve the sensitivity of classical radar. Immediate advantages are low energy and stealth monitoring. Here, we will report a simple theoretical model of the detection/measurement paradigm for a quantum radar, calculated using the Gaussian quantum information method, and discuss some physical implementations.  . | |  |
| **11:30-11:45** | **Ilian Despard** | | **Kuhr** |
|  | **Title:** Foundations of a dual species Quantum gas microscope  **Abstract:** The relentless advancement of new and improved technologies relies heavily on the ability to comprehend their complicated inner workings. For the case of solid state materials in which the time required for a complex computerised simulation to run, quickly outreaches the age of the universe, other methods are required. Atomic gas microscopy provides a quantum analogy to a solid state system, while allowing for fast measurement times combined with complete environmental and atomic control of individual parameters. By reducing the temperature of a dilute cloud of atoms we can reach a quantum state (Bose-Einstein condensate) where the Bose-Hubbard model, can be tested. In realism a system very rarely contains just a single atom in a square lattice. Our experimental setup aims to have duel species Rubidium within a variety of lattice orientations to probe out of equilibrium many body systems. | |  |
| **Lunch 12:00-13:30** | | | |
| **13:30-13:45** | **Jenny Morgan** | **McNeil** | |
|  | **Title:** Generation of light with orbital angular momentum in a free electron laser  **Abstract:** The common method for creating light carrying orbital angular momentum is to send a beam through an optical element. The damage threshold of these elements limits the wavelength and brightness of the light. In a free electron laser, FEL, OAM radiation is created through manipulation of the electron beam and these restrictions do not apply.  This talk will describe the generation of OAM in a FEL. A new scheme will be presented in which OAM radiation is generated in a FEL with the initial startup from SASE. Possible applications for OAM at short wavelengths and high brightness will be covered. |  | |
| **13:45 – 14:00** | **Katie McDonnell** | **Pritchard** | |
|  | **Title:** Towards a Mesoscopic EIT Gate  **Abstract:** I present work carried out towards the demonstration of a mesoscopic EIT gate by demonstrating two-photon ground state rotations between the hyperfine ground states of caesium and quantifying of the decoherence time of these states. This is followed by coherent Rydberg excitation on single trapped atoms and extended to the Rydberg blockade regime where we have seen a root(2) enhancement in the Rabi frequency for a pair of atoms separated by 6um. We successfully demonstrate entanglement between the hyperfine ground states of the caesium atoms following parity measurements with a loss corrected entanglement fidelity, 0.81 +/- 0.05. |  | |
| **14:00-14:15** | **Lewis Hill** | **Oppo** | |
|  | **Title:** Spontaneous Symmetry Breaking of Light in Ring Resonators  **Abstract:** The Lugiato-Lefever equation has been used to model a variety of nonlinear optical systems. One of its major successes has been in describing light propagating in ring resonators. A system of two coupled LL equations can be used to describe the interaction of two circularly polarised fields, and special cases of two counter-propagating fields, circulating in ring resonators.  In this presentation a brief introduction to the theory behind ring resonators is given followed by an explanation of the so-called ‘spontaneous symmetry breaking’ phenomena, its uses and a summary of recent progressions in the field completed by the presenter and collaborators. |  | |
| **14:15 – 14:30** | **Andreas Peter** | **Piani** | |
|  | **Title:** States as Tensor Networks  **Abstract:** In a composite quantum system, the possible configurations generally grow exponentially in the number of components.  Due to the possibility of interference, we have to keep track of all of them which leads to huge computational costs.  If we only care about low-energy states, we find that only a subset of the possible configurations contribute to the state.  Representing and manipulating these is possible using tensor networks of which we will consider the most simple case, the matrix product state, which we can use to find ground states of one dimensional systems. |  | |
| **Coffee Break 14:30-15:00** | | | |
| **15:00-15:15** | **Lucas Herdly** | **McConnell** | |
|  | **Title:** Characterisation and calibration of a 3D super-resolution microscopy system  **Abstract:** Conventional light microscopy is limited by the diffraction barrier around 250 nm as described by Ernst Abbe (1873). E. Betzig, W. E. Moerner and S. Hell received the Nobel Prize in chemistry in 2014 for the development of the techniques that overcome Abbe’s limit and for starting super-resolution microscopy.  Our work concentrates on dSTORM (direct STochastic Optical Reconstruction Microscopy), which consists of the photoswitching of fluorescent molecules and their localisation with nanometre precision.  A well-calibrated microscope system is paramount to achieve the best increase of resolution permitted by dSTORM, a few nanometres. The 3D capability of dSTORM will be discussed. |  | |
| **15:15-15:30** | **Giuseppe Baio** | **Robb** | |
|  | **Title:** Optomechanical Selfstructuring of cold atoms and Twisted Light  **Abstract:** The spontaneous emergence of spatio-temporal order is a prominent feature of out of equilibrium dynamics. When considering cold atoms, the optomechanical coupling between light and atoms is known to lead to instabilities and pattern formation. Due to their potential applications, light structures carrying orbital angular momentum (OAM) are also of central interest in quantum optics.    In this work we consider pure optomechanical structures consider a cold atomic cloud within a planar ring cavity geometry, interacting with a Laguerre-Gaussian mode of non-zero OAM.  We address rotational spatial instabilities, bistability domains and dissipative solitons. Numerical simulations tuned to possible experiments are presented. |  | |
| **15:30-15:45** | **Liam Rooney** | **Yao** | |
|  | **Title:** Control and applications of structured-light and chiral molecules  **Abstract:** My project is based around two main areas of research, fully structured light (FSL) and chirality. The aim of the project is to advance the theory of FSL and to investigate chiroptical interactions based on this theory. We look to identify different examples of FSL beams which reduce the dipole interaction force while also enhancing the chiral force through different superpositions of Laguerre-Gaussian modes. This will allow use to design light for interactions between light and molecules through different polarisation and intensity structures. |  | |

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| **15:45-16:00** | **Michael Wright** | **Griffin** |
|  | **Title:** Compact Cold-Atom Microwave Atomic Clocks  **Abstract:** Precise timing is built into almost every aspect of modern infrastructure including GPS, computer networks and smartphones – all requiring synchronization to billionths of a second. I will describe an atomic clock experiment based on laser-cooled 87Rb in a grating magneto-optical trap (GMOT). This experiment combines a Lin⊥Lin configuration for coherent population trapping (CPT) and a pulsed Ramsey interrogation to generate a clock signal. Short experimental cycle times help to make clocks more stable and so we have implemented a new release-and-recapture method to increase the repetition rate of our experiment. |  |