**Physics Post Graduate Conference**

**Thursday 21st August 2019**

**Carnegie Room**

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| **Time** | **Student** | **Primary Supervisor** |
| **09:30-09:45** | **Alasdair Lennon** | **Griffin** |
|  | **Title:** Implementation of a "painted" optical dipole potential for atom interferometry  **Abstract:** Atom interferometry is good for sensing applications such as inertial sensing, gravity sensing and tests for fundamental physics. It relies on the use of matter waves thus Bose-Einstein Condensates are a good candidate for an atom interferometer. To transition these into useful devices, a "painted" optical dipole trapping potential can be used to speed up the measurement process. This technique can be realised using an acousto-optic modulator that allows the mapping of a change in angle onto a change in position of the trap focus. Experimentally, this shows good agreement with the theory and a setup was designed and built to implement it. Initial data shows a noticeable improvement in atom number loaded into the dipole trap with "painting" compared to without. |  |
| **09:45 – 10:00** | **Simon Colin Armstrong** | **Riis** |
|  | **Title:** Grating-Chips for Compact Cold Atom Systems  **Abstract:** Laser-cooled atoms are of great interest in emerging Quantum technologies as they provide accurate metrology measurements and provide important insight into fundamental physics. Compact cold atom sources rely on small yet competitive subsystem components. Diffraction gratings have recently become highly useful in realising compact cold atom sources; we investigate a new grating profile and its potential usefulness as a replacement for current grating designs. We also investigate the potential use of imprinted gold wire structures on the grating chip surface.  . |  |
| **10:00 – 10:15** | **Tom Bintener** | **Daley** |
|  | **Title:** Dissipation and Entanglement Entropy for Bosons on a Lattice  **Abstract:** Studying the dynamics in quantum many-body systems is essential to understanding the behavior of entanglement in such systems. We are interested in the interplay between coherent and dissipative dynamics which over time increase and decrease entanglement respectively. We want to analyze how the effect of strong dissipation can modify the entanglement entropy in a system. Transitions in the entanglement entropy have been observed in random circuits [1], where transitions were observed as a function of measurement strength. The goal is to find a potential dynamical phase-transition in a tight-binding model of hard-core bosons on a lattice of the entanglement entropy as a function of the dissipation strength. |  |

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| **10:15– 10:30** | **Emma Abigail Butt** | | **Mathieson** |
|  | **Title:** Advanced Neural Interfaces for an Optoelectronic Retinal Prosthesis  **Abstract:** Vision loss is an increasingly common issue around the world. 200 people are estimated to be living with retinal degeneration by the year 2020. Retinal implants have been proposed as a treatment for sight restoration. Current tested implants are falling short in the visual acuities needed to restore the high resolution vision lost. This talk details the development of three-dimensional honeycomb return electrode structures for integration with optoelectronic retinal devices, offering greater integration with the retinal structure, lower stimulation thresholds and higher visual acuities. Different processes for photolithography have been investigated and their suitability evaluated. The electroplating process for growth of the return electrode structure has also begun. | |  |
| **10:30 – 10:45** | **Mark Carroll** | | **Papoff** |
|  | **Title**: Modelling semiconductor quantum dot nanolasers  **Abstract:** In recent years a lot of attention has been given to nanolasers with semiconductor quantum dots (QD) as the active material. These nonolasers have dimensions on the order of the wavelength of the emitted light resulting in a low modal volume, and along with high Q-factors allow for strong light-matter coupling. From a research point of view nanolasers offer attractive opportunities to study exotic behaviours in a new quantum limit. We investigate a model capable of reproducing experimental results and extend it further in search of bistability. | |  |
| **Coffee Break 10:45-11:15** | | | |
| **11:15 – 11:30** | **Andrew Daffurn** | | **Griffin** |
|  | **Title:** Mode arithmetic with Laguerre-Gaussian beams via four-wave mixing in rubidium vapour  **Abstract:** Using the four-wave mixing process in rubidium vapour it is possible to transfer orbital angular momentum (OAM) from two near-infrared Laguerre-Gaussian (LG) pump beams across the visible spectrum to blue light generated at 420 nm. Arithmetic including; addition, subtraction, and cancellation of OAM can be performed during the process. Additionally, phase matching requirements mean that when the pump beams have OAM of opposite handedness the blue light can be generated in the form of a LG beam with non-zero p index. This means that the blue light is produced with on-axis intensity where the pump beams have a vortex. | |  |
| **11:30-11:45** | **Joseph Gedge** | | **Oi** |
|  | **Title:** Adaptive Measurements on the Rebit  **Abstract:** We consider measurements performed on an unknown rebit state, in order to determine the "true" state. These measurements follow a non-adaptive scheme or one of two adaptive schemes. One of these schemes performs the adaptation based on the Mean Bloch vector, and the other performs the adaptation based on the Maximum Likelihood Estimate. It is found that, for randomly selected "true" states distributed uniformly over the Bloch disc, there is little improvement between the non-adaptive scheme and the adaptive schemes.  . | |  |
| **11:45-12:00** | **Ross Maurice Johnston** | | **Griffin** |
|  | **Title:** A Shielded Double Resonance Magnetometer  **Abstract:** Optically pumped atomic magnetometry has evolved over the last 50 years from the first experimental measurements by Bell & Bloom, to the modern day where magnetometers are capable of making precise measurements in a diverse range of fields. The aim of this project is to create an atomic magnetometer, using the double resonance technique, capable of measuring fields within the low kHz regime.  Work undertaken so far has been to calibrate and control all magnetic fields within a 4-layer shield. Magnetic resonance data will be shown, as will the work taken to improve them. | |  |
| **12:00-12:25** | **Lindsey Keary** | | **Pritchard** |
|  | **Title:** Progress towards a hybrid atom-superconducting interface  **Abstract:** The aim of this project is to develop a high-fidelity interface between superconducting and photonic qubits to realise an expansive quantum networking architecture. The long-term goal is to advance the progress of circuit-QED quantum computing approaches with the inclusion of coherent quantum information storage and microwave-to-optical conversion. Therefore, generation of a chip-based device where atoms are coupled to superconducting circuits via a superconducting microwave resonator enables and deterministic entanglement of photonic qubits. Trapping atomic ensembles above a superconducting coplanar waveguide (CPW) and generating long-distance entanglement remains experimentally challenging but is an essential requirement to build a scalable quantum network. | |  |
| **Lunch 12:15-13:30** | | | |
| **13:30-13:45** | **Martin David Lee** | **Hastie** | |
|  | **Title:** Narrow-linewidth, compact, vertical external-cavity surface emitting lasers for quantum technologies  **Abstract:** Frequency-stabilized, vertical external-cavity surface-emitting lasers (VECSELs) are ideally placed to meet the demand for ultra-narrow linewidth operation at novel wavelengths for emerging quantum technologies based on cold atoms. Intrinsic high beam quality and narrow-linewidth operation is provided by the high-finesse external laser cavity. In this work, a compact VECSEL emitting at 698 nm has been built as a candidate to target the ultra-narrow, sub-Hz, clock transition of neutral strontium, and the Pound-Drever-Hall frequency stabilising technique has been used to lock an AlGaInP-based VECSEL directly to an ultra-high finesse reference cavity for the first time. Here we propose a monolithic design to further reduce VECSEL linewidth, whilst simultaneously reducing SWaP-C. |  | |

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| **13:45–14:00** | **Adrian Costa Boquete** | **Ackemann** |
|  | **Title:** Self-organized Spin and Density Ordering of Thermal Atoms in Cavities  **Abstract:** This work studies novel phenomena in spatial self-organization due to light-mediated coupling between cold atoms in two and potentially three dimensions. A central vision is the exploration of novel phases and phase transitions in these systems.  Non-trivial structures in light and matter can form spontaneously from homogeneous laser driving and an initially homogeneous particle distribution via light scattering and optical nonlinearities. When using cold atoms, the existence of macroscopic matter transport due to optical forces leads to density self-organization. Utilizing the magnetic sub-levels of atoms, magnetic ordering can be simulated via spin-dependent light-matter interactions provided by optical pumping.  Building on previous investigations on feedback schemes, utilizing a single retro-reecting plane mirror, this project will investigate experimentally self-organization in longitudinally pumped multi-mode degenerate cavities containing cold thermal atoms. Numerical simulations were done to show the linear dependence between the strength of the light-induced interaction and the dispersive optical density for the feedback system. |  |
| **14:00-14:15** | **Ben Lewis** | **Griffin** |
|  | **Title:** A compact cold-atom clock  **Abstract:** Atomic clocks provide the most accurate and stable time standards in use. Recently, the chip scale atomic clock has provided miniaturised, portable atomic timekeeping but it is vulnerable to long-term drifts. Microfabricated optics allow the production of robust, compact laser systems for cooling atoms to the μK level. A cold atom clock based on this technology could have excellent long-term accuracy. Our progress towards such a clock is presented. |  |
| **14:15 – 14:30** | **Elliott Mansfield** | **Daley** |
|  | **Title:** Quantum Transport in Spin-Orbit Coupled Helical Waveguides  **Abstract:** In order to describe transport properties of helical waveguides, various non-interacting techniques were used in analysing different features of experimental data. An overshoot of the $\frac{2e^2}{h}$ conductance baseline has been illustrated in band structure calculations of the transport of electron pairs. Additionally, interference fringes in the transconductance have been displayed in calculations on spin precession. Finally, calculations were done on the interacting case, showing that spin-orbit coupling in helical waveguides leads to a strong pairing of the lowest two subbands. This shows that interaction strength can be tuned by varying the spin-orbit coupling, which could have applications in quantum simulation. |  |
| **Coffee Break 14:30-15:00** | | |

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| **15:00-15:15** | **Sean Patrick McLaughlin** | **Riis** |
|  | **Title:** Unshielded Double-resonance Magnetometry  **Abstract:** This talk will describe the construction and theory of a double-resonance atomic magnetometer, providing context and relevance for the field of magnetometry, as well as for the aims of this project. The magnetometer created features a double-pass of the atomic sample, the laser beam being reflected to propagate through the atoms twice. The aim is to create an compact, portable and highly sensitive unshielded magnetometer. Comparisons will be made between a single- and double-pass setup to determine the benefits of this feature on properties such as sensitivity. |  |
| **15:15-15:30** | **Pornthep Ponchalee** | **McNeil** |
|  | **Title:** Unaveraged Simulation of A Regenerative Amplifier Free Electron Laser  **Abstract:** A regenerative amplifier free-electron laser (RAFEL) design and simulation requires the modelling of both the electron-light interaction in the FEL undulator and the optical propagation within the cavity. An unaveraged 3D simulation was used to model the FEL interaction within the undulator using the Puffin code. This allows a broadband, high temporal-resolution of the FEL interaction. The Optical Propagation Code (OPC) was used to model the optical beam propagation within the cavity and diagnostics at the cavity mirrors. This paper presents the optical field conversion method between Puffin and the OPC codes and demonstrates the full model via a VUV-RAFEL simulation. |  |
| **15:30-15:45** | **Harry Pulham** | **Riis** |
|  | **Title:** Shielded Atomic Magnetometer for Nuclear Quadrupole Resonance detection  **Abstract:** Nuclear quadrupole resonance frequencies are specific to particular chemical compounds, and are used in detection of explosives and narcotics. Radio-frequency magnetic fields are used to induce and detect the transitions involved. Steps to build a sensitive atomic magnetometer to detect these fields are discussed, including diode laser and magnetic field control. Optimisation of the working magnetometer is undertaken. |  |
| **15:45-16:00** | **Miles Toon** | **Dawson** |
|  | **Title:** Nanoscale 3D transfer printing for hybrid photonic device fabrication  **Abstract:** This talk covers the progress made on my project as a first year PhD student to explore and realise novel heterogeneous devices through the use of nanoscale accurate 3D printing techniques. Collaboration with the University of Cambridge on a systematic study on the bowed nature of custom grown GaN HEMT structures is done to develop strain management with the growth to optimise the produced optical devices. Other methods such as computational models are used to ensure the best final result without the need for multiple iterations of devices. |  |