# Physics 2nd Year Poster Session – 20th August 2020

## Zoom link : https://strath.zoom.us/j/98558896914 (passcode : 632592)

| Time | Student Name | Title/Abstract |
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| | | **OPTICS** |
| 2.00 – 2.05 | Lindsey Keary | **Title:** Hybrid atom-superconductor interface<br><br>**Abstract:** A key challenge to exploiting the benefits of quantum information processing is the development of the next-generation hardware required to generate entangled photons incorporating quantum memory and integrated processing analogous to "quantum router". Hybrid quantum computation exploits the unique strengths of disparate quantum technologies, enabling realisation of a scalable quantum device. |
| 2.05 – 2.10 | Andrew Daffurn | **Title:** Gouy phase-matched angular and radial mode conversion in four-wave mixing<br><br>**Abstract:** We investigate the conversion between transverse mode structures in four-wave mixing in a heated rubidium vapour. While angular momentum conservation in this nonlinear process dictates the selection rules for the angular quantum number, the role of the radial quantum number is more esoteric. We demonstrate experimentally that a clean Laguerre-Gauss mode LGℓp=LG01LGpℓ=LG10 can be generated by converting LG10LG01 and LG−10LG0−1 near-infrared pump beams – but only if the length of the atomic medium exceeds the Rayleigh range. |
| 2.10 – 2.15 | Harry Pulham | **Title:** Wavelength Optimisation for an Optically Pumped Magnetometer<br><br>**Abstract:** A shielded atomic RF magnetometer using a paraffin-coated caesium cell and employing double resonance techniques, is used to detect weak oscillating magnetic fields. The sensor is designed to work at frequencies below 10 kHz, has a tuneable sensitive frequency, and magnetic linewidth in the region of 10 Hz, making it well suited for use in zero- and ultra- low field NMR experiments. |
| 2.15 – 2.20 | Sean McLaughlin | **Title:** Microfabricated Alkali Vapour Cell Characterisation for Double-pass Double-resonance Atomic Magnetometry<br><br>**Abstract:** Atomic magnetometry techniques have been used to create unshielded devices capable of measuring magnetic fields in the fT regime. In order to create these highly sensitive atomic magnetometer devices it is essential to maximize the spin polarization lifetime of the sample. This work focuses on reducing the intrinsic effects, the effects that occur within the microfabricated alkali vapour cell, which contribute to polarisation relaxation known as relaxation rates. |
| 2.25 – 2.30 | Ross Johnston | **Title:** Optimisation of a two-beam atomic magnetometer<br><br>**Abstract:** Atomic magnetometry allows for the precise detection of small magnetic fields. Here we describe the hardware for a two-beam magnetometer, working within a magnetically shielded environment, and the steps taken to optimise the device. Particular focus is paid to the optimisation of the laser frequency with regard to the effect on magnetic resonance amplitude. |
| 2.30 – 2.35 | Ben Lewis | **Title:** A cold atom clock in a microwave cavity<br><br>**Abstract:** Atomic fountain clocks, which launch cold atoms through a microwave cavity, are the basis of international atomic time. Trapping atoms within a microwave cavity could allow a much more compact high-performance, accurate clock. A prototype design has been produced using a diffraction grating to form a magneto-optical trap (MOT). |
| 2.35 – 2.40 | Harikesh Ranganath | **Title:** Single-atom imaging of fermions in a quantum-gas microscope<br><br>**Abstract:** Ultracold atoms in optical lattices have become a key tool to simulate and test fundamental concepts of condensed matter physics, in particular to study out-of-equilibrium dynamics in quantum many-body systems. These versatile quantum simulators can be used to investigate magnetism, charge/spin transport, superconductivity and other solid state phenomenon that are difficult to simulate classically. In our experiment, we image fermionic 40K atoms in an optical lattice with single-site and single-atom resolution. Previously we used electromagnetically-induced-transparency (EIT) cooling [1] to generate fluorescent photons to image the atoms. However, density dependent effects during the EIT cooling complicated the demonstration of atoms in the strongly-correlated regime. Here we apply another cooling scheme, Raman sideband cooling [2], for the detection of single atoms with a quantum-gas microscope. |

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| **2.40 – 2.45** | **Adrian Costa Boquete** | **Title:** Self-organized spin and density ordering of thermal atoms in cavities<br><br>**Abstract:** Light fields can induce interaction between atomic states. This project uses cold atomic cloud in a longitudinally pumped multimode optical cavity to drive that interaction. It can lead to spontaneous self-ordered optomechanical and/or magnetic cases. Potentially, the interaction between both phases could be explored. |
| **2.45 – 2.50** | **Mark Carroll** | **Title:** Collective Quantum Anti-Bunching Regions And Laser Thresholds In Nanolasers<br><br>**Abstract:** We consider a fully quantized model for a number N of emitters coupled to the modes of an optical cavity and we calculate analytically thresholds between different thermal, anti-bunching and lasing emission regimes. We find that the lasing regime is reached for a number of emitters above a critical number – which depends on the light-matter coupling and the dissipation rates – via a transition from thermal emission to anti-bunching to laser as the pump increases. The anti-bunching regime becomes vanishingly small in the control parameter space in the limit of large number of emitters, where the results of macroscopic laser theory are recovered. For a number of emitters below the critical number, laser emission cannot be achieved and, depending on the number of emitters, the system undergoes a transition thermal to anti-bunching emission as the pump increases, or has only thermal emission**.** |
| **2.50 – 2.55** | **David McLellan** | **Title:** Optical Binding of Multiple Atoms Including Pump Phase Modulation<br><br>**Abstract:** Cooperative effects in light-matter interactions can produce interesting and potentially useful effects e.g. superradiance or optical binding. For many atoms, light-mediated interactions cause complex behaviour and are thought to be the underlying cause of radiation-driven instabilities in MOT or potentially astrophysical environments e.g. photon bubbles, in which homogeneous distributions of matter become unstable.<br><br>We present a microscopic model and simulations of cooperative effects when light interacts with a cold atomic cloud including consequent atomic motion resulting from light-mediated optical forces. Examples of cooperative behaviour have been demonstrated in these simulations including instabilities arising from inter-atomic interaction due to cooperative scattering and we particularly focus on optical binding, dynamics of multiple atom systems and the effects of pump modulation on the interaction. |
| **2.55 – 3.00** | **Elliott Mansfield** | **Title:** Quantum Transport in Kronig-Penney Modulated Nanowires<br><br>Abstract: The poster discusses theoretical results based on recent experiments studying the effects of introducing an external periodic potential (Kronig-Penney like model) on the transport properties of nanowires. Investigating the conductance as a function of the external magnetic field and the chemical potential, a waveguide model is used to understand two main experimental results: the appearance of fractures in the conductance spectrum; and the enhanced electron pairing up to high magnetic fields, which are both not seen without the modulation. |
| **3.00 – 3.05** | **Pornthep Ponchalee** | **Title:** Unaveraged Simulation of a Regenerative Amplifier Free Electron Laser<br><br>**Abstract:** A 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 broad-band, 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. |
| **3.05 – 3.10** | **Tom Bintener** | **Title:** ENTANGLEMENT TRANSITIONS FOR 1D DIPOLAR PARTICLES WITH COHERENT AND DISSIPATIVE DYNAMICS<br><br>**Abstract:** Phase transitions resulting from the interplay between coherent dynamics and measurements have been found in random circuit models, identified by a transition between area- and volume-law behaviour of the entanglement entropy of subsystems. In this project, we are considering a 1D scenario with off-site interactions, we explore a continuous-time model of coherent dynamics and dephasing, identifying signatures of such transitions for restricted system sizes. |
| **BREAK 3.10 – 3.30** | | |

| NANOSCIENCE | | |
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| **3.30 – 3.35** | **Magdalena Lesniewska** | **Title:** Single particle behaviour in a liquid crystal microfluidic channel<br><br>**Abstract:** Liquid crystals are materials that have an intermediate state of matter with properties in between a fluid and a crystal. The molecules within are well ordered with the resulting internal structure called a director field that can be influenced by electric fields or flow. The presence of the internal order changes the properties of the material in comparison to a simple fluid. Those differences are investigated by inserting a particle and simulating its behaviour in a microfluidic channel. |
| **3.35 – 3.40** | **Shannan Foylan** | **Title:** Characterising an evanescent field for large field of view microscopy<br><br>**Abstract:** Conventional fluorescence microscopy forfeits high resolution detail for a large field of view. In cellular imaging, this translates to reducing statistical data over populations of cells. The Mesolens is a specialist multi-immersion objective lens with a lateral FOV of 36 mm^2, a working distance of 3 mm, a lateral resolution 700 nm and an axial resolution of 7 µm. To extend the axial resolution of the Mesolens, an illumination method based on the established Total Internal Reflection Fluorescence (TIRF) microscopy technique is being designed. We present details of the MesoTIRF arrangement together with novel evanescent field characterisation techniques. |
| **3.40 – 3.45** | **Petros Hadjichristodoulou** | **Title:** Adaptive Optics Multi-Purpose Light-Sheet Microscope for Imaging Freely Moving Living Organisms<br><br>**Abstract:** We present an adaptive optics light-sheet fluorescent microscope with a dual illumination and single detection configuration designed for imaging within 2mm field of view with an axial resolution of 9 $\mu$m and a lateral resolution of 2.9 $\mu$m. Adaptive optics are also implemented in both the illumination and detection arms with a SLM, a deformable mirror and a Shark-Hartmann wavefront sensor, responsible for light sheet manipulation and aberration correction. |
| **3.45 – 3.50** | **Mollie McFarlane** | **Title:** Characterisation of a deep ultraviolet light emitting diode emission pattern via fluorescence<br><br>**Abstract:** The emission pattern of an LED is the angular distribution of emission intensity and can be measured using a camera, although this is difficult to obtain in deep-UV LEDs due to the low sensitivity of cameras at short wavelengths. We report a method which overcomes this problem by using fluorescence to convert UV radiation into visible light such that it can be detected by a standard camera. We determine that the emission pattern of the LED is consistent with the predicted trend to an accuracy of 99.6%. We also demonstrate the ability of the technique to distinguish between LED packaging types. |
| **3.50 – 3.55** | **Jordan Murray** | **Title:** Optical Mesoscopy of Streptomyces<br><br>**Abstract:** Streptomyces are prolific producers of antibiotics with a unique multicellular morphology unusual to bacteria. Streptomyces colonies are large (1-10mm) and densely packed with hydrophobic aerial hyphae. This poses challenges for imaging and to date no three dimensional images of entire colonies exist within the literature. Using the Mesolens, we present a three dimensional scan of an entire Streptomyces coelicolor colony. |
| **3.55 – 4.00** | **Natakorn Sapermsap** | **Title:** Fluorescence lifetime detection in flowing cells<br><br>**Abstract:** The lack of sensitive and affordable tools for rapid and reliable diagnosis remains an important obstacle to reducing cancer mortality. Frequently a biopsy is performed but involves lengthy multiple processes and costly reagents. We present a rapid flow cytometry platform with time-resolved detection using the novel single-photon avalanche diode (SPAD) to facilitate tumour cell differentiation using our novel mRNA nanoprobes. We use the centre-of-mass method (CMM) and phasor plot for speedy fluorescence lifetime estimation. |
| **4.00 – 4.05** | **Eliana Battistella** | **Title**: Light Sheet Fluorescence Microscopy for Mesoscale Imaging<br><br>Abstract: A static light sheet can be used for fast mesoscale imaging in combination with the Mesolens. The limitation in terms of thickness and Rayleigh length due to the use of Gaussian beams can be overcome by producing a non-diffractive beam. We report a method to generate an Airy-like beam with a combination of aspheric optical elements. This results in a static light sheet thinner than 10 µm, and able to cover the entire Field Of View of the Mesolens. We demonstrate the possibility of coupling this light sheet setup with the Mesolens and imaging biological specimens. |
| **4.05 – 4.10** | **Douglas Cameron** | **Title:** Nanoprobing<br><br>**Abstract:** Semiconductor device miniaturisation creates many characterisation challenges. To combat some of these, we have installed a nanomanipulation setup in a scanning electron microscope. Allowing for fine control (0.5nm) of two fine probe tips (radius > 15nm). We can use these conductive probes to form dynamic contacts, allowing us to measure and manipulate small structures. Here we demonstrate the electrical, optical and mechanical measurement capabilities of our new instrumentation. |

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| **4.10 – 4.15** | **Ryan Corbyn** | **Title:** Towards using nanodiamonds as a temperature probe within live cells<br><br>**Abstract:** The focus of this project is to utilise nanodiamonds as a probe for measuring temperature changes within live cells. Fluorescent nanodiamonds are a bio-compatible nanomaterial that can be attached to sub-cellular structures without impairing the cells normal function. In this work we present the use of optically detected magnetic resonance experiments for determining the temperature dependence of the microwave resonant frequency of the nitrogen-vacancy centre within 90nm nanodiamond samples. |
| | | **IoP** |
| **4.15 – 4.20** | **Miles Toon** | **Title:** Strain Managed GaN LED Structures for 3D Transfer Printing<br><br>**Abstract:** Growth of GaN on silicon enables large-scale manufacturing of LEDs and other devices, but also introduces challenges in wafer and device bowing. For hybrid integration by transfer printing [1], the flatness of membrane devices released from the substrate is already crucial. Superior flatness control will underpin novel mechanical assembly routes with multi-layer stacking, for example to fabricate resonant cavity LEDs. Herein, improvements in flatness are demonstrated through an optimised ammonia pre-dose applied to silicon substrates before starting III-nitride growth [2].<br><br>We present curvature measurements on 100 x 100$\mu m^2$ membrane devices, both as-fabricated with mechanical supports, and after transfer printing. Commercial LED wafer material was compared with similar wafers purpose-grown for transfer printing, building upon earlier optimisation with unipolar transistor wafers. Optical profileometry results show positive correlations between original wafer bow and the radius of curvature (ROC) of suspended LED membrane devices. The smallest bow achieved across a 150-mm LED wafer was 6 µm, concave with respect to the growth surface, resulting in a ROC of 1.8 ± 0.07mm for suspended devices, which were bowed in the same sense. Suspended devices were transferred using elastomer stamps to a silicon receiver substrate. The ROC values increased by a factor of 1.5 for the custom-grown samples after such printing, and remained constant for the commercial material.<br><br>The reduction in ROC for transfer printed GaN membrane devices through growth optimisation paves the way for future scalable manufacturing and assembly of multi-layer devices.<br><br>[1] B. Corbett et al. “Transfer print techniques for heterogeneous integration of photonic components”. In: Progress in Quantum Electronics, Volume 52 (2017), p. 1-17. https://doi.org/10.1016/j.pquantelec.2017.01.001<br><br>[2] A. Kadir et al. “Influence of substrate nitridation on the threading dislocation density of GaN grown on 200 mm Si(111) substrate”. In: Thin Solid Films, Volume 663 (2018), p. 73. Doi: 10.1016/j.tsf.2018.08.011 |
| **4.20 – 4.25** | **Martin David Lee** | **Title:** Diamond Cooled, Compact, Monolithic-Cavity Semiconductor Disk Lasers<br><br>**Abstract:** Modern quantum optics experiments are continually pushing the performance requirements for stable, narrow-linewidth lasers at novel wavelengths. Semiconductor disk lasers (SDLs) are ideal candidates to enable future quantum technology due to their inherently low noise operation. To remove environmental noise, a rugged, monolithic-cavity SDL has been constructed with an emission wavelength at 690.3 nm. Using a right-angle prism, the oscillating laser field is contained within an air-free cavity by two total internal reflections. The device uses commercially available optics, including an unoptimised 0.2% output coupling mirror, and has a pump limited output power of 40 mW. It is hoped that this monolithic platform will provide stable and narrow free-running laser performance for future targeting of the neutral strontium optical clock and cooling transitions at 698 nm and 689 nm respectively. |
| **4.25 – 4.30** | **Emma Butt** | **Title:** 3D honeycomb structures for high resolution photovoltaic retinal devices<br><br>**Abstract:** Retinal degeneration diseases, such as Age-Related Macular Degeneration, are some of the leading causes of severe sight loss worldwide. High-resolution retinal prosthetics aim to restore the sight lost by patients with this condition through electric stimulation of the remaining retinal cells. Pixel size corresponds to the resolution that is possible, however for small devices, photoactive area, impedances, and the spherical expansion of the electric field produced becomes a limiting factor. We investigate electrically active 3D honeycomb return electrodes surrounding each pixel, aligning the electric field vertically and allowing for migration of retinal cells into the 3D cavity. We have carried out COMSOL simulations, comparing 3D honeycomb device with planar devices. These simulations have shown a reduction by a factor of 87 of the intensity thresholds for this 3D honeycomb structure. This shift should enable high resolution retinal prosthetics. We have also achieved the fabrication of 3D honeycomb walls in gold using thick high aspect ratio photoresist and electroplating with the correct dimensions for integration with existing microelectrode arrays and photovoltaic subretinal prosthesis. |

# PLASMAS

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| **4.30 – 4.35** | **Lewis Boulton** | **Title:** Seeded-Plasma Afterglow Diagnostic @ FLASHForward<br><br>**Abstract:** It has been observed that the enhanced plasma relaxation light due to the interaction of a particle driver beam and a laser generated plasma column is an effective laser-to-beam synchronisation diagnostic [1]. An overview of this 'Seeded-Plasma Afterglow' diagnostic is presented, in the context of the FLASHForward facility at DESY, Hamburg. |
| **4.35 – 4.40** | **Ruairidh McArthur** | **Title:** Lab based axion searches<br><br>Abstract: The traditional axion light-shining-through-a-wall (LSW) experiment is modified by incorporating plasma techniques to amplify signal strengths. A longitudinally magnetized plasma is used such that when stimulated Raman scattering (SRS) is induced the electromagnetic field is amplified, providing an increased source for the axion. |
| **4.40 – 4.45** | **Alastair Nutter** | **Title:** Plasma Afterglow & Plasma Torch at the HZDR facility<br><br>**Abstract:** Previous work at the SLAC facility, USA, has demonstrated the potential for the measured plasma recombination light to be used as a spatio-temporal synchronization diagnostic for laser and electron beams. An overview of the development of this diagnostic at both Linac (CLARA) and hybrid LPWFA facilities (HZDR) will be presented. Plasma Torch offers a highly tunable and effective method of electron injection for wakefield accelerators, and further discussion will be given to the implementation of this scheme in a hybrid LPWFA setup for the first time. |
| **4.45 – 4.50** | **George Holt** | **Title:** Re-imagining optical devices: a femtosecond, plasma-based waveplate<br><br>**Abstract:** The growing field of plasma optics is attracting increasing attention due to its potential to provide optical elements capable of withstanding incident laser intensities ~3 orders of magnitude greater than current solid-state devices. Recent advances include the ultra-high gain Raman amplifier [1, 2] and solid-density surface plasma holograms [3]. A plasma density grating can be generated in underdense plasma using two counter-propagating laser pulses [4]. The ponderomotive force of the beat of the pump laser fields causes electron bunching, which establishes a periodic space-charge field that drives ions to form a grating. The resulting structure exhibits transient birefringent properties that may be used to manipulate the phase of a probing laser pulse [5]. We present the first demonstration of the formation of such a plasma density grating at high power and show its action as a tuneable, time-dependent waveplate for a femtosecond probe laser. These results show the promise of plasma-based optical devices and lay the foundation for their use as robust, tuneable and transient elements.<br><br>[1] Malkin, V. M., Shvets, G. & Fisch, N. J., Fast Compression of Laser Beams to Highly Over-critical Powers. *Phys. Rev. Lett.* 82, 4448-4451 (1999).<br>[2] Vieux, G., et al., An ultra-high gain and efficient amplifier based on Raman amplification in plasma. *Sci. Rep.* 7, 2399 (2017).<br>[3] Leblanc, A., et al., Plasma holograms for ultrahigh-intensity optics. *Nat. Phys.* 13 440-443 (2017).<br>[4] Sheng, Z.-M., Zhang, J. & Umstadter, D., Plasma density gratings induced by intersecting laser pulses in underdense plasmas. *Appl. Phys. B* 77, 673-680 (2003).<br>[5] Lehmann, G. & Spatschek, K. H., Plasma-based polarizer and waveplate at large laser intensity. *Phys. Rev. E* 97 063201 (2018). |
| **4.50 – 4.55** | **Kieran Wilson** | **Title:** Simulations of a helicon plasma in the inductively coupled mode<br><br>**Abstract:** Numerical simulations of a helicon plasma source (under construction) for non-linear microwave coupling experiments are presented. The inductive mode of operation (sans static B-field) has been charecterised using COMSOL's finite element, mixed frequency/ time domain, fluid representation of an inductively coupled plasma. Results indicate potential plasmas of ne ~ 10^15 - 10^17 m^-3 and Te of a few eV for 1 - 30 MHz RF at a few hundred watts to a few kW. |