Physics 2nd Year Poster Session – 19th August 2021

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ROOM A			
Poster (room.number)	**Student Name**	**Title/Abstract**	**Supervisor**
A.1	**Abubakr Qaasim**	Quantum memory: Coupling spins in SiC to a Superconducting Resonator Quantum computing requires long-term memory storages. A spin-active defect in SiC coupled to a superconducting resonator is a candidate for such a quantum memory for superconducting quantum circuits. Defects in SiC are created by bombarding SiC with carbon atoms which create silicon or carbon vacancies. These defects are spin active and the divacancies which will be used have a spin triplet character. Applying a static magnetic field produces a two-level system where quantum information is stored and transferred from the superconducting resonator. This presentation will reveal results of the resonators that will be used, which shows a resonance at 3GHz.	Rossi
A.2	**Alan Bregazzi**	Grating magneto-optical traps in MEMS vacuum cells The development of the grating magneto-optical trap (GMOT) has allowed large reductions in the size and complexity of laser cooling. By coupling GMOTs with microfabricated MEMS vacuum cells we aim to reduce the size of laser cooling down to the chip-scale by replacing the traditionally large vacuum chambers required to maintain high vacuum.	Riis
A.3	**Alana Horne**	Investigating electron temperature scaling in tight-focus ultra-intense laser-solid interactions X-rays and protons produced in laser interactions have potential applications in imaging, ion therapies, etc. The electron dynamics in these interactions govern the radiation produced therefore measurements of electron properties, such as energies and flux, are vital. As we achieve higher peak laser intensity we require investigation of the influence of such on the electron population. A way of indirectly measuring the electron flux and temperature (average energy) is to characterise the bremsstrahlung x-rays they produce. We find that x-ray and electron temperatures scale slower with intensity than expected.	McKenna
A.4	**Alexander Blanchard**	Hyperspectral Imaging in feature identification for µ-LED based mask-less photolithography Intelligence is a key part of any autonomous system. In micro-scale photolithography, this can manifest in positioning, or identifying features on a sample. By adding a spectrometer to a micro-photolithography system, we have managed to tell apart similarly coloured microscale markers, via Hyperspectral Single Pixel Imaging. We present recent results using this technique, not only for identification, but also in free-space imaging using µ-LEDs. In the future, full integration into the photolithography system will allow custom structures to be cured depending on the marker present.	Dawson
A.5	**Allan McWilliam**	Free-Induction-Decay Magnetometry with Co-propagating Laser Sources We explore the construction and sensitivity of the obtained signals from an optically pumped magnetometer operating in a free-induction-decay mode. We implement a co-propagating dual-laser system in this configuration to create a net spin polarisation through optical pumping in a 1.5 mm thick microfabricated Cs vapour cell. The effect of the optical pumping light can be tailored and enhanced for magnetic field strengths close to that of the Earth's by employing synchronous amplitude modulation. The acquired signals, detected with a slightly detuned probe beam which allows an observation of the free spin precession of the Cs atoms are presented and analysed.	Riis

A.6	**Andrew Robertson**	Coarse-Grained Simulation of DNA The coarse-grained DNA model oxDNA allows for thermodynamically accurate simulation of DNA structures with drastically reduced degrees of freedom. DNA-based hydrogels have been shown to have many practical applications, and can form larger structures by finely tuning the temperature. By simulating these polymers while applying metadynamics, the free energy landscape of the molecule at various temperatures can be fully explored.	Hendrich
A.7	**Antony Pike**	Atom Interferometry for Inertial Sensing Atom interferometry offers precision measurements of various phenomena including rotation via the Sagnac effect, cold atoms and in particular Bose-Einstein condensates (BECs) offer an advantage in making such measurements due to their high phase-space density and narrow velocity distributions. We discuss our existing experiment and the planned improvements which will increase our sensitivity to phase shifts caused by rotation.	Arnold
A.8	**Antonio Lofrese**	Measurement of absorbed laser energy in relativistically transparent laser-dense plasma interactions In a laser-solid interaction, the measurement of laser energy absorption can be obtained experimentally through the use of optical diagnostics which quantify the components of light not absorbed. The coupling of laser energy to electrons is fundamental to almost all topics in intense laser-plasma interactions, including laser-driven ion acceleration. This work reports, for the first time, measurements of the degree of absorption in plasma that undergoes relativistic transparency through the use of an integrating sphere and scatter screens as diagnostic tools. In this regime the target becomes transparent which allows the transmitted laser beam to irradiate the inner walls of the sphere resulting in damage which compromises the operation of the sphere.	McKenna
A.9	**Beatrice Bottura**	Structural changes in E. coli biofilms under different nutrient availability and substrate stiffness observed with the Mesolens The morphology and internal structure of E. coli biofilms were studied using widefield epi-fluorescence microscopy with the Mesolens. Substrate properties (nutrient availability and stiffness) were varied to investigate their effect on the biofilm at the macro-scale, and on their internal organisation. Nutrient availability affected biofilm size, as well as width and distribution of intra-colony channels, whereas substrate stiffness did not seem to have an effect on these quantities.	McConnell
A.10	**Brendan Keliehor**	Towards a Two-photon 87Rb Portable Atomic Clock We present the progress toward creating a compact, portable optical atomic clock using a narrow-linewidth, 1556 nm telecoms fibre laser, frequency-doubled to 778 nm to resolve the F = 2 → F' = 4 hyperfine feature of the $5S1/2 \rightarrow 5D5/2$ two-photon transition in ^{87}Rb. An initial study was carried out using an external cavity diode laser, locked to this transition using Doppler-free spectroscopy. Stability measurements of the laser frequency have yielded a short-term stability of 8×10^{-11} at 1 s and 2×10^{-12} at 1000 s.	Riis
A.11	**Daniel Hunter**	Assessing the impact of secondary fluorescence on X-ray microanalysis results from semiconductor thin films The impact of secondary fluorescence on the material compositions measured by X-ray analysis for multi-layer semiconductor thin films is assessed using simulations performed by the DTSA2 and CalcZAF software tools. Three technologically important examples are investigated: AlxGa1-xN layers on either GaN or AlN substrates, InxAl1-xN on GaN and (SnxGa1-x)2O3/Si. Trends in the differences caused by secondary fluorescence are explained in terms of the propensity of different elements to reabsorb either characteristic or bremstrahlung X-rays and then to re-emit the characteristic X-rays used to determine composition of the layer under investigation. The overall impact is shown to be very small with a change of approx 0.07 molar percent for Al0.3Ga0.7N/AlN layers and a maximum change of 0.08 at% in the Si content of (SnxGa1-x)2O3/Si layers. This provides confidence that previously reported wavelength dispersive X-ray compositions are not compromised by secondary fluorescence.	Martin
A.12	**Daniel MacLure**	10.32 Gbps Wavelength Division Multiplexing Using Ultraviolet (UV) Micro-LEDs Here we present a Wavelength Division Multiplexing (WDM) set up using three high bandwidth UV microLED (µLED) devices, emitting at peak wavelengths of 285, 317 and 375nm. Using Orthogonal Frequency Division Multiplexing (OFDM) and Quadrature amplitude modulation (QAM), data rates of 4.17, 3.02 and 3.13 Gbps were achieved from the 285, 317 and 375 nm devices, respectively, for a combined data rate of 10.32 Gbps which to our knowledge is one of the highest reported in UV communications using LED technology.	Dawson

A.13	**David Campbell**	Stable and Quality Boosted Electron Beams from Plasma Wakefield Accelerators Particle accelerators have been at the forefront of scientific discovery for over a century. While laser-plasma based technology realises compact set-ups, stable beam outputs are not commonly observed in experiments. Here particle in cell simulations demonstrate a pathway towards predictable energy gain Hybrid Accelerators, by combining two non-linear Laser (LWFA) and Plasma (PWFA) Wakefield Accelerators, into a stability and brightness booster. Near term LWFA driver beams are synchronised with a colinear-Plasma Photocathode (Trojan Horse) for witness bunch injection in the PWFA stage. The witness bunches exhibit Brightness values that surpass current generation linear accelerators by orders of magnitude.	Hidding
A.14	**Edward Irwin**	Single beam caesium SERF magnetometry for MEG Optically pumped magnetometers (OPMs) have reached aT/√Hz sensitivity in the spin exchange relaxation free (SERF) regime. Achieving these sensitivities allows the devices to be used for application such as magnetoencephalography (MEG). MEG signals are produced in the brain, being able to understand them could lead to a better understanding of how it functions.	Griffin
A.15	**Eleni Margariti**	High-accuracy automated inspection method for transferred devices The integration of opto-electronic devices from multiple different material platforms allows the production of advanced systems with improved operating characteristics, low power consumption, and scalable manufacture. A major challenge in the manufacturing of these devices is the inspection of the transfer yield and accuracy. Here, we present a computational image processing method for large-area analysis using relatively low magnification optics. Using an image processing analysis technique, based on a cross correlation method, individual device central coordinates and rotational orientation can be calculated with sub-micron accuracy, even where the minimum optical resolution of the microscopy system is in the micron range.	Strain
A.16	**Evangelos Matzoukas**	Generation of relativistic mid-IR laser pulses with the use of two co-propagating laser pulses Since the laser was invented by 1960 it has become a powerful and important tool for various applications in fundamental science, industry and medicine. Ultrashort intense mid-IR pulses are particularly useful for ultrafast and high field physics, chemistry, biology such as attosecond pulse radiation, infrared spectroscopy, high resolution imaging of ultrafast molecular dynamics and filamentation. To generate intense mid-IR laser pulses with high efficiencies and controllable spectra we use two co-propagating laser pulses in an underdense plasma and we examine the relation of the trailing pulse duration and the effect it has on the mid-IR pulse generation.	Sheng
A.17	**Ewan Dolier**	Bayesian Optimisation of a Laser-Driven Ion Acceleration Source Using Automated PIC Simulations Protons accelerated during a high intensity laser-target interaction boast properties which make them an ideal source for applications such as oncology and nuclear fusion. The maximum proton energy of these sources must be increased before applications can be realised, and so this property was optimised in Particle in Cell (PIC) simulations where laser-target parameters were varied linearly, and by using Bayesian optimisation.	McKenna
A.18	**Grant Henderson**	Mutual self structuring and novel Kerr-like fragmentation in coupled light/matter-wave interactions We investigate coherent vortex beams propagating through a matter-wave i.e., a Bose-Einstein Condensate (BEC) [1]. We present the results of propagating vortex beams with different values of orbital angular momentum (OAM) in the case of a self-focusing medium and repulsive BEC interactions. We show the novel formation of coupled optical and BEC solitons, despite repulsive BEC interactions, and demonstrate that both light and BEC solitons carry angular momentum. Despite fundamental differences between our model and propagation in a Kerr medium [2, 3], the results are in remarkable qualitative agreement, and we find that the number of solitons depends on the OAM of the vortex light beam. [1] M. Saffman and D. V. Skryabin, in Spatial Solitons (Springer, 2001) pp. 433. [2] W. J. Firth and D. V. Skryabin, Phys. Rev. Lett. 79, 2450 (1997). [3] A. S. Desyatnikov and Y. S. Kivshar, Phys. Rev. Lett. 87, 033901 (2001).	Yao

ROOM B

Poster (room.number)	Student Name	Title/Abstract	Supervisor
B.1	**Ieva Cepaite**	Optimal Counterdiabatic Driving The ability to adiabatically prepare quantum states is fundamental in both experimental endeavours and in quantum computing protocols. In practice such state preparation schemes are difficult to implement and result in losses due to adiabatic limitations requiring infinitesimally slow rates. We introduce a new method for improving quantum state preparation and manipulation far from the adiabatic limit by combining ideas from quantum optimal control and approximate counterdiabatic driving techniques. We benchmark and analyse the resources required in our approach.	Daley
B.2	**Jack Goodman**	Onset time of relativistic induced transparency as a robust metric for the optimisation of laser-driven proton acceleration Laser-driven proton acceleration from solid targets is most effective for ultrathin foils that undergo relativistic self-induced transparency (RSIT) during the interaction. We demonstrate through a comprehensive series of particle-in-cell simulations that the onset time of transparency of the foil to the laser pulse is a robust metric for the optimisation of the maximum proton energy in ultra-high contrast laser-solid interactions. The onset time of RSIT can be controlled by varying the laser polarisation or by pre-expanding the target with a secondary laser pulse, therefore providing alternative routes to optimise the proton energies optically.	McKenna
B.3	**Josh Walker**	Dynamics of Optomechanical Droplets Optomechanical interactions between light and cold atomic gases can produce a range of interesting phenomena, including spontaneous formation of patterns in both the optical intensity and the atomic density [1,2]. The existence of quantum pressure in a Bose-Einstein Condensate (BEC) introduces an additional component to the interaction which is not present in the case of a thermal gas. The repulsive nature of the pressure can result in the formation of stable “droplets” – i.e. localised structures of BEC density and optical intensity [3]. Using numerical simulations, we investigate the dynamical behaviour of these droplets in a single mirror feedback configuration. We show that stable droplets can form in this system, can undergo uniform motion and acceleration, and that their motion can be controlled by adjusting the feedback mirror alignment. As the optical and BEC structures which constitute the droplets are mutually dependent, observation of the optical structure could provide a means of continuously and non-destructively monitoring the BEC density distribution. [1] G. Labeyrie et al., Nature Photonics 8, 321 (2014). [2] G. R. M. Robb et al., Phys. Rev. Lett. 114, 173903 (2015). [3] Y.-C. Zhang et al., Phys. Rev. Lett. 121, 073604 (2018).	Robb
B.4	**Liam Selman**	Progress on an experiment to study microwave coupling in plasma Coupling electromagnetic waves in plasma can give rise to complex nonlinear processes. Some of these are important for applications including fusion. This project aims to investigate a range of these processes including Raman, Brillouin coupling relevant to laser plasma interactions and beat wave cyclotron relevant to magnetically confined fusion in a cool tenuous plasma where diagnostics are relatively easy. The large plasma has been created in inductive mode and density estimated at 10^{16} m^{-3} by microwave interferometry. Microwave antenna have been fabricated to drive the plasma with powerful microwave beams.	Ronald

B.5	**Lorne Rutherford**	Plasma Wakefield Acceleration – Plasma Photocathode "Trojan Horse" Plasma photocathode injects electron bunches into the accelerating phase of the plasma wake using the energy from a laser pulse to liberate electrons. This means that the injected electrons are in a sense "decoupled" from the plasma wave. Currently my project consists of running PIC simulations of Trojan Horse and attempting to more clearly define the ideal parameter space for moving on to experiment eventually.	Hidding
B.6	**Madjid Hadjal**	Artificial Neural Networks for Chlorophyll a Retrieval Chlorophyll a is used as a measure of algal biomass and is an essential climate variable. Ocean colour satellites have operated continuously since 1997 and measure reflectance at the top of atmosphere (TOA). Atmospheric correction removes 90% of TOA signal with remainder used to estimate Chlorophyll using bio-optical algorithms. Standard Chlorophyll algorithms work well in clear ocean waters, but perform poorly in turbid coastal waters where sediment scattering disturb the atmospheric correction process and the algorithm performances. Here we develop a neural network (NN) approach to overcome atmospheric correction issues and deliver improved chlorophyll estimates for coastal waters.	McKee
B.7	**Marcin Mrozowski**	Instrumentation and Systems Engineering for Optically Pumped Magnetometry Atomic magnetometry presents a new outlook into ultra-high sensitivity magnetic field measurements. With an advent of portable, low power devices which are capable of operation at elevated or room temperatures with sensitivities approaching these of SQUIDs (Superconducting QUantum Interference Device), offering access to application such as magnetocardiography and magnetoencephalography, which were previously reserved for bulkier systems. We present the instrumentation around a Cs based SERF magnetometer that enables higher performance while at the same time minimises SWaP (Size Weight and Power).	Griffin
B.8	Matej Hejda	Neuromorphic Nanophotonic Systems for Artificial Intelligence In this poster, I will introduce numerical and experimental results on neuron-like excitable spiking behaviour in two different classes of photonic and optoelectronic systems: off-the-shelf semiconductor lasers (VCSELs) and circuits based on resonant tunnelling diodes (RTDs). I demonstrate how neuromimetic rate-coding functionality can be used in VCSELs to achieve an all-optical, high speed spiking encoder for digital image data, and introduce a model of a optoelectronic spiking neural network based on physical model of monolithic RTD nanosized devices. The RTD-based network can be trained to perform spatiotemporal spike pattern classification with a custom, spike-timing dependent network learning rule.	Hurtado
B.9	**Mateusz Mrozowski**	A practical compact source of heralded single photons for a simple detection LIDAR We present method of heralding single photons using compact and inexpensive pulsed laser system. Photon-pair is generated through spontaneous four-wave mixing in commercial birefringent optical fiber, pumped with transform limited picosecond pulses with GHz repetition rates derived from single mode laser diode using cavity enhanced optical frequency comb.	Pritchard

B.10	**Matt Mitchell**	Quantum simulation with driven matter waves in optical lattices Computational simulations of quantum many-body systems are limited by computer performance. Instead, we use ultra-cold atoms to simulate transport in many-body systems in condensed matter. We use an atomic gas of Caesium in optical lattice potentials, which are created by interfering laser beams, to study periodically driven matter waves. Recently, we demonstrated the existence of matter-wave Floquet solitons. Floquet solitons are dispersionless wave packets in lattice potentials, that evolve without changing their shape. They gain their stability from a rapid micromotion in momentum space. We demonstrated the stability of Floquet solitons in momentum and position space over 1s.	Haller
B.11	**Nils Wessling**	Versatile GaN micro optic devices for heterogeneous integration Heterogeneous integration of GaN microlenses paves the way to increased light coupling into highly-refracting semiconductors such as Si, SiC, diamond and others. The lenses are fabricated in standard photoresist by thermal reflow and transfered into GaN by dry etching. The employed GaN-on-Si layer stack allows the generation of suspended devices, which can be placed on a substrate of choice via micro-transfer printing. Nearly spherical microlenses with 3-15 µm diameter and up to 1.8 µm height with surface roughness below 2 nm have been demonstrated. Future work will include greyscale lithography for arbitrary surface profiles and optical characterisation of printed devices.	Strain
B.12	**Pierre Julien**	Diamond Based Amplifier for Eye-safe Laser Applications We report a diamond master oscillator power amplifier (D-MOPA) that uses a diamond Raman laser cavity to amplify a seed of wavelength 1515 nm. This is, to our knowledge, the first time that such an amplifier has been demonstrated using diamond. It achieved a maximum amplification factor of x1.4 on a proof-of-concept setup. From this, analysis using lab experiments and computer simulation of theoretical models was done to find potential improvements. This showed that parasitic 2nd Stokes output, pump jitter, and low seed pulse energy greatly limited the potential of the setup with ideal conditions in simulations showing a theoretical amplification of x145.1.	Kemp
B.13	**Rachel Dawson**	Machine Learning Optimisation for a Zero-Field Magnetometer The measurement of magnetic fields in the human body is having an impact in healthcare applications [1,2], with Optically Pumped Magnetometers (OPMs) demonstrating suitable signal resolution for these applications [3]. We have developed a single-beam caesium (Cs) zero-field OPM with a view to miniaturising this device for medical applications. To optimise for sensitivity, we have implemented four automated machine learning (ML) strategies, which have been effective in significantly improving the sensors sensitivity. [1] Boto, Elena, et al. PloS one 11.8 (2016): e0157655. [2] Wyllie, Robert, et al. Optics letters 37.12 (2012): 2247-2249. [3] Boto, Elena, et al. Nature 555.7698 (2018): 657-661	Riis
B.14	**Richard Murchie**	Quantum illumination for practical unspoofable LIDAR Use of non-classical photon number correlated light in a LIDAR scheme with detectors suitable for free-space optics promises advantages compared to conventional LIDAR. These include an increased signal to noise ratio, covertness, and spoofing prevention. The scheme uses an experimentally-feasible approach, in order to guide a practical quantum LIDAR.	Jeffers
B.15	**Sean Bommer**	In-situ transmission measurement module for optical feedback during transfer printing A limitation in any hybrid integration process is the difficulty to evaluate a components behaviour during placement, without which one cannot know if critical coupling has been achieved in real time. An in situ device monitoring system has been designed using a spatially controlled laser injection spot and a tuneable wavelength source. Live monitoring of the effective device transmission can be achieved by coupling to vertical grating elements on-chip during a print cycle. This paper discusses how use of original equipment manufacturer supplied optical hardware and consumer grade electronics are used to build such a system.	Strain

B.16	**Stacey Connan-McGinty**	Modelling Seasonal Light in the Arctic Ocean Surface Average Temperatures in the Arctic are increasing at twice the rate of the global average, resulting in a reduction in sea ice extent and thickness, reduced snow cover and increasing cloud cover. These changing environmental conditions may alter the magnitude and spectral composition of light entering the ocean. Light plays a crucial role in marine ecosystems and any changes could have lasting impacts on primary production, animal behaviour and the global carbon pump. We aim to develop a seasonal hyperspectral light model to study the effects of a changing light field on primary production and animal behaviour in the Arctic Ocean.	McKee
B.17	**Steven Anderson**	Design of a VECSEL-pumped optical parametric oscillator for the generation of squeezed states of light at the telecommunications wavelengths We report a solution to generating squeezed states of light at telecommunications wavelengths by intracavity pumping a singly-resonant optical parametric oscillator (SRO) within a vertical external-cavity surface-emitting laser (VECSEL). A schematic representation of the 4-mirror VECSEL and SRO cavities are displayed along with the theoretical estimation of the intracavity VECSEL power required to reach SRO threshold. An experimental characterization of the 4-mirror VECSEL laser has also been achieved, measuring >5 W of intracavity power at the VECSEL wavelength using a 1% transmission output coupler. Based on the theoretical and experimental results displayed, we hope to meet the criteria required for reaching SRO threshold and obtaining squeezed states of light below the shot-noise-limit.	Hastie
B.18	**Willow Pring**	On Investigating LWFA as a source of X-UV When a high power, short pulse, laser passes through a plasma, the LWFA phenomena can be observed. electrons in the plasma respond faster to the ponderomotive force and evacuate a bubble structure behind the pulse. As the bubble collapses the back reaches a high negative charge density positioned next to the high positive charge density within the bubble. This electric field gradient can accelerate electrons up to >100MeV in mere mm of plasma. [1] The goal of this project is to investigate UV, X-UV and X-rays created by various mechanisms from both electrons accelerated in this way and the bubble structure itself. The author is involved with several experiments, ongoing and upcoming, to investigate various sources and types of X-UV radiation from LWFA interactions [2] The data being produced in the current experiment is already looking promising and there are plans to extend the experiment to demonstrate it's use for imaging double slits and holography targets. The upcoming experiments on FELs and WAFELS hope to demonstrate robust diagnosis of predictable, controllable, betatron radiation [3] [1] Esarey, E., Schroeder, C. B., & Leemans, W. P. (2009). Physics of laser-driven plasma-based electron accelerators. Reviews of Modern Physics, 81(3), 1229–1285. https://doi.org/10.1103/RevModPhys.81.1229 [2]Experimental investigation of the emission of high-brightness extreme ultraviolet radiation from laser-plasma interactions. Lewis Reid. Student thesis: Doctoral Thesis http://digitool.lib.strath.ac.uk/R/?func=dbin-jump-full&object_id=32714 [3] Ersfeld, Bernhard & Bonifacio, R & Chen, S & Islam, Mohammad & Smorenburg, P & Jaroszynski, Dino. (2014). The ion channel free-electron laser with varying betatron amplitude. New Journal of Physics. 16. 093025. 10.1088/1367-2630/16/9/093025	Jaroszynski

POSTER ROOMS