Physics Post Graduate Conference

Wednesday 19th August 2020

Room 2

Zoom link : https://strath.zoom.us/j/96901295623 (passcode : 087432)

Time	Student	Primary Supervisor
09:30-09:45	**David Campbell**	**Hidding**
	Hybrid Plasma Accelerators: A Pathway To Brightness Particle accelerators have become a ubiquitous tool in fundamental science, medicine, defence as well as space applications. However, while current state of the art suffers from material breakdown issues, restricting the electric field gradients produced, plasma-based technology does not. Both laser wakefield (LWFA) and plasma wakefield (PWFA) accelerators offer the potential to shrink current, km scale linear accelerator (LINAC), technology to metre scale efficient accelerator platforms that could be used for future light source applications. However, while LWFA can deliver GeV scale energies, moderate energy spread and high current beams they suffer from dephasing and focusing issues which limit acceleration lengths substantially. On the other hand, PWFA does not readily suffer from this but currently relies on real estate intensive LINAC drivers due to the beam stability these offer. Hybrid plasma acceleration(LWFA-PWFA) aims to replace the requirement for LINAC produced electron bunches and instead utilise the short, high current beams produced in an LWFA as the driver of a second PWFA stage. By combing this with the plasma photocathode (Trojan Horse) injection scheme, high brightness, high quality and reproducible electron beams could be realised in university lab scale set-ups. The stabilisation offered to LWFA-PWFA witness beams when injected via Trojan Horse to combat the inherent jitters of the LWFA produced beams is currently under investigation. An overview of hybrid wakefield acceleration along with preliminary findings from such a study will be presented.	
09:45 – 10:00	**Lorne Rutherford**	**Hidding**
	Plasma Wakefield Acceleration and the Next Generation of Light Sources This talk will look at the background and recent advances in the theory and application of plasma wakefield acceleration, particularly in advanced injection techniques such as plasma photocathode (Trojan Horse), and briefly explain how these technologies are poised to overtake conventional linear accelerator-driven XFELs as the next generation of light sources. This talk will avoid jargon and explain what these concepts mean for a wider physics/scientific audience.	

10:00– 10:15	**Matej Hejda**	**Hurtado**
	Neuromorphic nanophotonic systems for artifical intelligence My PhD project investigates neuron-like functionality in optoelectronic nanodevices, with the aim of realizing new class of light-enabled brain-inspired information processing systems. During my first year, I focused on multiple aspects of this research problem. I investigated neuromorphic information coding and task processing functionality in photonic spiking neuronal models based upon Vertical-Cavity Surface Emitting Lasers (VCSELs). I also focused on nanofabrication techniques, using the so-called transfer printing technique that allows to individually integrate nanostructures in target surfaces with high precision. Here, the focus is on integration of nanopillar structures with embedded Resonant Tunnelling Diode (RTD) elements, to be used as nanoscale optoelectronic neurons. Finally, I also conducted a preliminary study of electronic circuits based on the RTD structures, both experimentally and numerically. These structures will serve as the main building blocks of a nanophotonic neuromorphic platform.	
10:15 – 10:30	**Sean Bommer**	**Strain**
	Hybrid Integration of Photonic Resonators for Photon Pair Generation for use in Quantum Sensing. Quantum photonics is developing rapidly since the last decade, with integrated photonics set to play a key role in the future of Quantum computers. A crucial component for this platform is a source of correlated/entangle photons as they underpin many quantum logic operations. Leveraging the direct transfer print method developed in TIC @ Strathclyde we aim to build upon the well-developed silicon platform by integration of semiconductor structures stacked directly on-chip. This integration allows for more efficient non-linear processes such as four-wave mixing to be achieved in a compact package, resulting in a high efficiency production of heralded single photons. This talk discusses the underlying theory behind this project along with the initial steps took in the design of an AlGaAs micro-ring resonator and the fabrication of integrated structures.	
10.30 – 10.45	**Daniel Hunter**	**Martin**
	Correlating the composition and optical properties of the wide bandgap semiconductor AlGaN doped with Si The structural and optical properties of the semiconductor material AlxGa1-xN have been investigated using the electron microscopy techniques of wavelength dispersive X-ray spectroscopy (WDX) and cathodoluminescence (CL). Series of samples with varying growth conditions were provided by collaborators at the Technical University Berlin. Results show a strong agreement between the compositions determined by the two techniques for AlN fractions ranging between 55-63%. The measured Si dopant concentrations are compared with the changing growth conditions and the Si incorporation within the bulk material is shown to be independent of AlxGa1-xN composition.	
	Break 10:45-11:15	

11:15-11:30	**Dale Waters**	**Trager-Cowan**
	Structural analysis of cubic and hexagonal GaN grown on microstructured silicon Conventional growth methods for GaN produce the thermodynamically stable, hexagonal form of the material. However, due to inherent piezoelectric polarisation, hexagonal GaN-based light-emitting diodes (LEDs) exhibit low efficiencies in the green spectral region. The metastable, cubic form of GaN demonstrates potential to overcome this “green gap” problem. Here, micro-stripes of GaN grown on V-grooved silicon substrates [1] are studied via electron backscatter diffraction (EBSD) in the scanning electron microscope (SEM). Initial hexagonal growth fronts give rise to the formation of cubic GaN. Crystal structure, orientation relationships and local misorientation of the hexagonal growth fronts and the cubic material are determined. [1] C. J. M. Stark et al., Appl. Phys. Lett. 103, 232107 (2013)	
11:30-11:45	**Eleni Margariti**	**Strain**
	A method for large area characterization of mass transfer-printed devices. In the past decades, there has been a large investigation on integration technology, as technology pushes its limits, offering new applications and capabilities, comprising small footprint, and high density devices. Heterogeneous integrated devices provide enhanced functionality and improved operating characteristics required by the targeted application at low cost and with low power consumption. One of the biggest challenging of the current integrated technology is wafer bonding for large scale integration. This should be compatible with the CMOS and back-end technology, high precise, efficient, fast and low-cost. Several techniques have been proposed in order to achieve large scale integration, including transfer printing processes, as it is not always possible to integrate devices through growth techniques. An important step towards mass-production of photonic integrated circuits is the development of an inspection method for the printed devices, in order to access the transfer printing process in terms of accuracy and transfer yield. In this respect, we have developed a computational image processing script which can be subsequently used after the printing process and analyze a large area of the printing devices. By using only a large magnification and high resolution image of the printed devices, a fully characterization and analysis of the quality of the printing process was achieved. As a result, the statistical analysis on roll-printed light-emitting diodes (LEDs) array of 12 x 12 elements shows a parallel printing accuracy of 1.68 µm ± 0.98 µm (3σ). This appears to be a very efficient and time saving technique for data processing and analysis.	

11:45-12:00	**Pierre Julien**	**Kemp**
	Review and optimisation of a diamond master oscillating power amplifier Using a diamond master oscillating power amplifier (D-MOPA) as a final power amplifier stage to compliment an erbium doped fiber amplifier (EDFA) we aim to show that significant amplification, and thus higher output pulse energy, can be achieved at an eye-safe wavelength. This would be especially useful in the context of Doppler LIDAR as used in wind surveying. A high intracavity first Stokes field was used to provide an amplification factor of $\times$1.4 to a 1515 nm seed laser as presented in Lukasz's Dziechciarczyk thesis. This amplification was limited by pump pulse jitter, parasitic 2nd Stokes field oscillation and low output EDFA power. This report will review these problems and optimise the setup by using lab-based experiments and a program that simulates the power transfers inside the cavity. The first optimisation found was to use a longer wavelength distributed feedback diode (DFB), which is used as a seed for the EDFA, to optimise its amplification. As the Nd:YAP pump laser for the diamond cavity was found to be tuneable to 1083 nm without significant loss of pulse energy this would mean a DFB of 1520 nm. This would enable a higher EDFA output pulse energy without compromising the intracavity first Stokes power thus leading to higher D-MOPA output pulse energy. Shorter pulses with higher peak powers would also enable more efficient amplification with a theoretical amplification factor calculated to be $\times$2.65 when seed pulse was shortened to 21 ns from 100 ns. Finally, using the program it was found that a highly transmitting anti-reflection coatings on the diamond at the first cascaded Raman wavelength would enable higher amplification factors.	
12:00-12:15	**Jack Goodman**	**McKenna**
	Investigation of Laser Contrast Effects on Ion Acceleration in the Relativistic Transparency Regime for Multi-PW Scale Laser Pulses The interaction of a high intensity (>10^{18} W cm^{-2}) laser pulse with thin soild foils produces MeV ion beams, useful for applications such as radiography, hadrontherapy and fast ignition inertial fusion energy. In the near future multi-PW scale laser facilities will push the peak laser intensities available into the range 10^{22}-10^{24} W cm^{-2}, orders of magnitude higher than most experiments to date, promising much higher energy ion beams. However, for the same laser contrast levels the intensity of the laser pre-pulse will also rise. The laser pre-pulse pre-expands the target foil, generally reducing the effectiveness of the acceleration process, and may have a more detrimental effect at higher peak laser intensities if the laser contrast is not further improved. Here we present the preliminary results of particle-in-cell and radiation-hydrodynamic simulations of the laser contrast effects on ion acceleration across several orders of magnitude in laser intensity up to 5x10^{22} W cm^{-2}.	

12:15-12:30	**Alana Horne**	**McKenna**
	Influence of focal spot size on x-ray production in ultra-intense laser-plasma interactions Electrons accelerated in laser-plasma interactions produce x-rays for example via bremsstrahlung. These bremsstrahlung photons have important potential applications, however, considerably more research is required to fine-tune their production. Additionally, with the advent of higher power lasers, the influence of peak laser intensity on bremsstrahlung x-ray generation required investigation. Here, x-ray measurements from an ultra-high intensity (up to 5x10^21 W/cm2) laser-solid experiment are presented. Laser intensity was varied through changing the laser energy and focal spot size. The highest intensities, until recently not possible on current laser systems, were achieved by a significant reduction in the focal spot size via the use of an F/1 focusing plasma optic [1,2]. The effects of different laser intensity at two focal spot sizes, using the system's F/3 optic and the F/1 focusing optic, were considered. We find that the x-ray flux was up to an order of magnitude lower with the smaller focal spot and was decreased by increasing the laser intensity. Additionally, the generated bremsstrahlung spectral temperature remained constant, contradicting the predicted increase with intensity from conventionally accepted electron temperature scalings [3]. The results presented here will aid in the development and modelling of next-generation laser-driven x-ray sources. [1] Wilson, R. et al. Ellipsoidal plasma mirror focusing of high power laser pulses to ultra-high intensities. Physics of Plasmas 23, 033106 (2016). [2] Wilson, R. et al. Development of Focusing Plasma Mirrors for Ultraintense Laser-Driven Particle and Radiation Sources. Quantum Beam Science 2, 1 (2018). [3] Wilks, S. & Kruer, W. Absorption of ultrashort, ultra-intense laser light by solids and overdense plasmas. IEEE Journal of Quantum Electronics 33, 1954-1968 (1997).	
	Lunch 12:30-13:30	

13:30-13:45	**Daniel MacLure**	**Dawson**
	Deep Ultraviolet LED Devices For Few Photon Optical Communications and Imaging As light-emitting diodes (LEDs) have become ubiquitous, there has been increased interest in using these devices for other non-lighting applications such as optical wireless communications (OWC). In the past two decades deep ultraviolet (DUV- UVB 280-315 nm, UVC 100-280 nm) has become very attractive for those working on short-range terrestrial communications, as it is possible to operate in a low noise environment since most natural DUV is absorbed by the upper atmosphere. Furthermore, due to the notable scattering of DUV by air, it is possible to use this region of the EM spectrum in non-line of sight communications. This presentation will examine the characteristics of deep ultraviolet emitting micro-LEDs ranging in diameter from 20 µm to 300 µm with peak emissions around 283 nm. The optical output power and -3 dB modulation bandwidth of the pixels were measured as these characteristics are of particular importance for optical communications. The power output and Bandwidth measurements both demonstrated a clear size dependence with the smallest devices achieving bandwidths as high as 570 MHz which to our knowledge is one the highest recorded in the deep UV. Other size-dependent characteristics, such as the emission wavelength and external quantum efficiency (EQE) as a function of bias current, will be also be discussed.	
13:45 – 14:00	**Nils Wessling**	**Strain**
	Scanning magnetometry with diamond and SiC photonic devices from bulk Scanning magnetometry with nitrogen vacancy centres in diamond offers nanoscale resolution and high magnetic field sensitivity down to nT field strength under ambient conditions. We demonstrate by simulation how microlens fabrication and micropillar shaping can be used to increase the collection efficiency and therefore the signal to noise ratio, that limits the detection. On the other hand, SiC is an emerging material platform in integrated optics for non-linear and quantum applications. We aim to develop a quasi-isotropic etch process with reactive ion etching plasma tools to generate functional photonic devices from bulk and transfer them on integrated photonic circuits with a pick and place technique.	

14:00 - 14:15	**Antonio Lofrese**	**McKenna**
	Investigating the Absorption of Laser Energy in Ultra-Intense Laser-Dense Plasma Interactions Intense laser pulses (>10^{18} W/cm^2) interacting with dense plasma can be used to accelerate electrons to MeV energies over micron scale distances. These exceptionally compact sources of high energy electrons can then be used as a source of high energy ions, gamma rays, as a driver of inertial confinement fusion and as a way to study astrophysics in the laboratory. A key challenge to fully realising these compact radiation sources is to understand the underlying physics of the laser-electron absorption mechanism and to develop ways to control it. We report on an experimental investigation of the absorption of intense laser pulses which interact with initially solid density aluminium foil targets ranging in thickness from 6um to 20 nm. In this range the laser absorption mechanism transitions from one dominated by surface processes to one where volume processes dominate, due to the onset of so-called relativistic induced transparency [1]. In order develop further control over when this transition between surface and volume processes occurs, we also investigate a scheme of modifying the target density profile by using two temporally separated laser pulses and measuring the resulting change in the laser absorption. In both cases, we report on the methodology developed to date to measure the total absorbed energy under these condition and compare the results from the previous work and establish the key issues in that measurement. **[**1] S. R. W. e. al., "Energy absorption and coupling to electrons in the transition from surface- to volume-dominant intense laser-plasma interaction regimes," New Journal of Physics, 2020.	
14:15 - 14:30	**Ewan Dolier**	**McKenna**
	Calculating the Fraction of Light Transmitted when an Ultra-Thin Target Undergoes Relativistic Self-Induced Transparency The interaction of ultra-high intensity laser pulses with solid density targets motivates a wide research field spanning several decades. Such interactions are interesting due to the wide variety of secondary sources produced, such as high energy ions, fast electrons, and x-rays. Owing to this versatility and the relatively compact nature of the systems, laser-driven particle accelerators are envisioned to be impactful in several global industries. At sufficiently high intensities, solid density targets are ionised by the laser electric field, forming an expanding quasi-neutral plasma at the target front surface. Under certain conditions the incident laser can propagate through the expanded plasma and emerge from the target rear in a process known as relativistic self-induced transparency (RSIT). It is important to measure the fraction of incident laser energy transmitted when RSIT occurs during an interaction, as this indicates the onset time of the mechanism in relation to the peak intensity of the pulse. Measurements of this parameter were made using the Gemini laser system at the Rutherford Appleton Laboratory (RAL) and were higher than expected compared to previous measurements, made under similar interaction conditions. This was investigated, and it was found that significant spectral broadening (likely due to self-phase modulation through optics before light was detected) was present in the captured data. As such, a method for calculating the fraction of energy transmitted through an ultra-thin target was developed, which notably takes full account of any spectral broadening which occurs before transmitted light is detected. Using this method, the fraction of energy transmitted was analysed as a function of several key laser-target interaction parameters.	
14:30 - 14:45	**Willow Pring**	**Jaroszynski**

	WAFEL - the Wake-field Accelerator, Free Electron Laser The purpose of this Ph.D. is to demonstrate the feasibility, by simulation and experiment, of using the wake-field bubble created in a laser-plasma interaction as an ion channel to electrostatically oscillate electrons in the transverse plane, resulting in radiation emission by the same mechanisms employed in the free-electron laser (FEL). The theory for this wake-field accelerator free-electron laser (WAFEL) has been linearly described by members of our group and the experimental realisation relies on several cutting edge techniques for accurately creating and placing a small bunch of relativistic electrons. Progress made thus far includes successful simulations to explore possible regimes and an ongoing experimental campaign to investigate the production of femtosecond electron bunches.	
Break 14:45-15:15		
15:15-15:30	**Steven Anderson**	**Hastie**
	Design of a VECSEL-pumped OPO for the generation of squeezed (quantum) states of light Optical parametric oscillators (OPO's) are laser devices commonly used as coherent, frequency tunable light sources for accessing wavelength regions that are unable to be accessed by conventional laser sources. Since OPO devices are the catalyst for producing spontaneous parametric down conversion (SPDC), which is an established technique for producing quantum states of light, these devices are an attractive solution for generating these light states. Here, we report an approach to generating squeezed states of light at fibre communications wavelengths (1.5μm) by pumping an OPO within a visible vertical external-cavity surface-emitting laser (VECSEL). The theoretical VECSEL intracavity power achievable with the use of GaInP QW gain material is estimated, along with the full theoretical temperature and pump wavelength tuning ranges for our proposed OPO. In addition, the OPO oscillation threshold has been determined for the estimated resonator losses. Moreover, once the VECSEL and OPO cavities are built, we aim to introduce active stabilization to the VECSEL in order to further reduce the noise within the system. Based on the results we have obtained thus far, from being able to reach OPO threshold and beyond using the VECSEL device, the VECSEL being free of relaxation oscillations, and once the VECSEL beam is actively-stabilized to pump the OPO, we hope to meet the conditions required for generating quantum states of light within VECSEL sources for the very first time.	

15:30-15:45	**Alexander Blanchard**	**Dawson**
	Hyperspectral single pixel imaging using visible light-emitting diode arrays and spectrometer for micro-fabrication applications Single pixel imaging is a technique that has seen much research interest lately, driven by potential applications in infra-red imaging. Single-pixel imaging uses a spatially dependent transmitter and a single point receiver, compared to most imaging systems, where a single point transmitter and a spatially dependent receiver are used. By sending patterns through the transmitter and recording the response from the point receiver, images can be made; the resolution of such a setup is limited by the transmitter. Here, we present efforts towards utilising the principles and ideas of single-pixel imaging for hyperspectral feature recognition, tracking, and multi-step alignment in a micro-fabrication setup. As a proof of concept, a blue 8x8 passive matrix array LED (nominal wavelength 450nm) and a plano-convex lens (100mm focal length, 155 mm from the LED array), were used to project patterns onto reflective targets 215 mm from the lens. The reflected light was collected by a polymer fibre (core width 1mm and NA 0.45) 100 mm from the image scene and recorded by a CCD-spectrometer. The targets were imaged with good fidelity in all spectrometer channels within the 15 nm spectral bandwidth (full width at half maximum) of the LED. We plan on expanding on these results by future integration of the spectrometer in a direct writing photolithography tool, using active-matrix micro-LED arrays (of either 16x16 or 128x128 pixels). The hyperspectral information allows identification of judiciously selected fluorescent markers in the exposure plane with unique spectral signature. We can align to these markers during photolithography. The setup will allow us to explore challenges such as the field of view, the contrast of the markers and automation of data analysis with attention on compressed sensing. The initial results taken confirm the feasibility of the current approach and will provide functionality previously unavailable in photolithography systems.	
15:45 -16:00	**Liam Selman**	**Ronald**
	Microwave antenna for a parametric wave-plasma interaction experiment. Wave-plasma interactions can occur in many situations, including magnetically and inertial fusion schemes. To explore these interactions a helicon plasma experiment is being currently being constructed at Strathclyde. The plasma will be formed in a magnetised vessel by driving a helicon wave, a form of bounded whistler wave near the lower hybrid resonance, using a flat spiral antenna. Helicon apparatus have been shown to be an efficient way of generating a dense, cool plasma in a modest magnetic field. A pair of microwaves beams must then be launched across the plasma which are coupled by their mutual interaction with the particles. This interaction can be controlled by detuning one from the other forming a beat wave at a natural plasma frequency. Using various diagnostics the interaction of this beat wave with the helicon plasma can be investigated to study the transfer of energy between electromagnetic waves and heating of the plasma. To launch microwaves into the plasma a custom antenna has been designed to create an HE1,1 microwave beam. This talk will give an overview of the experiment and then focus on the design of the microwave antennas.	

16.00 – 16.15	**Evangelos Matzoukas**	**Sheng**
	Generation of attosecond electron bunches with the use of up-ramp plasma density profile The generation of ultrashort electron bunches down to attosecond duration is of great interest in modern physical research. However, it’s been observed a noticable beam energy spread which needs further improvement and remains a huge challenge for scientists. My research is based on a method which uses up-ramp density profile for attosecond electron beam generation. The idea is to send an intense laser with a fairly broad spot through an underdense plasma slab with an up-ramp density profile followed by a plateau. Therefore wakes (buckets) are formed behind the laser pulse. As a result the phase velocity of the wakefield switches suddenly from above to below the light speed c at the up-ramp plateau transition (UPT), where 1D wave breaking occurs sharply. For an up-ramp density profile, the phase velocity can exceed unity and asymptotes to the group velocity along the up ramp. The phase velocity exceeds unity due to the fact that the plasma wavelength starts to shrink faster than the decrease of the group velocity. When the first bucket reaches the plateau the phase velocity reduces to group velocity which is less than unity. In nonlinear regime a group of electrons can get trapped. It is these trapped electrons which form a dense attosecond electron sheet (AES). In this project we will further investigate this process by examining different cases of laser intensities and electron densities to achieve a decrease in electron beam energy spread with charge over 30pC while the bunch must have a duration less than 1fs.	