Physics Postgraduate Conference

Wednesday 14th August 2024

JA 317

Time	Student	Primary Supervisor
10:00 - 10:15	**Andrew Adair**	**Hurtado**
	Neuromorphic Photonic Processing Systems for Light-Enabled AI Neuromorphic photonic systems, that take inspiration from the computational modalities of biological intelligence, are of increasing interest in research as information processing networks. Specifically, through the use of devices such as Vertical Cavity Surface Emitting Lasers (VCSELs) and Resonant Tunnelling Diodes (RTDs), we look to emulate the nonlinear transformations of bio-neurons, but with significantly faster operation speeds. Discussed in this talk are the results for noise-robust pulse to spike conversion with a multi-device free-space telecom to neuromorphic interface. Additionally, neuromorphic processing with a two-in-one photonic neural network in spiking mode, where the classification of datasets was performed will also be discussed.	
10:15 – 10:30	**Kierran Falloon**	**Henrich**
	Modelling protein-DNA interactions through AWSEM-oxDNA. Proteins are essential to biological function, taking on many active and passive roles in the regulation of cell function. Due to the nature of their actions, they often form complexes with other macromolecules. While established experimental techniques like SAXS provide some limited insights into structure and dynamics of protein-DNA complexes, there exists a gap in knowledge of kinetic pathways by which interactions key to life itself occur. Through theorising and developing a coupling of two leading coarse-grained models of protein and DNA respectively, AWSEM-oxDNA is created. This hopes provide accurate data into unknown protein-DNA mechanisms through molecular dynamics.	
10:30 – 10:45	**Alister Gorrie**	**Hastie**
	Future Entanglement-based Quantum Seal Optical seals are used to ensure the integrity of sensitive optical signals. Classical optical signals are encoded with information in amplitude and phase, making them vulnerable to different types of spoof attacks. To tackle this, we use a quantum seal, which utilises entangled photons. These are generated by bidirectionally pumping a type-II PPLN crystal to generate Spontaneous Parametric Down-Conversion within a Polarisation Sagnac Interferometer. By utilising entanglement properties, the quantum seal offers a solution to the vulnerabilities of classical optical signals where integrity is maintained. This is the framework for a future quantum seal that can detect authenticity and path length changes.	

10:45 – 11:00	**Robert Kyle**	**Ronald**
	RF breakdown in Cavities for the Muon Collider Muons are a form of subatomic particle first discovered in the late 1930s, research into muons has since lead to many interesting discoveries - from muon tomography to the anomalous magnetic moment of the muon - a new collider at CERN is being designed to utilize muons for high-energy collisions with the aim of discovering new physics. Due to the short lifetime of the muon, RF Cavities designed for the Muon Collider will utilize high electric field gradients of range 14-40MV/m, this talk will explore how breakdown occurs in these cavities by discussing the underlying physics alongside simulations of breakdown effects.	

Break 11:00-11:45

11:45 - 12:00	**Lewis Russell**	**Henrich**
	DNA Simulation on the Exascale The core focus of my PhD is to port the current LAMMPS implementation of oxDNA to be scalable and performance-portable to all current and foreseeable-future computing and HPC architectures. To do this, we utilise the KOKKOS library, explicitly designed for this purpose. When complete, new applications for the oxDNA model will be obtainable and answer open questions surrounding DNA dynamics at length and time scales currently out of reach by the current leading edge implementations.	
12:00 - 12:15	**Anjana Ganesh**	**Hastie**
	Lasers for the quantum-enabled position, navigation, and timing technologies This project proposes the design of a dual-frequency vertical-external-cavity surface-emitting-laser (VECSEL) for emission at 780 nm, aligning with the rubidium D2 line, crucial for clock's lambda-transitions. A frequency separation of 6.8 GHz is also required corresponding to the hyperfine splitting of rubidium's ground state, along with 1W of output power in each frequency mode. The AlGaAs-based VECSEL will be optically-pumped using an 18W pump laser at 532 nm. This configuration aims to replace the two high-power Ti:Sapphire laser systems for targeting the clock transitions of rubidium, thereby reducing the size, weight, power, and cost (SWaP-C) of the overall system.	

12:15-12:30	Bowen Wang	Chen
	Near-infrared fluorescent glutathione capped gold nanoclusters: impact of synthesis conditions and hairpin DNA functionalization This talk will focus on the synthesis of NIR fluorescent GSH-AuNCs and further DNA functionalization. We have investigated the influence of synthesis conditions on their fluorescence properties by adjusting pH, concentration of Au and reaction temperature. The purpose of experiment is to identify optimal conditions for generating GSH-AuNCs with strong NIR emission. Moreover, functionalization of GSH-AuNCs with thiolated hairpin DNA with cy5 has been investigated using a salting process. GSH-AuNCs with 640nm emission was tested as the spectroscopical overlapping between the emission of GSH-AuNCs and the absorption of cy5(638nm). FRET occurs between GSH-AuNCs(donor) and cy5(acceptor) when hairpin DNA binds to GSH-AuNCs. Fluorescence spectroscopy measurements confirmed that GSH-AuNCs could be successfully modified by hpDNA.	

Lunch 12:30-14:00

14:00 - 14:15	Amrutha Sankar	Chen
	Synthesis and Characterisation of Fluorescent Gold nanorod probes for Cancer detection This work aims to develop Nanoprobes which consists of small gold nanorods (SGNRs) functionalised with Hairpin DNA labelled with a fluorophore Cy5 for early detection of RNA biomarkers in cancer cells and in blood samples. SGNRs were synthesized using silver assisted seed mediated method. Ligand Exchange was performed to replace toxic CTAB bilayer formed during GNR synthesis with biocompatible Mercaptohexanoic acid (MHA), following salt aging procedure was done to functionalise SGNRs with Hairpin DNA. Two different nanoprobes were developed, namely VEGFaMOD and PSMA with two different Hairpin DNA sequences. Both nanoprobes were found to be sensitive to the complementary oligonucleotides, as indicated by significant changes in both fluorescence intensity and lifetime which indicates the potential of the probe for liquid biopsies.	
14:15 - 14:30	**Matthew Wilson**	**Strain**
	Integrated Photonic Extreme Learning Machine using Chaotic Microresonators The increasing demand for ultrafast and energy efficient solutions for machine learning is inspiring current research into novel neuromorphic photonic hardware, i.e. photonic systems that aim to emulate the information processing methods of the brain. Here I will present some of the initial work that I have carried out to develop integrated photonic devices for neuromorphic computing. Specifically, I will look at employing optical chaos to implement a hardware based photonic extreme learning machine. I will then discuss the future direction of this project including the steps towards a complete on-chip integration of this novel neuromorphic computer.	

14:30 - 14.45	Sahar Alshammari	Chen
	Monitoring Beta amyloid protein in Alzheimer disease using fluorescence spectroscopy One of the main causes of Alzheimer's disease is the accumulation of beta-amyloids. Beta-amyloid oligomers may be easier to detect at the molecular level, which might aid in early diagnosis and the creation of novel intervention therapy. Beta-amyloid's single tyrosine exhibited a three-exponential fluorescence intensity decay as it aggregated. This research has important implications for understanding the early stages of Alzheimer's disease, as beta-amyloid aggregation is a hallmark of the disease. Here we present a complementary approach based on the time-correlated single photon counting (TCSPC) of amyloids tyrosine excited at 279nm using different emission wavelengths (297nm,327nm). This technique can be useful in studying the early stages of protein aggregation and provides insight into the mechanisms behind Alzheimer's. Lysozyme-encapsulated gold nanoclusters (Lyz-AuNCs) can be a valuable tool for investigating protein denaturation. Current research focuses on the fluorescence properties of Lyz AuNCs under protein denaturation conditions, and their relationship to protein unfolding. Additionally, the study aimed to evaluate the potential of Lyz-AuNCs in inhibiting the aggregation of human beta-amyloid (1-40) Aβ40. A study was conducted to examine the interaction between Aβ40 and Lyz-AuNCs. Remarkably, Lyz-AuNCs were discovered to impede the development of Aβ40 fibrils. The findings indicate that Lyz-AuNCs can also be used as a tool to investigate the buildup of Aβ40 in AD pathogenesis.	