

Research Area:Project Title	Project Description (in brief)	Home PI	Project Department at IITKGP	Host PI	Host PI's Project Department at Manchester	Export Control
Mechanosensitive nanochannels:Controlling Ion Transport via Mechano-Sensitive Nanochannels	Nano- and Angstrom-scale capillaries have been studied intensively because of their importance in many natural phenomena and use in numerous applications. Embarking on a groundbreaking PhD journey, this research endeavors to revolutionize the landscape of biomimetics by developing artificial nanochannels inspired by biological mechanosensitive receptors. With a focus on mimicking the exquisite touch, force, pressure, and nuanced responses to various physical stresses found in human skin, the proposed nanochannels will be meticulously crafted from cutting-edge 2D materials. Leveraging the unique properties of these materials, such as graphene or other two-dimensional structures, our aim is to engineer nanochannels that not only respond to mechanical deformation but also enable controlled ion flows, mirroring the sensory sophistication of natural receptors. The primary aim of this research is to design and develop artificial nanochannels capable of mimicking the diverse sensory functions of biological mechanosensitive receptors. Specifically, the focus is on creating nanochannels that enable ion flows to distinguish between touch, force, pressure, and various forms of physical stress. This involves: Designing Nanochannels with Variable Sensitivity: Develop nanochannels with the ability to modulate ion flow in response to different magnitudes of mechanical stress, thereby mimicking the varied sensitivity of biological mechanosensitive receptors. Implementing Selective Ion Permeability: Engineer the nanochannels to exhibit selective ion permeability, allowing for the distinction between different types of mechanical stimuli. This can be achieved by controlling the size, shape, and chemical properties of the nanochannels. Integrating Signal Processing Mechanisms: Incorporate signal processing mechanisms within the artificial receptors to interpret the ion flow patterns and generate distinct electrical signals corresponding to touch, force, pressure, and various forms of physical stress.	Prof. Suman Chakraborty	Department of Mechanical Engineering	Prof. Radha Boya	Department of Physics and Astronomy	Supervisors have undertaken an appropriate Export Control self-assessment for the project in line with University of Manchester requirements. We have checked the 'goods checker tool' with key terms from the project and got the message "There aren't any control entries that match your search"  ECC03674
Sustainable management of plastics waste:Designing a Profitable Business Model for Plastics Waste using Circular Economy Approaches	This project undertakes a comprehensive exploration of sustainable management strategies, with a particular focus on the educational and hospitality sectors to address the escalating challenges posed by plastics waste. Encompassing a meticulous blend of literature reviews, optimization models, and real-world applications, the research unfolds across distinct phases, each contributing to a nuanced understanding of plastics waste dynamics and the development of effective waste management strategies in contrasting case studies from developed and developing economies. Based on this analysis, a new business model will be proposed to make the most of the generated plastics waste. This study stands not only as an academic endeavor but also guides municipal officers and policymakers through the intricate terrain of sustainable plastics waste management, offering tangible, applicable solutions with minimal environmental impact and economic viability.	Prof Vinay Yadav	VGSOM	Prof. Maria Sharmina	Tyndall Centre for Climate Change Research, MACE Department	Confirmed
Control Systems Engineering:Development of negative imaginary systems theory to control feedback systems with hysteresis nonlinearities	Hysteresis nonlinearities are commonly encountered in a wide variety of dynamical processes in which the input-output variables involve memory effects. For example, the use of smart materials in actuators introduces hysteresis nonlinearities into feedback control loops. Hysteretic behaviour, that changes with input frequency, greatly restricts the speed of response. Its memory effect and multi-valued mapping produce poor performance or even instability if the hysteresis nonlinearity is not properly handled by the controller. Inversion-based hysteresis compensation, a well-known strategy for control, often results in a complex control structure and generates erroneous control actions when the model is inexact, or the hysteresis parameters vary. Negative-imaginary (NI) systems theory has shown its potential to tackle feedback control loops that involve hysteresis nonlinearities. Unique advantages of NI systems theory include its simple steady-state gain condition and its ability to stabilize a feedback control loop with just position measurement (i.e. output feedback). However, existing NI results for absolute stability analysis and for hysteresis nonlinearities are far from mature. In this work, to capture a wide class of hysteresis nonlinearities, absolute stability results for NI systems will be extended by considering the class of slope-restricted monotone nonlinearities. In a dissipative framework, the class of negative-imaginary systems shows pervasive dissipation, and thus, they are suitable for power shaping control, unlike the energy shaping concept applied to passive systems. This work will search for a suitable storage function for the modified Prandtl-Ishlinskii hysteresis model that would satisfy negative-imaginary dissipation inequalities. With the established stability analysis results, a parameterised strictly NI controller will be designed for hysteretic systems to achieve tracking performance and to inject damping to feedback control loop.	Assoc. Prof. Sourav Patra	Electrical Engineering	Prof. Alexander Lanzon	Electrical and Electronics Engineering	Confirmed. Export Controls Compliance Request was submitted with the UoM Regulator Compliance team on 19th November 2024. ECC reference number is ECC03671. Waiting for an outcome from the Export Control Team. They are currently experiencing long delays to review cases, see below: "We are currently dealing with a large number of enquiries. Our processing times are currently longer than usual. Apologies for any inconvenience caused. We will look at your case as soon as possible."
Development of hybrid functionally graded metal/ceramic composites and in situ synchrotron X-ray imaging of its damage development	Interpenetrating phase composites (IPC) with co continuous phases offer significantly enhanced overall properties over conventional particle or long-fiber reinforced metal matrix composites. In functionally graded composites (FGM), the composition and microstructure are varied along a certain direction to attain variation in properties within the same material. While IPCs and FGMs have been established as advanced structural materials individually, combining the two concepts to develop hybrid functionally graded interpenetrating metal/ceramic composites has been studied very little. Within the scope of this work, open porous alumina/zirconia ( $Al_2O_3/3Y-TZP$ ) with a gradient pore morphology will first be fabricated using a combined pressureless sintering and pore-former route. Due to alumina's high hardness and wear resistance and the transformation toughening operative in zirconia, alumina/zirconia composites offer an excellent combination of strength and toughness. In the next step, the open pores within the porous ceramic composite preform will be infiltrated by molten Al-alloy via squeeze casting to develop the hybrid functionally graded interpenetrating phase composites. An in-depth understanding of the damage propagation, when stressed, is critical to developing the hybrid composite, as a delayed crack propagation will enhance both the strength and toughness required for the end application. The deformation and damage mechanism in the composites will be studied under in situ loading using high-energy synchrotron X-ray-5 based computed tomography at the European Synchrotron Radiation Facility, Grenoble, France. Synchrotron X-ray is ideal for imaging crack propagation in multiphase bulk materials due to its large penetration depth, high flux, and material specific attenuation behavior, readily allowing sharp image contrast among different phases based on density or atomic number. An in-situ loading offers direct observation of the structural changes under an applied load, and this is advantageous over more conventional ex-situ fractographic studies, where the final prognosis is often based upon many strong assumptions. To our knowledge, such in-situ damage study in hybrid functionally graded IPCs has never been reported in the literature. The knowledge developed from the in-situ damage evolution study will be used to optimize the structure of the developed hybrid composites. While this is basic fundamental research, it has long-term potential for end applications such as advanced structural components in the automobile, aerospace, transport, and energy sectors.	Dr. Siddhartha Roy	Department of Metallurgical and Materials Engg.	Prof. Phil J. Withers	Department of Materials, Henry Royce Institute	An export control compliance request has been submitted (ECC03616).
Development of sustainable, graphene-enhanced bio-based elastomer composites	In this project, we will develop graphene-enhanced bio-based polyurethane elastomers. The bio-PU will be formulated with bio-derived isocyanate from bio-mass sources and bio-derived polyols from vegetable oils, cellulose, starch, sugars, and lignin. The isocyanate and polyol chain lengths and functional chemistries will be varied to give different mechanical properties to the base polyurethanes. The graphene will be suitably functionalised to interact with the PU during 2-part formulation or melt-compounding in the case of thermoplastic PU. The graphene-enhanced bio-PU will be designed and formulated to enhance their mechanical properties and electrical conductivity.	Dr. Titash Mondal	Rubber Technology Centre	Prof Aravind Vijayaraghavan	Department of Materials	Confirmed (ECC03647) has been submitted and a meeting has been held with an ECC officer. The application is pending decision by ECC team but supervisor has confirmed to ECC team that there is no controlled items in the
Flexible Electronics: Development of Functional Inks for Flexible Electronics	The project aims to contribute to the evolution of flexible electronics by focusing on developing cutting-edge functional inks. These inks are crucial for enabling the fabrication of electronic components on flexible substrates, unlocking new possibilities for lightweight, portable, and conformable electronic devices. The research will explore diverse formulations of functional inks, emphasizing their conductivity, flexibility, and compatibility with various printing processes.	Prof. Kinsuk Naskar	Rubber Technology Centre	Prof. Cinzia Casiraghi	Chemistry	Yes
Physical Oceanography: Particle transport in realistic ocean environments	Understanding how particles are transported by ocean waves and currents is of critical importance for a wide range of areas, from designing offshore structures (e.g. offshore wind turbines) to understanding sediment transport, microplastic dispersion and the health and behaviours of underwater ecosystems. Understanding is, however, limited for realistic ocean environments and realistic particle size distributions. There have been several barriers to accurately numerical modelling these problems ranging from a lack of appropriate theory to provide boundary conditions, to a lack of appropriate modelling architectures to capture the multi-scale complex interplay between waves, sheared currents, and turbulence at all relevant scales. This project will bring together state-of-the-art theoretical developments in wave plus sheared current flows, and simulation methods to address the outstanding questions regarding these processes in realistic ocean environments. For example, what is the effect of vertically sheared currents on particle transport and drift in waves? How do waves and currents influence turbulence statistics and anisotropy, and how does this affect the dispersion characteristics of particles? These factors are often omitted yet are known to play a considerable role on ocean kinematics and associated particle transport. A combination of analytical models and novel high-order numerical simulation methods will be developed to tackle this problem. We will perform Direct Numerical Simulation (DNS) of the Navier Stokes equations to quantify the effect of both large-scale (waves, sheared currents, larger turbulent structures) and microscale turbulent phenomena on stochastic particle transport. This will be conducted over a range of realistic conditions and particle properties. The resulting analytical and numerical models, and associated outputs, will have broad applicability and implications across areas in ocean and coastal engineering and oceanography. Through this project, we aim to transform our understanding of particle dispersion in the oceans.	Mohammad Saud Afzal	Civil Engineering	Samuel Draycott	Civil Engineering and Management	Yes confirmed: ECC03724
Integrated Quantum Photon Sources Based on 2D Semiconductor Heterostructures	Applications are invited for an innovative split-site PhD position jointly hosted by the University of Manchester (UK) and IIT Kharagpur (India), focusing on the development of integrated quantum photon sources based on 2D semiconductor heterostructures. This four-year program offers a unique international research experience, combining advanced 2D quantum materials fabrication and device integration at IIT Kharagpur with cutting-edge quantum optical characterization at Manchester's Photon Science Institute. The successful candidate will spend the first year at IIT Kharagpur developing expertise in 2D semiconductor growth (MoSe <sub>2</sub> , WSe <sub>2</sub> ) and heterostructure synthesis via CVD and van der Waals device integration and on-chip optoelectronic device fabrication on-demand followed by two years at Manchester's Photon Science Institute focusing on advanced optical characterization and quantum measurements, before returning to IIT Kharagpur for the final year of device optimization and integration. Key research activities include the development of COMSOL-based optical modelling, micro-transient absorption spectroscopy, scanning single-photon microscopy, and the fabrication of electronic-grade 2D heterostructures for quantum device applications. The project will contribute to India's National Quantum Mission through the development of scalable quantum light emitter sources for quantum communication applications. Candidates should hold a Master's degree in Physics, Materials Science, Electronic Engineering, or related fields, demonstrating strong backgrounds in optics, semiconductors, or quantum physics. Essential qualities include excellent experimental and analytical skills, willingness to work across international locations, and strong communication abilities. The position offers access to state-of-the-art facilities at both institutions, expert supervision from leading researchers in quantum photonics and 2D materials and heterostructures, and comprehensive training in advanced characterization techniques. This position represents an exceptional opportunity to develop expertise in physics, materials science, photonics and quantum technology while building an international research network at the forefront of quantum photonics research.	Prof. Prasana Kumar Sahoo	Materials Science Centre	Dr Patrick Parkinson	Physics and Astronomy	ECC02816 – same as previous
Tailoring Functional Mucoadhesive Polymer Gel in oral Cancer Therapy; A milder Approach	Despite significant advances in cancer therapeutics, improving the prognosis of late-stage oral cancer remains challenging. Mucoadhesive polymers with specific functionalities can improve oral cancer patients' overall outcome by offering enhanced oral mucosa bioavailability, better drug distribution and tissue targeting, and minimizing systemic side effects. The aim of this project is to design a mucoadhesive smart polymer gel, having covalent as well as noncovalent crosslinking and to use this in the management of oral cancer. This new and milder avenue for oral cancer therapy via designing a new mucoadhesive functional polymer will be done by a doctoral student with materials synthesis skills and its bio-applications.	Prof. Nikhil Kumar Singha	Professor at Rubber Technology Centre	Prof. Jonny Blaker	Professor in Biomaterials, Materials Engineering	Confirmed

<p>Nanoscience and Nanotechnology : 2D Confinement of atomically precise metal nanoclusters and their uses in water filtration</p>	<p>Atomically thin 2D nanomaterials, known for their exceptional mechanical and optoelectronic properties, are typically produced via exfoliation, taking advantage of strong intralayer bonds over weaker interlayer interactions. The success of graphene exfoliation has led to the exploration of other 2D materials, such as transition metal dichalcogenides, MXenes, boron nitrides, and clays. While quantum confinement in these materials opens up applications in flexible optoelectronic devices, a less-explored approach involves self-assembling metal nanoparticles (NPs) into 2D monolayers. These self-assembled materials show tunable optoelectronic and mechanical properties but face challenges like uncontrolled aggregation, polydispersity, and slow diffusion, making it difficult to achieve homogeneous, high-quality assemblies. Despite these hurdles, methods like evaporation-induced assembly, interfacial assembly, and Langmuir-Blodgett film formation have enabled the creation of 2D arrays of nanoparticles, including gold and silver. However, controlling size dispersity, ligand structure, and density remains a challenge, as these factors affect the reproducibility and performance of NP-based 2D structures. Uniformity in size, density, and spacing in monolayers, such as those made from plasmonic silver nanoparticles, can significantly improve surface-enhanced Raman spectroscopy (SERS) sensitivity. Atomically precise, ligand-protected noble metal nanoclusters (NCs) offer the potential for creating well-defined assemblies with tunable properties. These NCs are promising building blocks for 2D materials, as 5 their ligands can interact through various forces (e.g., hydrogen bonding, electrostatic, and van der Waals). By controlling these interactions, it's possible to guide the geometry and crystallization of NC assemblies. Recent work on gold and silver NCs has shown how symmetry breaking can be induced via specific ligand interactions, facilitating the creation of well-ordered 2D nanostructures. However, achieving large-area, precisely controlled nanoparticle membranes with consistent thickness and mechanical properties remains a significant challenge.</p>	<p>Dr. Indranath Chakraborty</p>	<p>School of Nano Science and Technology</p>	<p>Prof. Rahul Raveendran Nair</p>	<p>Chemical Engineering</p>	<p>Confirmed ECC reference number - ECC03734</p>
<p>Stability, Control, and Protection of Renewable-dominant Power Grids: Co-design of Control and Protection Algorithms for Improved Stability of the Renewable Dominant Power Systems</p>	<p>As we transition to cleaner energy sources, power grids are undergoing a significant transformation. Modernised power systems are dominated by renewable energy sources like solar and wind farms and energy storage systems. These new energy sources and storage systems connect to the grid using sophisticated interfaces. Short outline of project for advertising purposes (500 words max) called Inverter-Based Resources (IBRs). While this shift is vital for a sustainable future, it brings new challenges in maintaining a stable and reliable electricity supply. In conventional power systems the protection and controls are designed separately, this is mainly because of time separation in their responses. However, with the integration of more and more inverter based resources, which utilizes the very fast controllers, the protection of the power system needs a revisit for better algorithms along with the appropriate control strategies. This PhD project, joint between The University of Manchester and IIT Kharagpur, aims to tackle the protection and control issues with large renewable integrations and proposes solutions by co-designing them while incorporating the stability challenges for the IBR-dominated power systems. The research focuses on two critical areas: • Co-designing of the control and protection algorithms for renewable dominant power systems; • Developing the tools for stability analysis in renewable dominant power systems. The successful PhD student will work with both detailed and reduced-order models suitable for mathematical and control-theoretic analysis of the global behavior of large-scale power systems dominated by IBRs. In particular, the PhD student is expected to leverage control measurements for the protection purpose and develop more effective, scalable, and less conservative methods for ensuring the stability of future power grids. The effectiveness of the developed methods will be experimentally validated by experimental setups available at IIT Kharagpur. The successful PhD candidate must have a strong background in electrical engineering, control systems, or applied mathematics. Experience with power electronics or power system modelling would be beneficial. This project offers a unique opportunity to work at the forefront of sustainable electrical power systems research with guidance from a multidisciplinary team of supervisors across two world-class institutions.</p>	<p>Deepak Pullaguram</p>	<p>Electrical Engineering</p>	<p>Mahdieh S. Sadabadi</p>	<p>Electrical and Electronics Engineering</p>	<p>Confirmed-ECC03634 An export controls compliance request form was submitted (with reference number ECC03634). It is under review with the Export Control team. Please note that the topic of the proposed PhD project is not controlled.</p>
<p>Experiments, modelling and optimization of continuous crystallization: Multi-dimensional population balance modelling of continuous crystallization of high-aspect ratio crystals</p>	<p>Continuous crystallization has many advantages over traditional batch production such as cost effectiveness, consistent product quality, easy scale-up possibility, and enhanced process safety. This continuous process has widely used in chemical engineering and industry, especially in the manufacture of pharmaceuticals. Consequently, the search for optimal operating conditions and adequate control strategies largely lies on the accuracy of the mathematical model representing the process. The general framework of population balance model we adopt here is more challenging because of the increased dimensions like multiple internal coordinates due to the length and width of the crystals. This model becomes even more intricate with the existence of different morphologies such as rod-like or needle-shape crystals of high aspect ratios, common in the pharmaceutical and fine chemicals industries.</p> <p>The primary aim of this project is to develop and experimentally validate population balance models for continuous crystallization, followed by related studies on numerical simulation and optimization/control. More precisely, the research objectives are:</p> <ol style="list-style-type: none"> <li>1. Continuous crystallization experiments of high-aspect ratio crystals</li> <li>2. Development of the population balance model characterizing the crystallization nucleation and growth process</li> <li>3. Numerical simulations and optimization/control related to the population balance models</li> <li>4. Modelling, simulation and optimization of related spherical crystallization.</li> </ol>	<p>Dr. Debasis Sarkar</p>	<p>Chemical Engineering</p>	<p>Dr. Yanghong Huang</p>	<p>Mathematics</p>	<p>ECC is being applied (Case number: ECC03735).</p>
<p>Development of self-healing bio-concrete with CO2 sequestrating capability: Development and performance assessment of a cyanobacterial bio-concrete capable of self-healing by sequestering CO2 from atmosphere</p>	<p>Concrete and traditional Portland cement materials are responsible for around 7-8% of the anthropogenic carbon dioxide (CO2) production. Also, concrete made up of traditional cement are more prone to damages. Both micro as well as macro level crack formation takes place, gradually damaging the concrete structure through ingress of moisture with time. This poses potential threat to the civil infrastructure, which increases the necessity for the self-healing technology in concrete. Therefore, this project explores the potential of cyanobacteria for the development of self-healing bio-concrete. Cyanobacteria, being photosynthetic microorganisms, utilize CO2 from the environment to generate metabolic oxygen. The cyanobacterial calcification coupled with CO2 utilization would expectedly develop a new technology of self-healing concrete capable of capturing CO2 directly from atmosphere in a built-environment.</p> <p>The project begins with the identification and selection of a potential cyanobacterial strain capable of developing self-healing bio-concrete. The conditions necessary for the healing would be then fine-tuned and optimized using advanced experimental designs. Next, a systems biology approach would be employed to understand the molecular pathways responsible for cyanobacterial calcification. The construction of detailed pathways for calcification are critical for enhancing the self-healing properties of the bio-concrete.</p> <p>With the optimized conditions in place, lab-scale production would be carried out. A heat tolerant self-healing powder mixture would be developed considering the heat generation during the time of concrete mixing.</p> <p>The self-healing bio-concrete, made by blending Portland cement with the powder, would be tested for a variety of parameters including self-healing efficiency, CO2 sequestration potential, and the mechanical strength of the concrete both before and after the healing process. The bio-concrete's durability would be assessed under real-world conditions, including aging and simulated polluted environments, in order to evaluate its practical viability for use in sustainable construction. A small-scale building-like structure would be constructed in a controlled, glasshouse environment, replicating outdoor weathering and pollution conditions. This would serve as a pilot demonstration for testing the long-term performance of the self-healing bio-concrete under real environmental stress. Key metrics such as durability, healing time, CO2 sequestration during the healing process etc. would be monitored, paving the way for future deployment in large-scale construction projects. Thus, by combining cutting-edge Biotechnology with Civil Engineering, this project potentiates to create a new generation of construction materials which are not only durable but also environmentally sustainable. The self-healing bio-concrete developed through this project could drastically reduce maintenance costs, extend the lifespan of structures, and contribute to the global efforts made to reduce CO2 emissions.</p>	<p>Prof. Ramkrishna Sen</p>	<p>Bioscience and Biotechnology</p>	<p>Prof. Cise Unluer</p>	<p>Department of Civil Engineering and Management</p>	<p>ECC03732</p>
<p>Coordination chemistry, magnetism and luminescence spectroscopy: "Luminescent supramolecules for applications in data storage"</p>	<p>Quantum computing is a paradigm-shifting computation that has the potential to revolutionise the way we store, process and compute complex data and is set to transform the digital world, as we know it. Quantum computation relies on quantum information processing (QIP) to perform specific tasks, where quantum 'bits' replace the currently used classical computing bits of '0' and '1' since they can exist in a quantum superposition of their two states and are entangled. Individual manipulation of these states by external stimuli is vital to realise quantum computing, achievable via the assembly of qubits into quantum logic gates.</p> <p>Remarkable advancements have been made in the chemical and physical engineering of solid-state qubits that utilise electronic spins; exemplars include vacancies in silicon carbide and nitrogen vacancies in diamond. However, they suffer from decoherence of the superposition states that are a prerequisite of any qubit. Since vacancies introduced in solid-state materials cannot be controlled, single molecules offer an attractive alternative to creating spatially controllable magnetic qubits whose properties can be optimised.</p> <p>In this Ph.D. project, we propose to develop single supramolecule qubits using our combined leading expertise in coordination chemistry and state-of-the-art magnetic measurements, in combination with EPR and luminescence spectroscopies. We propose that following optical stimuli, the entanglement between the spin wavefunctions of two or more qubit components can be modulated and controlled by laser light irradiation. To achieve this, we propose to use the optical properties of trivalent and divalent lanthanide ions (e.g., Eu, Gd, Ce, Sm, Dy, Yb) to create a paramagnetic excited state that can interact more strongly (or more weakly) with one or more qubits thereby modulating the entanglement of states for QIP. Lanthanide ions are ideally suited as they possess long-lived excited states (tunable from nanoseconds to milliseconds), emit high colour purity light across the UV-visible and near-infrared spectral regions (therefore giving an optical readout), and, importantly, possess significant magnetic differences between their ground and excited states (e.g., diamagnetic to paramagnetic).</p>	<p>Pradip Kumar Chakraborty</p>	<p>Chemistry</p>	<p>Louise Natrajan</p>	<p>Chemistry</p>	<p>ECC02720</p>
<p>Coastal Engineering: Transforming coastal protection through novel breakwater designs</p>	<p>Coastal protection is becoming a global priority due to climate change-induced rising sea levels and increased extreme weather events. The costs associated with coastal erosion damage and preventative protection measures are in the billions of pounds and are expected to continue to rise. Although relatively well understood, conventional engineering approaches to coastal protection are expensive and can change marine habitats considerably. Here, we will explore the use of novel submerged breakwaters that exploit the use of focusing mechanisms, resulting in wave breaking and energy dissipation. This builds on recent work showing that for carefully designed 2D bathymetric features, local wave amplitudes may be amplified up to 15 times relative to the incident wave amplitude and thus readily induce breaking even for incident waves far from the breaking limit. Previous studies on breakwaters demonstrate their effectiveness in enhancing mudflat stability, mitigating shoreline erosion, attenuating waves, and supporting fisheries production.</p> <p>The project will use a combination of to-be-developed low-order linear models and fully nonlinear models able to capture wave breaking. Low-order models will be used to optimize the design of combinations of submerged 2D structures able to locally focus and dissipate energy over a broad range of wave periods. In parallel, fully nonlinear models will be used to capture the full nonlinearity, breaking process, and associated dissipation (validated by experiment) of proposed combinations. Nonlinearity has been shown to play a very substantial role in these sorts of problems, including triggering breaking onset. The low-order and high-fidelity models will be combined to come up with feasible broadband designs able to dissipate meaningful wave energy while limiting the ecological consequences (and increasing accessibility) due to their submergence. We will explore these aspects by quantifying both dissipation and mean flows, informing sediment pathways with implications for marine ecosystems and beach morphology. Breakwaters, the focus of this study, are structures that eventually break incoming waves to reduce their energy at the shoreline, will finally be able to trap sediments, and thus can promote the strengthening of the coast.</p> <p>Through this project, we will be able to explore and demonstrate alternative novel solutions for coastal protection at a critical time for the UK, India, and globally.</p>	<p>Trilochan Sahoo</p>	<p>Ocean Engineering and Naval Architecture</p>	<p>Benedict Rogers</p>	<p>Civil Engineering and Management</p>	<p>Confirmed (ECC03733)</p>

<p>Electrical &amp; Electronic Engineering - Power and Energy : Developing Online FRA Transformer Winding Mechanical Incipient Fault Detection Methods through Transient Monitoring and Machine Learning</p>	<p>Power transformers in electrical power networks experience operational stresses such as short circuit currents and associated electromagnetic forces, making their reliable operation crucial for ensuring uninterrupted power supply. The excessive electromagnetic forces can lead to winding mechanical deformation and/or dislocations – termed as mechanical faults, responsible for over 50% of transformer failures globally, as reported in various international studies. Since the downtime associated with in-service transformer failure is costly, early detection of winding mechanical faults is paramount. The Frequency Response Analysis (FRA) method so far has demonstrated unparalleled sensitivity for fault detection in this regard. FRA is currently practiced offline, its online application could unlock significant potential, by enabling real-time transformer monitoring.</p> <p>In an offline and onsite FRA test, the transformer's frequency response is measured across a wide frequency range (typically from 2 Hz to 2 MHz) and compared to a healthy or reference trace, known as the transformer's signature. Any deviation between the two responses indicates a potential mechanical fault. Faults locally alter the inductance and capacitance of the transformer equivalent circuit, causing changes in the measured frequency response, which forms the basis of fault detection by FRA.</p> <p>The fundamental approach to fault detection in the online FRA monitoring techniques to be developed, is likely to remain the same; however, its implementation presents several key technical challenges as outlined below, hence renders a PhD research project:</p> <ol style="list-style-type: none"> <li>1) Developing wide frequency band sensors and measuring transients at high voltage terminals of a transformer</li> <li>2) Exploring the constraints of network configurations on online FRA measurements, in contrast to offline transformer standalone test mode</li> <li>3) Extracting the frequency response of transformer winding from online FRA measurements</li> <li>4) Improving the quality and reliability of online FRA data, which is susceptible to noise and interference from the network connected</li> <li>5) Extracting key features from online FRA data to enhance fault detection sensitivity</li> </ol> <p>Exploring methods for online FRA measurements and developing a fault-detection algorithm using Machine-Learning (ML) are key objectives of this project. While significant research has advanced FRA offline testing, efforts to implement online FRA testing remain very limited. First, to address challenges in online FRA measurements at high voltage terminals, the approach should explore utilising system transient voltages and currents. Insights from offline measurements, both for a transformer in isolation and with external networks connected to transformer can help develop Machine Learning algorithms for extracting the transformer windings' true frequency responses, denoising and data preparation for fault analysis.</p> <p>Developing an online FRA transformer winding deformation detection method can prevent in-service transformer mechanical failures and significantly reduce the downtime of transformer and ensure uninterrupted electrical energy supply.</p>	<p>Dr. Saurav Pramanik</p>	<p>Electrical Engineering</p>	<p>Prof. Zhongdong Wang</p>	<p>Electrical and Electronic Engineering</p>	<p>The compliance risk assessment for the project has been carried out under the ECC reference number ECC03737</p>
<p>Multi-scale modelling of composite manufacturing process: Investigating the effects of multi-scale porosity on the physics of flow of resin in an FRP composite</p>	<p>Lightweight and sustainable materials are now common in almost all engineering sectors. However, manufacturing of such lightweight parts is not free from defects which are essentially process-induced. Composites are one such lightweight materials which are composed of two distinct phases – the reinforcements and the matrix. The reinforcements may come in a woven or unidirectional fabric architecture for long fibre composites. Hence, the system consists of three physical scales – yarn level, ply level and the composite level. One of the popular fabricating methods of these composites is infusing a liquid resin to enter into the reinforcements (or gaps between the fibres). Following which, the liquid resin is solidified (or cured), subject to application of temperature and/ pressure. During the manufacturing, 8 each of the above physical scale contributes to the flowability of resin, leading to resin rich or resin deficit areas. This eventually deteriorates the part quality. In this project, we aim to develop a multi-scale model that captures the source of formation of defects during resin flow and its effects on the flow kinetics. The model will be verified by experimental setup which enables capturing of flow front of resin during the vacuum infusion process. The final outcome of the project will be to predict the formation and site of the defects and identify the process parameters responsible, leading to a proposal of mitigation pathways to enhance the resin flow through the reinforcement.</p>	<p>NILANJAN DAS CHAKLADAR</p>	<p>MECHANICAL ENGINEERING DEPARTMENT</p>	<p>CHAMIL ABEYKOON</p>	<p>DEPARTMENT OF MATERIALS</p>	<p>The UoM supervisor has submitted the Export Controls Compliance Request and received an ECC reference number of ECC03643.</p>
<p>Application of Machine Learning for natural language processing: Application of dynamic mode decomposition in large language models (LLM)</p>	<p>Dynamic Mode Decomposition (DMD) is a data-driven technique that is widely used now for different applications. It is a machine learning technique. As a data-driven approach, it does not need any prior mathematical model to describe the behaviour of a dynamical system. The model is entirely based on the measurement data. It is able to effectively provide lowdimension reduction and identify key modes. In contrast to the alternative techniques, it does not only capture key modes and yields pattern reconstruction but also allows us to predict the system behaviour. A recently developed modification of DMD based on the optimal prediction (Katrutsa et al. 2023) is capable of taking into account the effect of uncertainties in the input data in the most optimal way. It seems very attractive to use DMD for the large language models (LLM) and natural language processing (NLP). It is to be noted that there are only a few attempts in this way so far (see Akrouf., 2024; Kumar et al., 2020). The project provides an excellent opportunity to make a breakthrough research in this new area.</p>	<p>Prof Animesh Mukherjee</p>	<p>Computer Science and Engineering</p>	<p>Dr S. V. Utyuzhnikov</p>	<p>Mechanical and Aerospace Engineering</p>	<p>Confirmed.</p>