# Sussex EPSRC Doctoral Landscape Projects and Themes for Autumn 2026

Engineering and Physical Sciences Research Council

UNIVERSITY OF SUSSEX


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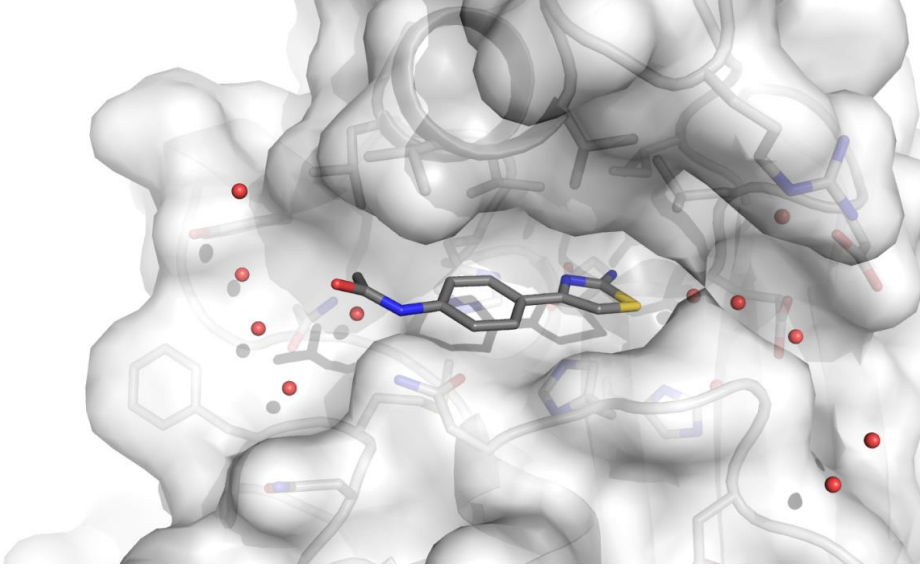
# Chemistry



## Theoretical and Experimental Molecular Design (EP26/1)

EPSRC category: Mathematics and Theoretical Foundations

Lead Supervisor: Alfredo Vargas

Department: Chemistry

Research outline:

We look into rationally designing stable and functional molecules under mild conditions which are amenable to synthesis, production, and stabilisation in solution and/or solid state media including functionalised surface. The underlying approach for the design and engineering lies in the use and incorporation of key features including: charge redirectional nodes/ electron and spin-density sinks, actionable structural reorganisation networks, electromagnetic and/or thermally excitable centres and usual constrainers like sterics and intra/inter molecular interactions. Building and confining properties will be carried out through computations which will be synergetically coupled to inorganic experimental synthesis, analysis and testing in a cyclic development scheme. Target systems will include high-performance switchable systems, catalysis and small molecule activation platforms and energy storage systems. Theoretical development will be driven and validated by dedicated experimental results.  Electron-density and wavefunction-based approaches will be employed.

Key Publications:

Mattock JD, Vargas A. (2018). Boron centres allow design, control and systematic tuning of neutral homoaromatics for functionalization purposes. ChemPhysChem, 19, 2525-2533. (link)

Sampani SI, Zdorichenko V, Devonport J, Rossini G, Leech MC, Lam K, Cox B, Abdul-Sada A, Vargas A, Kostakis GE. (2021). Structural and electronic control of 1-(2-pyridyl)benzotriazole bidentate ligand in copper chemistry with application to catalysis in the A3 coupling reaction. Chemistry: A European Journal, 27, 4394-4400. (link)

## Development of new MRI contrast agents for cancer imaging (EP26/2)

EPSRC category: Interdisciplinary Research

Lead Supervisor: Deborah Sneddon

Department: Chemistry

Research outline:

In my group we are interested in creating new imaging agents to detect and monitor disease progression, particularly focused on cancer. For this, we exploit the many properties of the f-block lanthanide elements, utilizing their paramagnetism for magnetic resonance imaging (MRI), their luminescence for the visualisation of cell biomarkers, progressing to use their radioactive isotopes for nuclear imaging. The proposed project builds on our previous work developing new MRI contrast agents with directed targeting and improved contrast. It will involve the synthesis of novel chelators and supramolecular scaffolds, working between organic and inorganic chemistry.

Key Publication: Foster, CA. Sneddon, D; et al. (2025). LnDOTA Releasing Probes for Luminescence and Magnetic Resonance Imaging. Inorg. Chem. 2025, 64, 13, 6640–6647 (link)

## Laboratory studies of the processing of astrochemical ices (EP26/3)

EPSRC category: Experimental approaches to Understanding

Lead Supervisor: Wendy Brown

Department: Chemistry

Research outline:

My research is in the area of laboratory astrochemistry. I use surface science techniques to investigate surface processes of relevance to astrophysical environments such as the interstellar medium, comets and disks. I also undertake work at FELIX, the free electron laser at Nijmegen, The Netherlands to investigate infrared induced photo-desorption from model astrochemical ices. I am looking for a PhD student to join my research group to undertake investigations of ice processing, by thermal, UV, IR and electron irradiation of model ices grown on dust grain analogue surfaces. This PhD position will also involve a 2-3 month research placement at FELIX.

Key Publication: Slumstrup, L., Thrower, J., Schrauwen, J.G.M., Lamberts, T., Ingman, E.R., Laurinavicius, D., De Vine, J., Terwisscha van Scheltinga, J., Santos, J.C., Noble, J.A., Wenzel, G., McCoustra, M.R.S., Brown, W.A., Linnartz, H., Hornekaer, L., Cuppen, H.M., Redlich, B., Ioppolo, S. (2025). IRFEL selective photodesorption of pure CO and CO on ASW ice. ACS Earth & Space Chemistry, 9, 1607–1621. (link)

## Chemistry for the Nuclear Skills Pipeline: Frontiers in Low-Valent Actinide Coordination Chemistry (EP26/4)

EPSRC category: Experimental approaches to Understanding

Lead Supervisor: Richard Layfield

Department: Chemistry

Research outline:

Richard Layfield's EPSRC research focuses on low-oxidation-state f-element chemistry, exploring the synthesis, structure, and reactivity of lanthanide and actinide complexes in unusual oxidation states. The group investigates fundamental bonding, reactivity, and molecular materials with novel magnetic behaviour.

A PhD starting in 2026 will target low-valent uranium and thorium complexes, with a possible extension to neptunium and plutonium in collaboration with the Helmholtz Zentrum Dresden-Rossendorf. The aim is to understand metal-ligand bonding and how these compounds can be used to activate small molecules. The work is relevant to the nuclear industry, informing actinide redox processes, waste management, and advanced fuel-cycle chemistry.

Key Publication: Barluzzi, L., Ogilvie, S. P., Dalton, A. B., Kaden, P., Gericke, R., Mansikkamäki, A., Giblin, S. R., Layfield, R. A. (2024). Triply bonded cofacial pi-dimers stabilized by tetravalent actinides. J. Am. Chem. Soc. 2024, 146, 4234-4241. (link)

## Novel Linkerology Towards Heterobifunctional Moieties Including Protacs and Antibody Drug Conjugates (EP26/5)

Collaborative project with non-university partners

EPSRC category: Experimental approaches to Understanding

Lead Supervisor: John Spencer and Storm Hassell-Hart in the Sussex Drug Discovery Centre

Department: Chemistry

Research outline:

We both work in library synthesis, making drugs in quicker, more atom economical ways, streamlining processes, reducing energy, solvent use, time and cutting out bottlenecks. The Spencer group focusses on drug targets, the Hassell Hart group works on novel synthetic greener methods to hard-to-access druglike molecules.

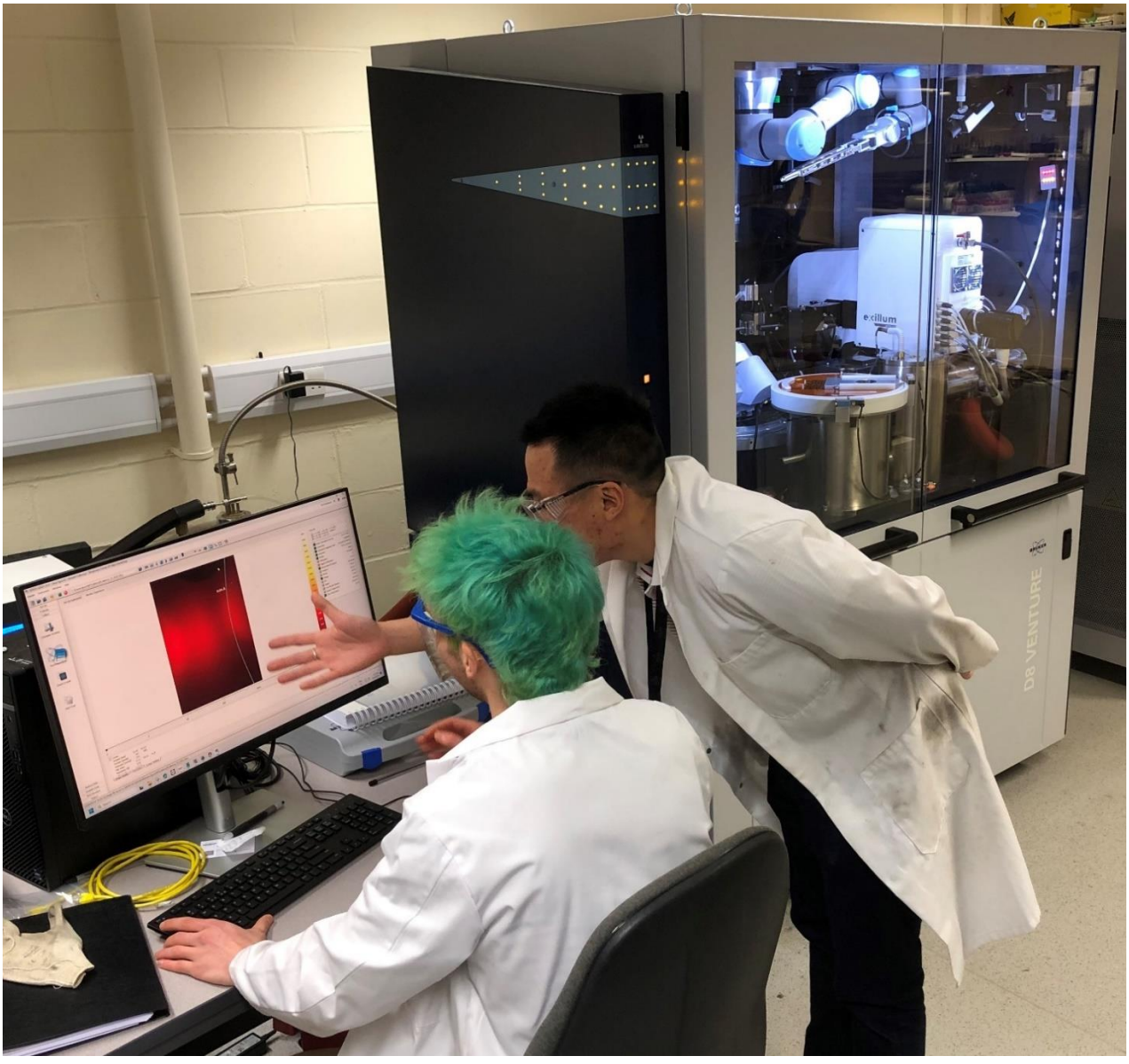
Proteolysis Targeting Chimeras (PROTACs) are an exciting state-of-the-art methodology that is revolutionising how new drugs can be developed. Traditional inhibitors rely on binding to druggable pockets (binding sites) and blocking their biological activity for a limited duration. In contrast, PROTACs act by hijacking the ubiquitin system, targeting proteins for degradation via the proteasome. This mode of action is catalytic and enabling multiple turnovers and results in a longer onset of action. This project aims to address the development of new "linkerology" ie improving linker chemistry, which is crucial to many properties of protacs including solubility, selectivity,

metabolism. We will develop novel chemistry to prepare a library of linkers suitable for PROTAC chemistry (and even other areas such as antibody drug conjugates (ADCs)). The most promising linkers will be elaborated into PROTACs and tested in model biological systems for protein degradation alongside our project partners.

Key Publications:

Grosjean, H., Aimon, A., Hassell-Hart,S., et al (2025). Binding-Site Purification of Actives (B-SPA) Enables Efficient Large-Scale Progression of Fragment Hits by Combining Multi-Step Array Synthesis With HT Crystallography. Angew. Chem. Int. Ed. 2025, 64, e202424373. (link)

Edmonds, A.K., Balourdas, D., Marsh,G.P., et al. (2025) Structure-Guided Design of ISOX-DUAL-Based Degraders Targeting BRD4 and CBP/EP300: A Case of Degrader Collapse. Journal of Medicinal Chemistry 2025 68 (9), 9638-9660. (link)




# Engineering

## Mathematical Modelling and Visualisation of Laser Shape and Scan Strategy Effects on Alloy Characteristics in Additive Manufacturing (EP26/6)

EPSRC category: Applied Research for a Better World

Lead Supervisor: Chang Wang in the Energy and Materials Engineering Research Centre

Department: Engineering

Research outline:

The combined influence of laser beam shape and scan strategy is critical in additive manufacturing, as it governs thermal distribution, melt pool geometry, and the resulting microstructure and mechanical properties of alloys. This research explores how different laser profiles, such as Gaussian, ring-shaped, and elliptical, interact with various scanning paths to affect alloy behaviour. Through mathematical modelling, the study predicts heat flow, melt dynamics, and solidification processes. Advanced computer visualisation techniques uncover relationships between laser configurations and microstructural features like grain orientation, porosity, and strength. The goal is to optimise laser and path parameters for improved material performance.

Key Publication: Roberts, I. Wang, C. Esterlein, R. Stanford, M. and Mynors, D. (2009) A three-dimensional finite element analysis of temperature field during laser melting of metal powders in additive layer manufacturing. International Journal of Machine Tools and Manufacture, Vol. 49, pp. 916-923. (link)

## Cybernetic Modelling of the Evolution of Motor Control Across Species (EP26/7)

EPSRC category: Interdisciplinary Research

Lead Supervisors: Carlo Tiseo and Jimena Berni

Department: Engineering

Research outline:

Animals have evolved extremely efficient and resilient ways of interacting with the environment maximising the chance of successful encounters. This characteristic is conserved across species

despite the different cognitive and motor abilities. Interestingly, during evolution, animals' nervous systems have added more complex structures built on top of the primitive nervous system of primigenial species. What role have these structures played in the preservation of new species?

It is challenging to isolate each neuronal structure in a single animal. However, approaching this research across multiple species at different levels of evolution will enable to isolate motor circuits and understand how the higher structures have developed and integrated during evolution.

Starting from the experiments with Drosophila larvae, with its simple nervous system, you will develop a dynamic simulation of a foraging experiment using a virtual artificial larva. This larval model will be developed using robotics methods to mimic biomechanics and control in a state-of-the-art simulation environment (MuJoCo). Subsequently, you will introduce evolution into the agent. You will expand the model by introducing neuro-motor using observations from more complex species. Enabling the addition of motor capabilities and neural circuits to reveal how efficiency evolves to ensure the preservation of the species.

Key Publications:

Tiseo C, et al (2021) "Exploiting spherical projections to generate human-like wrist pointing movements," 2021 43rd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC), Mexico, 2021, pp. 6192-6197. (link)

Jimena Berni (2024) Perception: How larvae feel the world around them eLife 13:e96708. (link)

## Integrated Sensing and Communications using Rydberg Atomic Quantum Receivers (EP26/8)

EPSRC category: Applied Research for a Better World

Lead Supervisor: Menguc Oner and Maziar Nekovee in the Advanced Communications, Mobile Technology and IoT (ACMI)

Department: Engineering

Research outline:

Rydberg atomic quantum receivers (RAQR) represent an emerging quantum mechanics based sensing technology that exploits the sensitivity of atoms whose valence electrons are excited to extremely high energy levels (i.e. Rydberg atoms) to variations in the ambient electric field. RAQRs promise a revolutionary alternative to existing antenna based receivers for wireless communications and RF sensing, with a plethora of advantages, such as lower thermal noise, considerably higher sensitivity, broadband tunability, direct to baseband conversion, reduced coupling between adjacent elements and many more.

Since the physical mechanisms underlying RAQRs are fundamentally different than their conventional antenna based counterparts, the integration of this technology into wireless communications and sensing is an emerging research area of considerable theoretical and practical interest. The focus of this project is the use of RAQRs in integrated communications and sensing for future wireless communication systems including 6G and beyond. A hybrid transceiver structure consisting of a classical antenna based RF transmitter, which is still required to generate the RF transmit signal, and the RAQR based receiver will be considered, and novel waveforms and signal processing algorithms specifically tailored to this unique scenario will be investigated, including signal and target detection, parameter estimation, beamforming, velocity and range estimation.

Key Publications:

Oner M, Sorguven E (2023).Channel characteristics for diffusive molecular communications in a spherical Shell. IEEE Communications Letters vol.27 Issue 4 pp. 1120-1124. (link)

Ayaz F. ,Nekovee M. (2024). Quantum optimization for bidirectional telecom energy exchange and vehicular edge computing in green 6G networks. 2024 IEEE International Conference on Communications, Control, and Computing Technologies for Smart Grids, Oslo, Norway, 2024, pp. 385-390. (link)

## Applications of Human Activity Recognition (HAR) (EP26/9)

EPSRC category: Applied Research for a Better World

Lead Supervisor: Dr Phil Birch

Department: Engineering

Research outline:

Human Activity Recognition (HAR) has many applications from sport tracking, and healthcare, to robotics and automatous vehicles. One method is to analyse the stray reflected signals that are generated using common Wi-Fi signals. As a person walks through the EM field, these reflections can be measured.  By training deep learning models, we can then infer what multiple people are actually doing and where they are going. Understanding and modelling social interaction could give better models, potentially producing more accurate results when presented with complex environments.

Key Publication: Han, X., Oishi, N., Tian, Y. et al. (2025) ETTrack: enhanced temporal motion predictor for multi-object tracking. Applied Intelligence 55, 33. (link)

## Accelerating Discovery at the Interface of Nanomaterials, AI and Automation (EP26/10)

EPSRC category: Interdisciplinary Research

Lead Supervisor: Dr Philip D. Howes in the Energy and Materials Engineering Research Centre

Department: Engineering

Research outline:

This cutting-edge multidisciplinary project sits at the interface of nanomaterials chemistry, automation and AI. You will develop/use automated systems for nanomaterials synthesis, allowing for rapid and data-rich experimentation. You will use AI to analyse gathered data and to drive experiments in search of specific research outcomes. You will discover new nanomaterials synthesis and processing approaches, and optimise these for target applications. This project is ideal for students inspired by interdisciplinary and high impact research. Candidates from a broad

variety of academic backgrounds are welcome, and you will join a group where interdisciplinary and diverse thinking are embraced.

Key Publication: Munyebvu, N; Dunn, S; Howes, P. D. (2025). Multiobjective platform for autonomous property targeting and optimization of colloidal lead halide perovskite quantum dots. Chemistry of Materials, 37, 6629–6641. (link)

## Optimizing Energy Efficiency in RIS-Aided ISAC with Low-Resolution Massive MIMO for 6G (EP26/11)

EPSRC category: Interdisciplinary Research

Lead Supervisor: Dr Reza Mohammadkhani

Department: Engineering

Research outline:

This research integrates Integrated Sensing and Communications (ISAC) with Reconfigurable Intelligent Surface (RIS)-aided massive MIMO systems, focusing on energy efficiency for 5G and 6G networks. RIS technology reshapes the wireless environment, improving signal propagation and mitigating channel impairments while reducing power consumption. By employing low-resolution quantization in ADCs and DACs, the system significantly reduces hardware complexity and energy usage, enabling sustainable massive MIMO deployment. AI-driven techniques further optimize resource allocation, signal processing, and decision-making, achieving a balance between sensing accuracy, system performance, and spectral efficiency. This approach advances intelligent, energy-efficient, and high-capacity wireless networks for the future.

Key Publication: Azizzadeh, A., Mohammadkhani, R., Makki, S.V.A.D. and Björnson, E., (2019). BER performance analysis of coarsely quantized uplink massive MIMO. Signal Processing, 161, pp.259-267. (link)

## Turbomachinery component design optimisation assisted by AI and rapid prototyping (EP26/12)

EPSRC category: Applied Research for a Better World

Lead Supervisor: Dr Vasudevan Kanjirakkad in the Thermo-Fluid Mechanics Research Centre

Department: Engineering

Research outline:

Applications are invited from highly motivated candidates with an appropriate background to work on a turbomachinery aerodynamics project. This work will concentrate on AI-assisted optimisation of axial compressor/turbine components to improve the thrust-to-weight ratio and/or the aerodynamic efficiency of jet fans/engines. The research methodology (experimental/numerical/mixed) will depend on the applicant's skill and the requirements for

developing a successful concept. The geometry optimisation will aim to take advantage of rapid prototyping methodologies both at the testing and prototype level. Example problems of interest include (but not limited to), fan-inlet bellmouth optimisation, compressor shroud/casing optimisation, turbine rim-seal optimisation.

Key Publication: Mustaffa, A.F., Kanjirakkad, V., (2021) Casing-groove optimisation for stall margin in a transonic compressor rotor. International Journal of Numerical Methods for Heat & Fluid Flow 31 (2): 694–717. (link)

## Reconfigurable Optical Neural Networks for Next Generation AI Systems (EP26/13)

EPSRC category: Applied Research for a Better World

Lead Supervisor: Leila Yousefi

Department: Engineering

Research outline:

Research Interests:

Artificial intelligence (AI) has made significant strides across various fields, often surpassing human capabilities. Neural networks are central to these advancements, but traditional electronic computing systems face limitations such as high power consumption, limited bandwidth, and high costs. These challenges have led to growing interest in optical neural networks (ONNs), which offer ultra-low power usage, high-speed parallel processing, and exceptional bandwidth. ONNs present a promising alternative for next-generation AI systems. This project aims to design and develop reconfigurable optical neural networks that can support more efficient, scalable, and high-performance AI applications, addressing the limitations of conventional electronic architectures.

Key Publication: Abed, O, Yousefi, L, (2020). Tunable metasurfaces using phase change materials and transparent graphene heaters. Optics Express, Vol. 28, pp. 33876-33889. (link)

## Developing models and methods for numerical analysis of the dynamics of critical structures and their optimisation (EP26/14)

EPSRC category: Applied Research for a Better World

Lead Supervisor: Yevgen Petrov

Department: Engineering

Research outline:

The major research topics are developing models and methods for numerical analysis of the dynamics of critical structures and their optimisation. The models and methods are aimed at application to practical structures using large-scale finite element models and accurate modelling of contact interactions in jointed structures with friction, gap and other nonlinear interactions. The

comprehensive analysis of nonlinear forced response and self-excited vibrations is performed with the assessment of stability, sensitivity and robustness of the vibration regimes. The problems of modelling aeroelastic interactions of structures with fluid and modelling the effect of heat generation by friction in high-energy rubs are considered.

Key Publication: Petrov, E. (2019) Analytical formulation of friction contact elements for frequency-domain analysis of nonlinear vibrations of structures with high-energy rubs, ASME J. Eng. Gas Turbines Power, vol. 141, pp. 121006-1-121006-12. (link)

## Renewable hydrogen production for sustainable integration (EP26/15)

EPSRC category: Mathematics and Theoretical Foundations

Lead Supervisor: Fan Zhang

Department: Engineering

Research outline:

The team focuses on renewable hydrogen production for sustainable integration across different sectors. It looks into the system integration, control, and optimisation of renewable power generation and utilisation systems, especially using hydrogen as an energy carrier for storage, and investigates the feasibility of extending such a system into different sectors, such as agriculture, transportation, and industry etc. The work ranges from dynamic modelling and control to ensure optimal integration of electrolytic/storage/fuel cell systems with renewable electricity supply, to wider applications, such as stand-alone and grid-connected renewable hydrogen systems, fuel cell system applications, especially as an alternative fuel for transportation.

Key Publication: Basnet, S., Deschinkel, K., Le Moyne, L. and Péra, M.C., (2023). A review on recent standalone and grid integrated hybrid renewable energy systems: System optimization and energy management strategies. Renewable Energy Focus, 46, pp.103-125. (link)

## MOF-Based Electrochemical Recovery and AI-Optimisation of Critical Metals (EP26/16)

EPSRC category: Applied Research for a Better World

Lead Supervisor: Fan Zhang in the Energy and Materials Engineering Research Centre

Department: Engineering

Research outline:

Join the UK's Green Industrial Revolution at Sussex! This PhD tackles water security and critical-mineral supply for UK manufacturing. You'll synthesise and characterise MOF-based electrochemical materials to recover lithium and vanadium from water and industrial streams, and develop advanced anti-corrosion coatings. This is a lab-first project with training in AI-assisted

process optimisation—no prior coding required. Based in the School of Engineering and Informatics, and working with Jaguar Land Rover and SSAB, you'll gain hands-on R&D experience, deliver validated materials and processes, and build a high-impact career powering the UK's circular, low-carbon economy.

Key Publication: Zhao J, Wang D, Zhang F, Pan J, Claesson P, Larsson R, Shi Y. (2022). Self-powered, long-durable, and highly selective oil–solid triboelectric nanogenerator for energy harvesting and intelligent monitoring. Nano-Micro Letters, 14, 160. (link)

## Enhancing prediction accuracy for elderly people during robot assisted locomotion (EP26/17)

EPSRC category: Interdisciplinary Research

Lead Supervisor: Hsien-Yung Huang in the Centre for Robotics and Sensing Technologies

Department: Engineering

Research outline:

The stability of a human locomotion is commonly investigated in elderly population as the consequences are often significant. To provide suitable robotic assistive technology for elderly people, it is demanded to create a robust prediction model to separate abnormal locomotion behaviour. As shown in the key publication, a simple setup using high-density electromyography on two key muscles allows accurate locomotion transition prediction within a range between 100-400ms using convolution neural network. The aim of the new project is to leverage on existing research and identify critical setup for improved prediction accuracy, coupled with robotic systems and potential commercialisation.

Key Publication: Jing, S., Huang, H.Y., Jouaiti, M., Zhao, Y., Yu, Z., Vaidyanathan, R. and Farina, D., (2024). Enhancing the Prediction of Locomotion Transition with High-Density Surface Electromyography. IEEE Journal of Biomedical and Health Informatics, 9, 6263-6275 (link)

## Electric Vehicle thermal comfort control using an AI observer – collaboration with Jaguar Land Rover (EP26/18)

EPSRC category: Applied Research for a Better World

Lead Supervisors: Peter Fussey and Mark Puttock-Brown in the Energy and Materials Engineering Research Centre

Department: Engineering

Research outline:

Vehicle thermal management systems use significant amounts of the battery stored energy, impacting vehicle range. In partnership with Jaguar Land Rover, we are researching how to achieve a more efficient, comfortable and integrated thermal experience. This project considers the full vehicle and user experience eco-systems, including the user's home, travel and destination.

You will consider how a thermal comfort control system can observe the passenger's thermal comfort (feedback) and adapt to the different situations, e.g. clothing, body size, gender, weather, metabolic rate, Heating Ventilation Air Conditioning (HVAC) settings. The research will start with a series of subjective assessments to parameterise an AI thermal comfort observer, establishing the minimum information to provide a robust estimate of thermal comfort. The observer will be embedded into a representative HVAC controller and tested with a range of conditions and candidates to evaluate how effective the observer is to disturbances and delivering a comfortable environment.

The thermal comfort observer will be used in an integrated thermal experience for users transitioning from different locations e.g. from a building to the car, via a brief period outside. The goal is to develop a multi-objective trajectory planning algorithm based on an AI enhanced thermal comfort control.

Key Publications:

Fussey, P. et al. (2025) Demonstration of Model Predictive Control to Optimise Cabin Thermal Comfort in a Battery Electric Vehicle, SAE Technical Paper 2025-01-8145. (link)

Puttock-Brown, M, et al (2024). A physics informed neural network for solving the inverse heat transfer problem in gas turbine rotating cavities. University of Sussex. Journal contribution. (link)

## Programmable Diffractive Neural Networks Based on Space–Time Coding for Next-Generation Terahertz Communications (EP26/19)

EPSRC category: Applied Research for a Better World

Lead Supervisor: Mohammad Neshat

Department: Engineering

Research outline:

My research focuses on terahertz technology, using the 0.1–10 THz band that future wireless networks will exploit to achieve unprecedented data rates and capacity. This project builds on our previous research on space–time-coded (STC) arrays, which enable dynamic manipulation of electromagnetic waves across space and time. Its novelty lies in developing a programmable diffractive deep neural network based on STC principles, enabling analog processing with exceptional speed and energy efficiency—addressing the key bottlenecks of conventional digital processing. The proposed approach will be tested in ultra-high-speed THz communication and sensing scenarios, addressing many of the current challenges.

Key Publication: Gholami M., Khajavi S., Neshat M., Tewes S. and Sezgin A., (2025) Wireless localization with space–time-coded reconfigurable intelligent surfaces. IEEE Transactions on Antennas and Propagation, vol. 73, no. 8, pp. 5650-5657. (link)

## Design and Control of Soft and Adaptive Exoskeletons for Hand Rehabilitation and Assistive Applications (EP26/20)

EPSRC category: Interdisciplinary Research

Lead Supervisor: Leonardo Garcia-Garcia in the Centre for Robotics and Sensing Technologies

Department: Engineering

Research outline:

The EPSRC research area is on robotics, focused on enabling healthy or independent living. I will be able to host a PhD project focused on the development of a soft, adaptive hand exoskeleton for assistive and rehabilitative applications. Combining mechanical design, soft robotics, and intelligent control, the research aims to create a lightweight, ergonomic device capable of supporting natural hand motion. Multimodal sensors (e.g. EMG, force, motion) will be integrated for real-time user-intent detection and adaptive assistance. The project involves designing and fabricating the exoskeleton, developing embedded control algorithms, and evaluating performance through human trials. Outcomes will include novel designs, control frameworks, and experimental validation, contributing to next-generation wearable robotics for restoring and enhancing hand function in healthcare and daily living.

Key Publication: García-García, L.A., Rodríguez-Salvador, M., Moya-Bencomo, M.D. (2019). Development of a Customized Wrist Orthosis for Flexion and Extension Treatment Using Reverse Engineering and 3D Printing. In: Lhotska, L., Sukupova, L., Lacković, I., Ibbott, G. (eds) World Congress on Medical Physics and Biomedical Engineering 2018. IFMBE Proceedings, vol 68/2. Springer, Singapore. (link)

## Embedded ultrasonic sensors for lithium-ion battery degradation diagnosis (EP26/21)

EPSRC category: Applied Research for a Better World

Lead Supervisors: Ming Huang and Peter Fussey

Department: Engineering

Research outline:

Lithium-ion batteries are essential for achieving net zero, yet degradation shortens their lifespan and creates safety hazards. Existing monitoring methods provide only bulk measurements and cannot identify internal defects or track degradation in individual layers. Building on the supervisors' recent breakthroughs in battery diagnostics, this project will create embedded ultrasonic sensors for continuous internal monitoring. These sensors will combine ultrasonic measurements with machine learning to track changes in individual electrode layers throughout battery operation. The sensors will capture degradation in real time, including lithium plating, particle cracking, and layer delamination. This will enable accurate prediction of remaining battery life and early detection of potential failures. By providing precise health diagnostics, this technology may also unlock battery reuse and second life applications. The project will deliver transformative benefits for electric vehicles and energy storage systems, turning batteries into intelligent, self-monitoring devices that maintain optimal performance and safety throughout their lifetime.

Key Publications:

Huang, M. (2022). Quantitative characterisation of the layered structure within lithium-ion batteries using ultrasonic resonance. Journal of Energy Storage, 50, 104585. (link)

Fussey, P. (2024). An electric-potential turbocharger speed sensor. Proceedings of the International Conference on Turbochargers and Turbocharging, 476-487. (link)

## High precision robotics and sensing for skin assessment in regenerative medicine (EP26/22)

EPSRC category: Interdisciplinary Research

Lead Supervisor: Elizabeth Rendon-Morales and Rodrigo Aviles-Espinosa in the Centre for Robotics and Sensing Technologies

Department: Engineering

Research outline:

Biomaterial based scaffold have emerged as a potential intervention for wound healing forming the foundation of skin tissue regeneration. These scaffolds are intricate three-dimensional frameworks, serving as carriers for cells, medications, and genes, facilitating their integration and delivery into the body.

This research project in collaboration with Queen Victoria Hospital (East Grinsted) is about improving the design and fabrication of 3D printed tissue scaffolds and exploring novel cell or drug delivery mechanisms. We aim at optimizing the scaffold fabrication and understanding their interactions with tissue. The project also explores the adoption of novel robotic based volumetric imaging and its integration with AI tools for the development of personalised 3D printed models of the skin (i.e. dermal equivalents). The mechanical and structural properties of dermal equivalents will be characterized and compared to in vitro human skin. These findings will contribute to understanding the suitability of dermal equivalents in clinical applications.

Key Publications:

Yan, C., Aviles-Espinosa, R., Wang, S., Rendon-Morales, E. (2024). Design and fabrication of 3D-printed magnetically triggered soft-porous scaffolds for drug delivery. 21st IEEE International Conference on Networking, Sensing and Control. (link)

Huang, X., Rendon-Morales, E., and Aviles-Espinosa, R. (2024). A Biomedical Robotic Platform Combined with an Application-Specific Laser-Based End-Effector for Achieving High Precision Neurosurgery. 2024 IEEE International Symposium on Medical Measurements and Applications (MeMeA), Eindhoven, Netherlands, 2024, pp. 1-6. (link)

## Design of novel optical devices and sensors for applications in robotic microsurgery (EP26/23)

EPSRC category: Interdisciplinary Research

Lead Supervisors: Rodrigo Aviles-Espinosa and Elizabeth Rendon-Morales in the Centre for Robotics and Sensing Technologies

Department: Engineering

Research outline:

Most commercially available robotic systems can achieve millimetre accuracies with very few examples of high precision instruments achieving accuracies slightly below the millimetric scale. Medical applications such as reconstructive microsurgeries, surgical anastomosis, vitreoretinal eye surgery, and neurosurgery still require achieving precision comparable to the size of human cells.

This project in collaboration with Queen Victoria Hospital (East Grinsted) is about the design of innovative photonic microsurgical tools and novel sensing devices (using visible, and infrared (IR) illumination) to perform high precision tissue soldering tasks in blood vessels and nerves. Our sensing approach will serve to evaluate the tissue properties including its ability to absorb, scatter or reflect the emitted radiation. Such unique attributes of the tissue will be used as a feedback to finetune the laser beam properties including its power, energy density, and spectral emission. The second phase of the project will be focussed on optimizing the soldering performance, improve accuracy and to conduct evaluation experiments for validating the novel device and its ability to reduce collateral damage in tissue during microsurgery.

Key Publications:

Huang, X., Rendon-Morales E., and Aviles-Espinosa R. ROMI: Design and Experimental Evaluation of a Linear Delta Robotic System for High-Precision Applications. Machines 2023, 11, 1072. (link)

Loza-Alvarez, P., Avilés-Espinosa, R., et al. (2014) QD Ultrafast and Continuous Wavelength Laser Diodes for Applications in Biology and Medicine. Physics and Engineering of Compact Quantum Dot Based Lasers for Biophotonics, Vol. 9783527411849, pp. 171-230. (link)

## Research on Hybrid Model of Optimal Vehicle Control and Macroscopic Dynamic Traffic Assignment for Mixed Traffic Network Capacity Maximization (EP26/24)

EPSRC category: Applied Research for a Better World

Lead Supervisor: Shangbo Wang in the Advanced Communications, Mobile Technology and IoT (ACMI)

Department: Engineering

Research outline:

In this project, we will investigate the maximum capacity a mixed traffic network can achieve, by devising a hybrid model of CAVs' optimal control strategy and macroscopic dynamic traffic assignment method, which has never been done before. The main objective of the optimal control

strategy is to minimize the link average travel time and fuel consumption by adaptively adjusting CAVs' speed and acceleration, based on which the aggregate Macroscopic Fundamental Diagram (MFD) for mixed traffic flow will be formulated for understanding the impact of the optimal control strategy on link density and flow. Based on the derived macroscopic link model and node model, we will devise a dynamic traffic assignment method to maximize the network capacity at the dynamic Wardrop equilibrium, which incorporates the spatial queuing dynamics, CAVs' optimal control strategy and adaptive traffic signal setting. We will also propose a dynamical system, which can achieve the dynamic Wardrop equilibrium by adaptively swapping route flow and adjusting signal settings. The condition for existence and uniqueness of the dynamic Wardrop equilibrium will be derived and stability of the dynamical system will be proved by the Lyapunov stability theorem.

Key Publication: Gu, H., Wang, S., et al. (2024). Large-Scale Traffic Signal Control Using Constrained Network Partition and Adaptive Deep Reinforcement Learning. IEEE Transactions on Intelligent Transportation Systems, pp. 7619-7632, July 2024. (link)

## Critical infrastructure resilience and reliability (EP26/25)

EPSRC category: Interdisciplinary Research

Lead Supervisor: Spyros Skarvelis-Kazakos in the Energy and Materials Engineering Research Centre

Department: Engineering

Research outline:

Research interests include energy network resilience and reliability, real-time simulations of power system cascading failures, critical infrastructure interdependencies, graph theory, impact of climate change and pandemics on energy networks, adaptation and mitigation of those impacts, intelligent control / aggregation of Distributed Energy Resources, multiple energy carriers / integrated energy systems, micro-grids, Virtual Power Plants, energy storage, multi-agent systems, electric vehicles.

Potential PhD project topics include:

- Network Theory Resilience Metrics for interdependent multilayer critical infrastructure networks
- Preventing electrical network blackouts with epidemic control techniques
- Climate adaptation of critical infrastructure networks
- Forest fires, climate change, pandemics and critical infrastructure resilience

Key Publication: Skarvelis-Kazakos, S., Van Harte, M. et al. (2022). Resilience of electric utilities during the COVID-19 pandemic in the framework of the CIGRE definition of Power System Resilience, International Journal of Electrical Power & Energy Systems, Vol. 136, 107703. (link)

## Developing a robotic system for ultrasound scan for diagnosis of rheumatoid arthritis (EP26/26)

EPSRC category: Applied Research for a Better World

Lead Supervisor: Yanan Li

Department: Engineering

Research outline:

This project will develop a robotic system for ultrasound scan for diagnosis of rheumatoid arthritis (RA). This system will function in two modes: i) an autonomous mode that scans hand joints to capture clear and accurate joint information and detect potential early signs of RA; ii) a teleoperation mode, where, after the initial autonomous scan, clinicians can intuitively manipulate the robotic probe to assess specific joints of concern. This dual-mode system will save clinicians' time and effort, improve the reproducibility of ultrasound procedures, and provide a more standardized approach, facilitating its adoption as a routine method for early RA diagnosis.

Key Publication: Li, Y et al. (2018). Force, Impedance, and Trajectory Learning for Contact Tooling and Haptic Identification. IEEE Transactions on Robotics, vol. 34, no. 5, pp. 1170-1182. (link)

## Digital Twin Empowered Integrated Sensing and Communications (DT-ISAC) for Smart Transportation (EP26/27)

Collaborative project with non-university partners

EPSRC category: Experimental approaches to Understanding

Lead Supervisors: Zhengguo Sheng and Shangbo Wang in the Advanced Communications, Mobile Technology and IoT (ACMI)

Department: Engineering

Research outline:

Addressing traffic safety is the foremost priority in current smart transportation research, as it serves as the foundational basis for other core requirements, such as traffic capacity, energy efficiency, time delay and so on. Meanwhile, vehicular communications and sensing are crucial for achieving universality, flexibility and integrated solutions within 6G network scenarios, and is key to connect with the broader infrastructure to optimize traffic flows and to achieve intelligent transportation. However, most of the existing works only address vehicular communication or sensing functions respectively, which is far away from meeting the 6G requirements in availability and synchronization particularly for digital twin based vehicular applications. Inspired by the recent advancement in integrated sensing and communication (ISAC), this project will investigate new opportunities to explore the ISAC capacity for traffic and pedestrian safety. Essentially, the proposed solution should reuse Ultra-wideband such as 5G mmWave or optical wireless communications (OWC) to construct communication/sensing channels for achieving concurrent message exchange and status awareness between vehicles and pedestrian at urban crossings. In essence, this integration can provide a theoretical foundation and methodological support for digital twin, while the digital twin serves as a powerful enabler and necessary extension for real

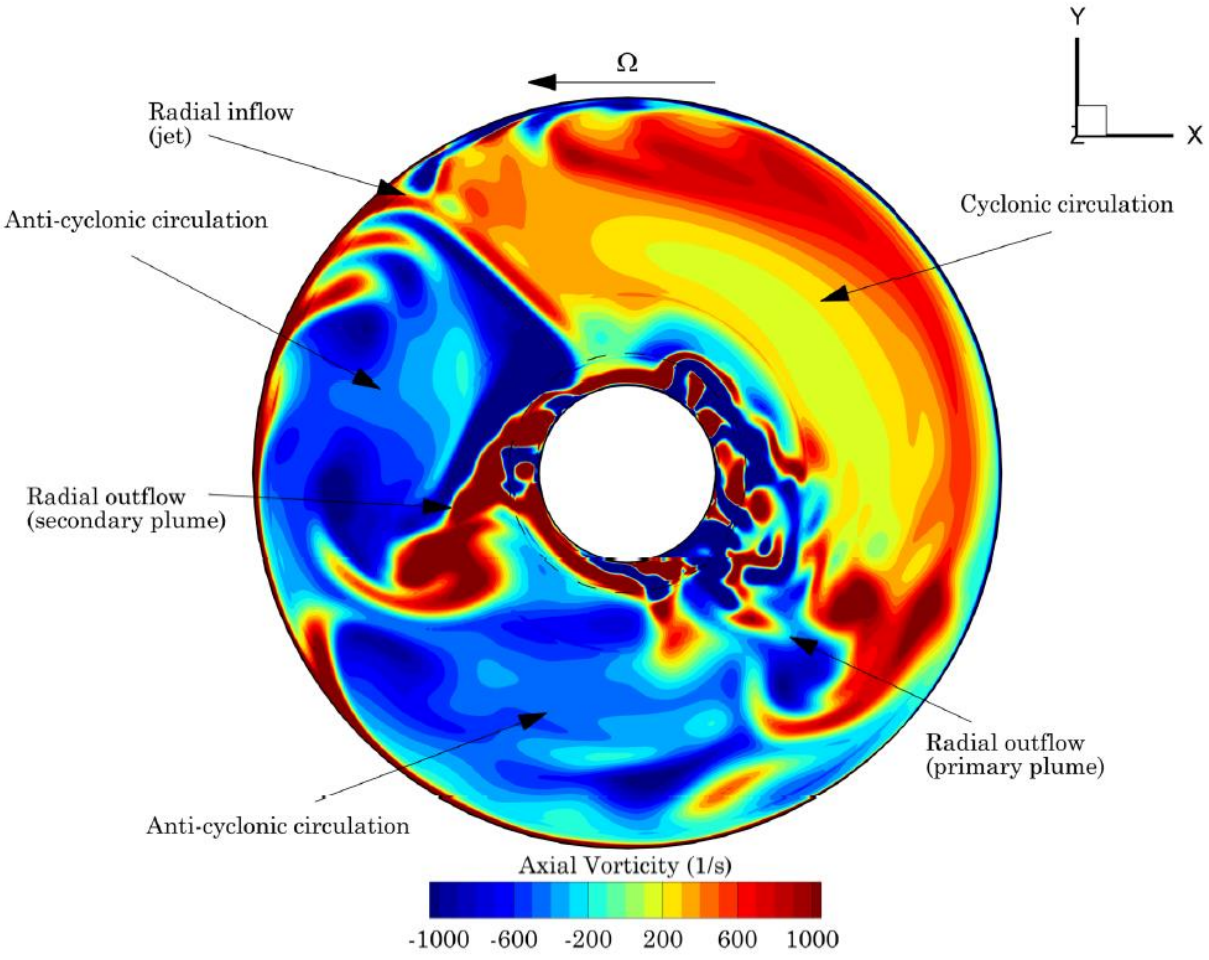
time traffic optimization and prediction. Together, they complement each other and form a comprehensive research framework addressing transportation challenges.

Key Publications:

Song, Y., Mo, R., Zhang, P., Wang, C., Sheng, Z., and Bing, Y. (2024). VehicleTalk: Lightweight V2V Network Enabled by Optical Wireless Communication and Sensing. Proc. of IEEE Vehicular Technology Conference (VTC) 2024, Singapore. 10.1109 (link)

Su, J., Cai, H., Sheng, Z., Liu, A. and Baz, A. (2024). Traffic prediction for 5G: A deep learning approach based on lightweight hybrid attention networks. Digital Signal Processing. (link)

Su, J., Mao, Q., Liao, Z., Sheng, Z., Huang, C. and Zhang, X. (2023). A Cross-Domain Wi-Fi-based Gesture Recognition System For Digital Twins. IEEE Journal on Selected Areas in Communications. 10.1109/JSAC.2023.3310073



# Informatics

## Active visual learning (EP26/28)

EPSRC category: Interdisciplinary Research

Lead Supervisor: Andrew Philippides

Department: Informatics

Research outline:

Perception is not passive. Animals actively explore their environments to acquire the information they need to guide future behaviour and evolution has shaped the animal movements to shape incoming information to make it easier to learn/recall. This is seen across animals from choreographed learning flights of bees to eye movements of humans. However, precisely how active vision is co-evolved with task, environment and visual system is not well understood. This project will explore this question either experimentally, theoretically or both with details guided by the student with applications ranging from insects to humans, and AI to robots.

Key Publication: Philippides, A., de Ibarra, N. H., Riabinina, O., & Collett, T. S. (2013). Bumblebee calligraphy: the design and control of flight motifs in the learning and return flights of Bombus terrestris. Journal of Experimental Biology, 216(6), 1093-1104. (link)

## Classical simulation techniques for quantum computation (EP26/29)

EPSRC category: Experimental approaches to Understanding

Lead Supervisor: Niel de Beaudrap

Department: Informatics

Research outline:

I engage in research in mathematical techniques to analyse and simulate quantum processes, aimed towards helping to develop better quantum software. The project which I propose would be to develop techniques to simulate quantum computations, beyond the stabiliser formalism, to natively accommodate measurement and random classical data, with emphasis on efficient

simulation of Pauli observable measurements. To this end, there is a good prospect to develop similar techniques as demonstrated by Amy (link) but for Hermitian operators. This would allow very effective simulation of states encoded in stabiliser codes, stabiliser code deformations, and processes with random outcomes.

Key Publication: de Beaudrap, N. (2022) Fast stabiliser simulation with quadratic form expansions. Quantum 6, 803 (link)

## Fast model-checking on GPUs (EP26/30)

EPSRC category: Experimental approaches to Understanding

Lead Supervisor: Martin Berger in the Foundations of Software Systems group

Department: Informatics

Research outline:

Despite extensive research into the parallelisation of algorithms for software and hardware verification (e.g., model-checking), these algorithms generally do not achieve good performance on graphics processing units (GPUs), the workhorses of high-performance computing that provide orders of magnitude speedup to applications compatible with their programming paradigm. As verification is bottlenecked by the available compute, this performance gap is a growing concern for modern society with its increasing reliance on computers for many systematically important. The proposed research aims to start addressing this issue by solving the long-standing open problem of scaling-up model-checking workloads on GPUs.

Key Publication: Berger, M. (2024). LTL learning on GPUs. Computer Aided Verification CAV 2024. Lecture Notes in Computer Science, vol 14683. Springer. (link)

## Understanding and Improving Language Models (EP26/31)

EPSRC category: Experimental approaches to Understanding

Lead Supervisor: Jeff Mitchell in the AI Research Group

Department: Informatics

Research outline:

The standard transformer architecture has been extremely successful in driving recent advances in Natural Language Processing, resulting in tools such as ChatGPT, Gemini, Grok and others. However, these models consume several orders of magnitude more data than a human language learner and yet continue to have problems with correctness and reliability. Which aspects of the transformer are responsible for these weaknesses? What benefits would other architectures bring? How could we best incorporate human-like learning biases?

Key Publication: Mitchell, J & Bowers, J. (2020) Priorless recurrent networks learn curiously. Proceedings of the 28th International Conference on Computational Linguistics. 5147-5158. (link)

## Can AI be conscious? (EP26/32)

EPSRC category: Interdisciplinary Research

Lead Supervisor: Anil Seth in the Sussex Centre for Consciousness Science

Department: Informatics

Research outline:

As AI systems increase in capability there is increasing debate about whether such systems can be not only intelligent, but also conscious. Addressing this question is of enormous technological and ethical significance. Many researchers assume that 'computation' or 'information processing' is sufficient for consciousness, but there are reasons to doubt this assumption. This project will address the question of 'AI' consciousness through either (i) theory and modelling related to 'substrate independence' of neural processes (e.g., mortal computation), and/or (ii) societal/ethical implications of AI that either is, or appears to be, conscious.

Key Publications: Seth, A.K. (2025). Conscious artificial intelligence and biological naturalism. Behavioural and Brain Sciences (link)

## Leveraging machine learning (ML) to address verification and synthesis challenges in timed logics (EP26/33)

EPSRC category: Mathematics and Theoretical Foundations

Lead Supervisor: Hsi-Ming Ho

Department: Informatics

Research outline:

This project explores leveraging machine learning (ML) to address verification and synthesis challenges in timed logics, which model systems with temporal constraints. It aims to enhance scalability and efficiency in verifying system behaviours, generating counterexamples, and providing explanations. Key steps include developing data representations, feature engineering, training ML models, and integrating them with existing tools. The research promises novel ML methodologies tailored to formal verification, improved verification performance, and automated synthesis capabilities. Over three years, the project will progress from data collection and experimentation to methodology development, integration, and evaluation, contributing insights to both formal methods and ML.

Key Publication: Brihaye, T., Geeraerts, G., Ho, H. M., & Monmege, B. (2017, July). MightyL: A compositional translation from MITL to timed automata. In International Conference on Computer Aided Verification (pp. 421-440). (link)

## Machine learning for ecologically relevant spatiotemporal representations (EP26/34)

EPSRC category: Interdisciplinary Research

Lead Supervisors: Ivor Simpson in the AI Research Group

Department: Informatics

Research outline:

Ecosystems involve a complex web of interactions across a range of temporal and spatial scales. Several ecological monitoring data sources exist: ecoacoustics (audio); camera traps (image); vegetation, soil and human surveys (tabular), each of which provides a limited perspective of underlying processes. This complicates data interpretation and limits our capability to assess ecological health and nature recovery. This project will create novel machine learning methods that interpretably describe the underlying processes given spatiotemporal data. This builds on existing research, datasets, and collaborations with Chris Sandom (Ecology) and Alice Eldridge (Music). Students require ML expertise and interests in ecology and audio.

Key Publication: Gibb, K.A., Eldridge, A., Sandom, C.J. and Simpson, I.J., (2024). Towards interpretable learned representations for Ecoacoustics using variational auto-encoding. Ecological Informatics, 80, p.102449. (link)

## A computational neuroscience of cognitive effort (EP26/35)

EPSRC category: Experimental approaches to Understanding

Lead Supervisors: Warrick Roseboom and Maxine Sherman

Department: Informatics

Research outline:

We are hoping to jointly supervise projects that apply techniques from machine learning, AI, mathematical biology and computational neuroscience to further our understanding of high-level cognitive phenomena. Of particular interest to us is cognitive effort. Cognitive effort refers to the experience associated with allocating a high degree of mental resource to a problem or task, and is severely under-studied despite clearly being critical for understanding motivation and metacognitive control – and by extension, almost all of human cognition. The first step of this project would involve analysing and modelling pre-existing neuroimaging data (e.g. fNIRS or PET) that can be taken as a proxy for metabolic cost to test the degree to which cognitive effort is comparable to physical effort. From there, the student might develop computational models of cognitive effort drawing on approaches from statistical physics and/or mathematical biology, apply techniques from machine learning to test hypotheses on neuroimaging data, draw on models of cognitive effort to build metacognitive control into artificial systems, or a combination of these.

EPSRC research areas: Analytical Science; Artificial intelligence technologies; Biological Informatics; Mathematical Biology; Synthetic Biology; Vision, Hearing and Other Senses .

Key Publications:

Fountas, Z., Sylaidi, A., Nikiforou, K., Seth, A. K., Shanahan, M., & Roseboom, W. (2022). A predictive processing model of episodic memory and time perception. Neural computation, 34(7), 1501-1544. (link)

Sherman, M. T., Fountas, Z., Seth, A. K., & Roseboom, W. (2022). Trial-by-trial predictions of subjective time from human brain activity. PLOS Computational Biology, 18(7), e1010223. (link)

## Neuro-AI and deep learning for animal behaviours (EP26/36)

EPSRC category: Interdisciplinary Research

Lead Supervisor: James Bennett in the AI Research Group

Department: Informatics

Research outline:

The Bennett Lab works at the intersection of neurobiology and AI. Ongoing projects in the lab include: i) Efficient learning through multi-objective optimisation in bio-inspired neural networks, in which neurons are grouped by distinct neurotransmitters and optimisers to exploit efficient coding properties of the brain; ii) Reinforcement learning (RL) algorithms for continual, open-ended learning paradigms, and their relationship with dopamine circuits in neurobiology, including control theoretic extensions that enhance the robustness and adaptivity of RL, and hierarchical RL for risk-sensitive decision-making; iii) Building a self-supervised deep learning platform for the analyses of animal behavioural data in collaboration with experimental labs.

Key Publication: Bennett JEM, Philippides A, Nowotny T. (2021). Learning with reinforcement prediction errors in a model of the Drosophila mushroom body. Nat. Comms. 12:2569. (link)

## Event-based machine learning (EP26/37)

EPSRC category: Interdisciplinary Research

Lead Supervisors: James Knight and Thomas Nowotny

Department: Informatics

Research outline:

Event-based Spiking Neural Networks (SNNs) are inspired by the efficiency of biological neurons and with recent advances such as Eventprop (Wunderlich & Pehle (2021), Nowotny et al. (2024)) we can train them using supervised learning. However, there are technical difficulties and the methods have thus far only been applied to a few benchmark problems. Equally important, like in ML more generally, lack of labelled data is becoming a problem. Self-supervised approaches are an exciting and competitive alternative (Chen et al. (2020), Illinger et al. (2020), Halvagal & Zenke (2023)).

We are looking for PhD students interested in working on these challenges using our GPU-accelerated SNN simulation framework (Knight et al. (2021), Knight & Nowotny (2023) to:

- further improve methods for gradient descent in SNNs
- extend gradient descent methods towards real-world problems
- combine SNNs and self-supervised learning to solve real-world tasks
- train SNNs for deployment on neuromorphic hardware like Loihi 2

Key Publications:

Nowotny T, Turner, JP, Knight, JC (2024). Loss shaping enhances exact gradient learning with EventProp in spiking neural networks, arXiv. (link)

Knight, JC & Nowotny, T (2023). Easy and efficient spike-based machine learning with mlGeNN. Neuro-Inspired Computational Elements Conference, 115–120. (link)

## An adaptive STEM learning environment that supports personalised representations (EP26/38)

EPSRC category: Applied Research for a Better World

Lead Supervisors: Kate Howland and Sam Berens

Department: Informatics

Research outline:

Kate Howland's research is in human-computer interaction, with a focus on technologies for learning and education. She evaluates educational interfaces based on empirical evidence about how we learn, particularly systems that take account of the embodied, enactive and situated nature of learning. Recent work has included investigating a concreteness fading approach to designing interfaces for computing education, enhancement of social-motor synchrony through multisensory full-body interaction and the use of gestures and gestural interaction in both programming education and language learning.

Sam Berens' research aims to understand the cognitive and neural mechanisms that enable us to learn general knowledge and solve problems. He's particularly interested in how we learn concepts that help us make sense of the world. To do this, he investigates the neural representations and computations involved in combining information across different events, identifying commonalities/differences, and extracting generalisable patterns. Berens' work uses a combination of bespoke cognitive tasks and model-based analyses of behavioural and functional MRI data.

Proposed joint project: The design, development and evaluation of an adaptive learning environment that builds on neuroscientific evidence about learning and generalisation to support personalised representations that match learners' needs based on their current performance on learning tasks.

Key Publications:

Trory, A., Howland, K., Good, J., du Boulay, B. (2025). Concreteness fading for primary school computing. ACM Transactions on Computing Education. (link)

Berens, S. C., & Bird, C. M. (2022). Hippocampal and medial prefrontal cortices encode structural task representations following progressive and interleaved training schedules. PLOS Computational Biology, 18(10), e1010566. (link)

## The Art of Slow Machines (EP26/39)

EPSRC category: Experimental approaches to Understanding

Lead Supervisors: Maria Teresa Llano Rodriguez

Department: Informatics

Research outline:

In creative settings there is a growing interest in moving beyond the dominant framing of Generative AI as a tool for optimisation and efficiency, towards more reflective uses. Like novelists, painters, and writers, etc., who explore the expressive potential of their mediums, artists can engage AI for its unique affordances, finding satisfaction in its creative possibilities.

Guided by the principles of slow technology, this project seeks to explore alternative forms of interaction with AI for artistic expression—emphasising reflection, appreciation, anticipation, and long-term evolution. The aim is to uncover new, sustainable, and meaningful ways of integrating AI into artistic workflows.

Key Publication: Krol, S.J., Llano, M.T. and McCormack J. (2025) Supporting Creative Ownership through Deep Learning-Based Music Variation. Proceedings of The Thirty-Ninth Annual Conference on Neural Information Processing Systems (NeurIPS'25), Creative AI Track. (link)

## Developing optimal transport methods for modelling disease progression with neuroimaging data (EP26/40)

EPSRC category: Interdisciplinary Research

Lead Supervisor: Peter Wijeratne and Ivor Simpson

Department: Informatics

Research outline:

Dr Wijeratne's EPSRC research area is artificial intelligence (AI) in healthcare and neuroscience, with a particular focus on data- and computationally-efficient probabilistic modelling of disease progression with a strong theoretical foundation. Along with Dr Simpson, who has expertise in developing machine learning approaches and Bayesian models for inverse problems with spatiotemporal data, we are looking to supervise PhD projects that develop innovative and statistically principled machine learning approaches for incorporating multi-modal medical imaging data into models of disease progression. This will build on Dr Wijeratne's recent optimal transport (OT) model of disease progression and utilise structured data likelihoods (from Dr Simpson's work) to robustly incorporate different sources of evidence. This project has multiple research directions, including the development of the intersection of OT and Bayesian methods to power the next generation of image-driven disease progression models. Multi-disciplinary applications include phenomenological insights, early diagnosis and prediction of dementia.

Key Publications:

Wijeratne, PA, Alexander, DC. (2024). Unscrambling disease progression at scale: fast inference of event permutations with optimal transport. Advances in Neural Information Processing Systems (NeurIPS). (link)

Simpson, IJA, Vicente, S, Campbell, NDF. (2022). Learning structured Gaussians to approximate deep ensembles. Computer Vision and Pattern Recognition (CVPR). (link)

## Understanding the dynamics of land use change and supporting the co-creation of pathways towards sustainable land use (EP26/41)

EPSRC category: Interdisciplinary Research

Lead Supervisors: Novi Quadrianto and Fiona Marshall

Department: Informatics

Research outline:

This transdisciplinary project is concerned with understanding the dynamics of land use change and supporting the co-creation of pathways towards sustainable land use that address biodiversity, climate change, food security and poverty concerns. The focus is on opportunities for sustainable food estate programmes in Indonesia, in the context of major concerns about their adverse environmental and social impacts. We work with farming communities, NGOs, conservation agencies and government agencies; drawing together quantitative and qualitative data (and formal and informal knowledges) to visualize and assess the multiple values of landscapes and impacts of food estate interventions at sites with a variety of monocrop and agroforestry systems. We seek to support productive, evidence-based dialogue through the development and use of an open access mapping and modelling tool; developing land use scenarios that integrate climate resilience and biodiversity conservation into initiatives that support sustainable livelihoods of farming communities and wider food security concerns. Through participatory action research and capacity building activities with key stakeholders, we identify land use planning and policy process opportunities and practical intervention points.

Key Publication: Dolley, J., Marshall, F., Butcher, B. Butcher, Reffin, J., Robinson, J.A., Eray, B., Quadrianto, N. (2020) Analysing trade-offs and synergies between SDGs for urban development, food security and poverty alleviation in rapidly changing peri-urban areas: a tool to support inclusive urban planning. Sustainability Science. (link)

## Develop new models and data sets to address current technical challenges in the recognition of sign language (EP26/42)

EPSRC category: Applied Research for a Better World

Lead Supervisors: Ronald Grau and John Walker

Department: Informatics

Research outline:

British Sign Language is the primary means of communication for many deaf and hearing-impaired people in the UK. There is a clear need to promote sign language proficiency within this group, as this has been declining over recent years, especially among younger people. However, learning sign language requires the acquisition of psychomotor skills, and these are not easily obtained without practice and feedback. AI-supported learning tools would not only help address this problem but also make sign language more accessible to the general population and so, help improve inclusion for deaf and hearing-impaired people in society.

Previous research has shown the potential of computer vision algorithms and convolutional neural networks for transforming image data of signs into actionable insights and providing feedback in real time - a major improvement over passive approaches such as instructional videos. The PhD project will build on previous developments of BSL training prototypes, the latest of which won the Sussex University JRA competition in 2024. The project will develop new models and data sets to address current technical challenges in the recognition of signs but also contribute towards ongoing work for developing and evaluating methods to integrate AI-supported techniques into established sign language pedagogy.

Key Publications:

Aldahir, R., Grau, R. (2024). Using convolutional neural networks for visual sign language recognition. Towards a system that provides instant feedback to learners of sign language. 21st International Web for All Conference (W4A '24), 70-74. (link)

O'Brien D, Hodge G, Gulamani S, Rowley K, Adam R, Emery S, Walker J (2023). Deaf professionals' perceptions of 'trust' in relationships with signed language interpreters. The International Journal of Translation and Interpreting Research, 15(2), 25-42. (link)

## AI for Parkinson's pain level assessment (EP26/43)

EPSRC category: Applied Research for a Better World

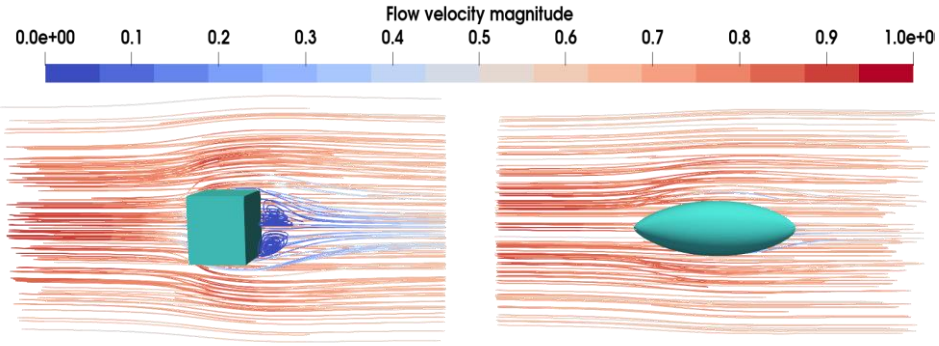
Lead Supervisor: Temitayo Olugbade

Department: Informatics

Research outline:

Persistent pain is one of the non-motor symptoms that contributes to the considerable burden of Parkinson's disease on those living with the condition. This project will investigate automatic pain level assessment in daily life with Parkinson's, toward facilitating personalized pain management as well as clinical trials of potential treatments. While there are a large number of studies on motor symptoms of Parkinson's, pain has received much less attention despite its significance. The project will contribute novel machine learning methods that advance the area. The project will also involve creation of new datasets and engagement with people with lived experience.

Key Publication: Olugbade, T., de C Williams, A. C., Gold, N., & Bianchi-Berthouze, N. (2023). Movement representation learning for pain level classification. IEEE Transactions on Affective Computing, 15(3), 1303-1314. (link)




# Mathematics

## Interacting particle systems and percolation models (EP26/44)

EPSRC category: Mathematics and Theoretical Foundations

Lead Supervisor: Nicos Georgiou

Department: Mathematics

Research outline:

The available projects are broadly on rigorous probability and stochastic processes, especially interacting particle systems, queueing theory, percolation models and epidemic spreads but with on outlook towards applicability, such as traffic or finance. All models can be viewed as interacting particle systems- if you (particle) are standing in a queue, you can only move if the person ahead of you moves (interaction). If there is a flue epidemic, you can mostly get infected when in the vicinity someone who is contagious. The broadest epidemics models are modelled via a `contact process' which is also a percolation model.

In each of the areas above, several potential PhD projects can be offered, based on the interests of the applicant:
1. Directed particle systems on random trees and other networks (see also linked article).
2. Fractional queueing theory applied to heavy-tailed double auction models.
3. Laws of large numbers and fluctuations for space-time inhomogeneous percolation models.
4. Inhomogeneous models of epidemic process on finite and infinite graphs.

Key Publication: Gantet, N., Georgiou, N., Schmid D., (2021) The TASEP on Galton–Watson trees, Electron. J. Probab. 26: 1-38. (link)

## Branching processes (EP26/45)

EPSRC category: Mathematics and Theoretical Foundations

Lead Supervisor: Minmin Wang

Department: Mathematics

Research outline:

The branching process is a fundamental concept in probability theory. More precisely, it refers to a class of stochastic processes that model the evolution of populations, where each individual independently produces a random number of offspring. Branching processes have widespread applications across fields such as biology, nuclear physics, epidemiology, and computer science.

This project focuses on a particular type known as the spatial branching process, in which individuals move randomly within a given domain between birth events. The primary goal is to study the large deviation properties of these processes.

Key Publication: Harris, S., Horton, E., Kyprianou, A. and Wang, M. (2022). Yaglom limit for critical non-local branching Markov processes. Annals of Probability, 50(6), 10.1214/22-AOP1585 (link)

## Asymptotic Freeness and applications (EP26/46)

EPSRC category: Mathematics and Theoretical Foundations

Lead Supervisors: Antoine Dahlqvist

Department: Mathematics

Research outline:

Free probability is a non-commutative probability theory where independence is replaced by freeness. It initially emerged to prove properties of von Neumann algebras and in particular of the free group.  A key idea was to approximate freeness by classical independence and rotational invariance in distribution for random matrices of large size.

This project follows a reversed paradigm: free probability allows to study random matrices or tensors of large size, and it does so under much weaker invariance assumptions. This opens the door to possible projects and many applications in particular to geometric analysis, random tensors or deep learning.

Key Publication: Au, B., Cébron, G., Dahlqvist, A., Gabriel, F. and Male, C. (2021). Freeness over the diagonal for large random matrices. Annals of Probability, 49, 157-179. (link)

## Probability and statistics: random matrix theory and its interactions with other fields of mathematics and physics (EP26/47)

EPSRC category: Mathematics and Theoretical Foundations

Lead Supervisor(s): Dr Nicholas Simm

Department: Mathematics

Research outline:

I am offering PhD projects in probability and statistics, specifically on topics related to random matrix theory and its interactions with other fields of mathematics and physics. One of the projects is to understand the relationship between random matrix theory and the Riemann zeta function, the latter being of central importance in number theory. The main focus of the project will be about statistical properties of characteristic polynomials of random matrices. The aim will be to use these

properties to make precise number theoretical predictions about the behaviour of the Riemann zeta function close to the critical line.

Key Publication: Najnudel, J. and Paquette, E. and Simm, N. (2023). Secular coefficients and the holomorphic multiplicative chaos. Annals of Probability, Vol 51, No. 4, 1193-1248. (link)

## Regularised optimal transport (EP26/48)

EPSRC category: Mathematics and Theoretical Foundations

Lead Supervisor: Lukas Koch

Department: Mathematics

Research outline:

Optimal transport has been a very active area of research in the recent past driven by applications in machine learning and theoretical advances. In particular, a number of variants have been explored which contain additional penalty terms. These variants have been introduced in order to facilitate numerical computation of optimal transport maps, as well as to better model physical phenomena, such as congestion. I am interested in studying regularity properties of these models, possibly with numerical applications depending on applicant's interest.

Key Publication: Gvalani, R. and Koch, L. (2025) Uniform large-scale ε-regularity for entropic optimal transport. (link)

## Mathematical modelling to explore the intricate dynamics of microbial interactions and diversity in the soil microbiome (EP26/49)

EPSRC category: Interdisciplinary Research

Lead Supervisor: Marianna Cerasuolo in the Mathematics Applied to Biology research group

Department: Mathematics

Research outline:

The soil microbiome is essential for soil health and ecosystem sustainability. The PhD project will integrate statistics and mathematical modelling to explore the intricate dynamics of microbial interactions and diversity. By developing network-based approaches and stochastic dynamical systems, we aim to construct assembly maps that uncover pathways of microbiome development. State-of-the-art Bayesian inference methods will be extended to analyse sparsely sampled datasets and infer ecosystem-level dynamics. These models will provide insights into how ecological dependencies shape microbial community assembly, stability, and resilience, with applications to environmental challenges such as agricultural interventions and climate change impacts.

Key Publication: K Begum, R Zornoza, R Farina, R Lemola, J Álvaro-Fuentes, M Cerasuolo (2022) Modeling soil carbon under diverse cropping systems and farming management in contrasting climatic regions in Europe. Frontiers in Environmental Science 10, 819162. (link)

## Bayesian approach to inverse problems involving diffusion processes (EP26/50)

EPSRC category: Mathematics and Theoretical Foundations

Lead Supervisor: Masoumeh Dashti

Department: Mathematics

Research outline:

Many dynamical processes involving noise are modelled by stochastic differential equations (SDEs). Often in applications all or part of the coefficients of the model are unknown but we have access to some data generated by the process itself. This project studies some problems related to the estimation of diffusion and drift coefficients of an SDE using discrete measurements of its solution. A Bayesian approach will be employed and some aspects of well-posedness and approximations of the solution to this approach will be investigated. The project has both theoretical and computational components and uses techniques from the analysis of SDEs, parabolic partial differential equations, applied probability and sampling methods.

Key Publication: Dashti, M., Stuart, A. M. (2017). The Bayesian approach to inverse problems, In Handbook of Uncertainty Quantification, pages 311--428. (link)

## Mathematical and computational methods for Schrödinger type Partial Differential Equations (EP26/51)

EPSRC category: Mathematics and Theoretical Foundations

Lead Supervisor: Michael Melgaard

Department: Mathematics

Research outline:

Potential Projects include:

- New numerical tensor methods and tensor-structured neural networks in quantum physics.
- Nonlinear PDEs (in astrophysics, electronic structure models etc).
- Spectral and scattering properties of quantum systems.

Group articles:

- Bound-state stability of Coulomb three-body systems using numerical tensor methods. Phys. Rev. A 109 (2024), 062812.

- Spectral approximation scheme for a hybrid, spin-density Kohn-Sham Density-Functional Theory in an external (nonuniform) magnetic field ..., J. Math. Chem. 62 (2024), 711-760.

Poisson wave trace formula for Dirac resonances at spectrum edges..., Asian J. Math. 25 (2021), no. 2, 243-276.

Key Publication: Melgaard, M. et al (2024), Bound-state stability of Coulomb three-body systems using numerical tensor methods. Phys. Rev. A 109, 062812. DOI (link)

## Numerical methods for delay differential equations (EP26/52)

EPSRC category: Mathematics and Theoretical Foundations

Lead Supervisor: Peter Giesl

Department: Mathematics

Research outline:

The project (together with Prof. Yuliya Kyrychko) aims to develop numerical methods for delay differential equations, in particular to compute Razumikhin- and Krasovskii-Lyapunov functions. Lyapunov functions show the stability and serve to estimate the basin of attraction of stable solutions. While numerical methods have been employed successfully to construct Lyapunov functions for dynamical systems given by ordinary differential equations, this project aims to adapt those methods to delay differential equations. In particular, we aim to use meshfree collocation or to formulates the construction as an optimization problem.

Key Publication: Giesl, P., Hafstein, S., Suhr, S., Wendland, H. (2025). Minimization with differential inequality and equality constraints applied to complete Lyapunov functions. Discrete Contin. Dyn. Syst. Ser. B 30 No. 2, 449-473. (link)

## PDE constrained shape optimisation: from theory to practice (EP26/53)

EPSRC category: Mathematics and Theoretical Foundations

Lead Supervisor: Philip Herbert

Department: Mathematics

Research outline:

Optimal design is key to many industrial applications, ranging from hydro and wind energy harvesting to space travel and telecommunication. Finding optimal designs is notoriously challenging, especially when this requires determining optimal component shapes (e.g., of wind turbine blades) whose performance will depend on the solution of a PDE. Numerical methods to solve shape optimisation problems are available, but their approximation qualities (and hence reliability) are not well understood. We aim to develop the state of the art, to further develop novel mathematical concepts and scientific software to assess and improve the performance of

numerical shape optimisation.  This project is flexible and can range from functional analysis and PDE-theory to numerical analysis.

Key Publication: Deckelnick, K, Herbert, P.J, and Hinze, M.  PDE-constrained shape optimization with first-order and Newton-type methods in the W1,∞ topology, Optimization Methods and Software. (link)

## Geometric properties of random convex hulls (EP26/54)

EPSRC category: Mathematics and Theoretical Foundations

Lead Supervisor(s): Vladislav Vysotsky in the Probability and Statistics research group

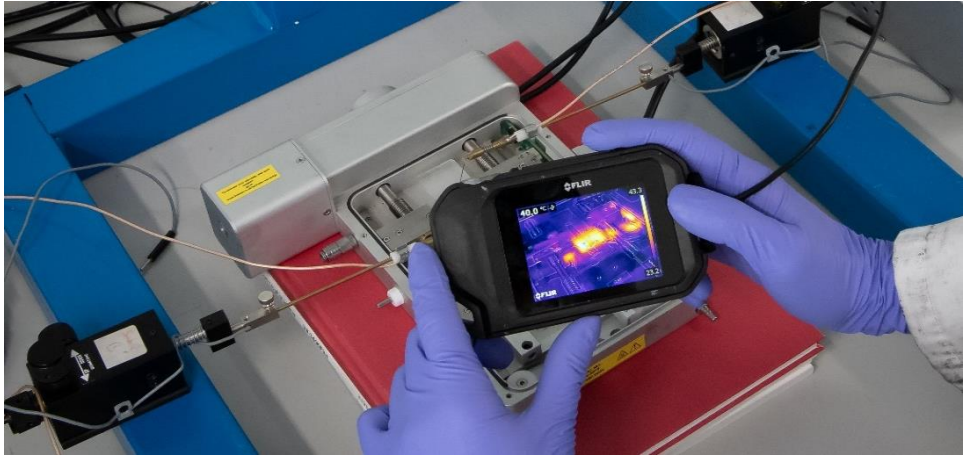
Department: Mathematics

Research outline:

Convex hulls provide a tractable yet reasonably accurate approximation for sets of more complicated structure. Selecting the sets at random, for example taking a finite number of points in the space according to some probability distribution, produces a random convex hull. The most popular models assume that these points are sampled independently or represent the steps of a random walk. This PhD project in theoretical probability aims to study geometric properties of the random convex hulls of such type, e.g. when the number of points is large. Some of the problems arising require additional use of convex geometry and combinatorics.

Key Publication: Z. Kabluchko, V. Vysotsky, D. Zaporozhets (2017) Convex hulls of random walks, hyperplane arrangements, and Weyl chambers. Geometric and Functional Analysis, v. 27, pp. 880-918. (link)

# Physics



## Nanomaterials including graphene and 2D materials, for a diverse range of nanotechnologies and device applications (EP26/55)

EPSRC category: Applied Research for a Better World

Lead Supervisor(s): Alan Dalton and Sean Ogilvie in the Materials Physics Group

Department: Physics

Research outline:

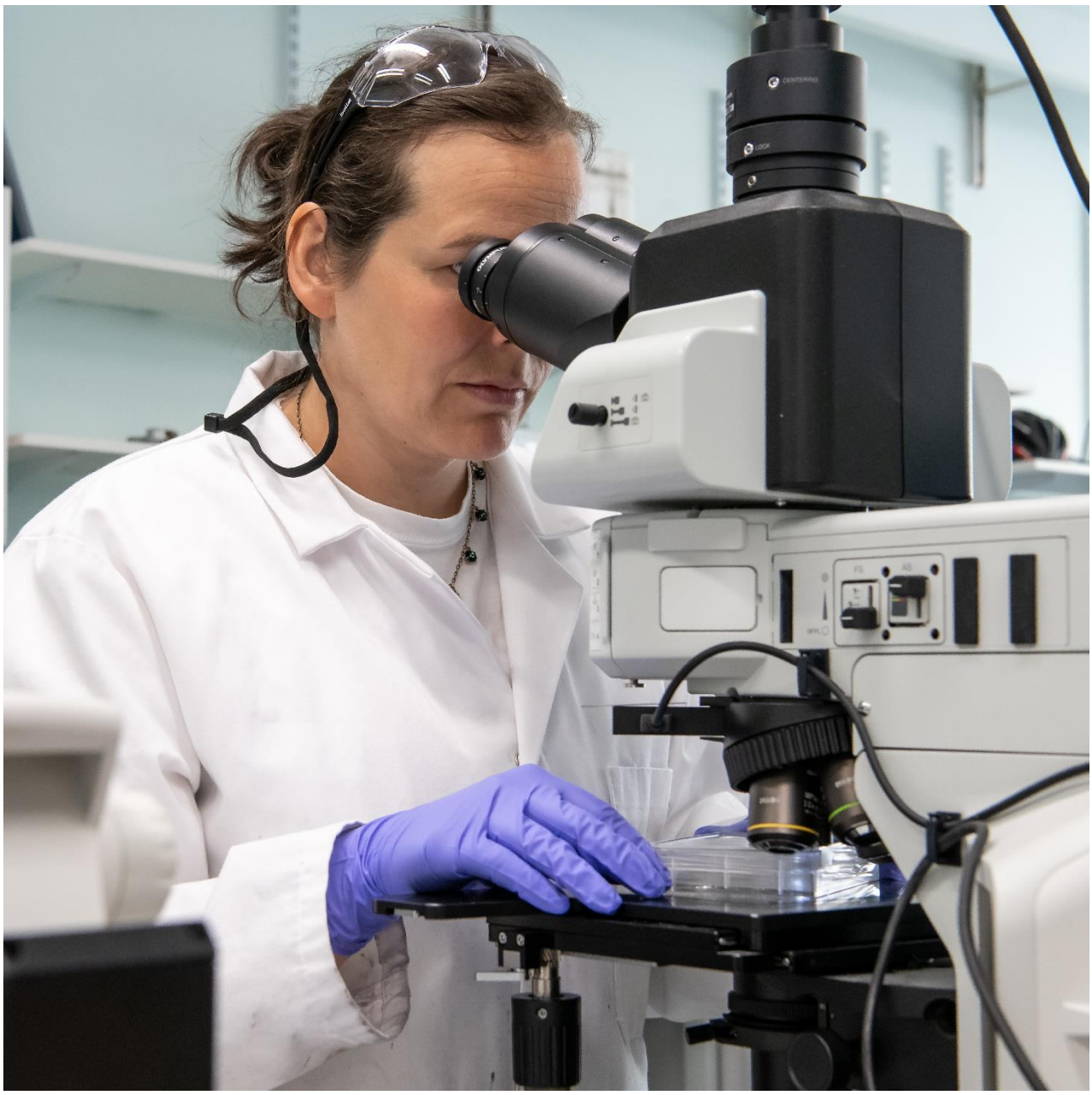
In Materials Physics, we process and study nanomaterials with emergent functional properties, including graphene and 2D materials, which have the potential to enable a diverse range of nanotechnologies and device applications. We work primarily with scalable solution processing techniques, allowing us to develop functional inks, coatings, composites, and free-standing hierarchical structures. Our work ranges from nanoscale characterisation of optoelectronic and nanomechanical properties of materials for quantum technologies to the assembly of nanomaterials into macroscopic structures and devices. Our current research streams include the understanding and enhancement of electrical transport in nanomaterial networks, which has supported the development of conductive inks for radiofrequency applications such as printed RFID tags and absorbing panels for NASA's Europa Clipper mission. We are also investigating nanomaterial-based electromechanical sensors for strain monitoring, including applications in electric vehicle batteries and, in collaboration with clinicians at St Thomas' Hospital London, wearable devices for health monitoring. Additionally, we explore the use of nanostructures for tissue engineering to understand cellular interactions, and we are developing nanomaterial functionalities for energy devices such as electrochemical energy storage, solar infrared smart windows, and thermoelectric heat capture. Our team is a diverse and dynamic group of interdisciplinary researchers with backgrounds across physics, chemistry, engineering, and materials science, and we have a wide network of external and industrial partners. Contact us to discuss how your experience and research interests align with ours to develop an exciting new project in one of these areas.

Key Publication:

King, A.A.K., et al (2022). Tuneable synthetic reduced graphene oxide scaffolds elicit high levels of three-dimensional glioblastoma interconnectivity in vitro. Journal Materials Chemistry B. (link)

Dalton. A.B., et al (2023). Explosive percolation yields highly-conductive polymer nanocomposites. Nature Communications. (link)

Ogilvie S.P., et al (2024). Emergent high conductivity in size-selected graphene networks. Carbon, 218. (link)



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