IMPERIAL

PHD OPPORTUNITIES

THE MATTER COMMUNITY

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THE MATTER COMMUNITY

Community Head
Professor Will Branford
w.branford@imperial.ac.uk

Research mission

The Matter community tackles problems ranging from fundamental physics to climate change. Our theoretical and experimental research aims to enhance the efficiency of renewable energy, design new materials for imaging, sensing and computation, and build novel quantum sensors and simulators. We seek to understand how collective phenomenaemerge in large interacting ensembles, explore how matter behaves on nanometre sizescales and attosecond time scales, and probe the character of dark matter and thefundamental symmetries of nature.

Research areas

- Cold Atoms and Molecules
- Complexity and Networks
- Correlated Quantum Systems
- Ion trapping
- Materials Physics
- Metamaterials
- Nanomagnetism
- Neuromorphic Computing
- Plasmonics & Nanophotonics
- Plastic and Optoelectronics
- Renewable Energy and Material for Energy Efficient Use
- Research at the Interface with Biomedical Sciences
- Security and Sensors
- Superconductivity
- Topological Matter

Our research is funded by various sources including the European Union, the Engineeringand Physical Sciences Research Council, the Science and Technology Facilities Council, and the Royal Society. We have strong links with other major laboratories in the UK and with industry.

Dr Niladri Banerjee
Senior Lecturer
n.banerjee@imperial.ac.uk

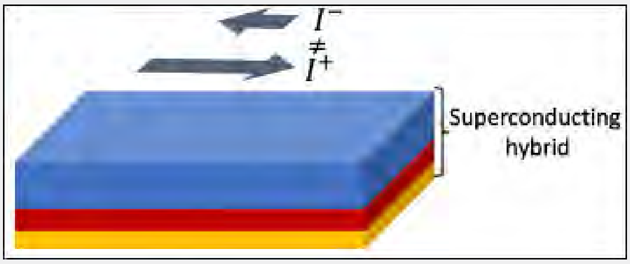
Prof. Lesley Cohen
Associate Provost (Equality, Diversity and Inclusion)
l.cohen@imperial.ac.uk

Electronic transport of superconducting spin-orbit coupled hybrids

Our work in the last decade helped to establish the field of triplet superconductivity which, in contrast to conventional superconductivity, carries a net spin or magnetism. The combination of magnetism and superconductivity open intriguing possibilities of new devices for quantumtechnologies and low-dissipation computing.
We have recently demonstrated that relativistic spin-orbit coupling can drive the conversion of conventional to unconventional superconductivityin ultra-thin film hybrids. Interestingly, such hybrids also show non-reciprocal current flow similar to a diode. The project will investigate theunderlying physics including the role of the spin-orbit field underpinningthis diode effect.

In this project you will:

- Learn and use thin film deposition
- Develop expertise in nano fabrication using standard optical and/or electron beam lithography and etching.
- Learn low-noise and low-temperature electronic and magnetic measurements.
- Advanced data analyses and simulation and modelling of experimental results



Dr Niladri Banerjee
Senior Lecturer
n.banerjee@imperial.ac.uk

Prof. Lesley Cohen
Associate Provost (Equality, Diversity and Inclusion)
l.cohen@imperial.ac.uk

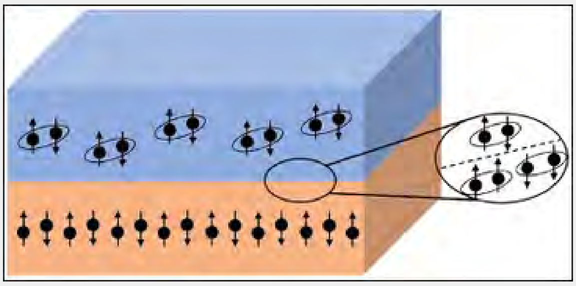
Superconductor-antiferromagnet proximity effects

Bringing two dissimilar materials in close contact often results in unexpected emergent phases with unusual properties. One example is a superconductor/ferromagnet hybrid where the interaction between superconductivity and magnetism under some special conditions can produce a unconventional superconductivity with a net spin or magnetism. Studying such phases can lead to future devices and applications in low-dissipation information processing or quantum technologies.

In this project, we will investigate the coupling of superconductors with antiferromagnets where the electron spins are antiparallel. Oddly, even in such systems unconventional and topological superconductivity has been predicted under special circumstances which we will investigate experimentally.

In this project you will:

- Perform advanced thin film deposition using pulsed laser deposition and/or sputtering
- Develop expertise in nano fabrication using standard optical and/or electron beam lithography and etching.
- Learn low-noise and low-temperature electronic and magnetic measurements.
- Advanced data analyses and simulation and modelling of experimental results.



Prof. Lesley Cohen
Associate Provost (Equality, Diversity and Inclusion)
l.cohen@imperial.ac.uk

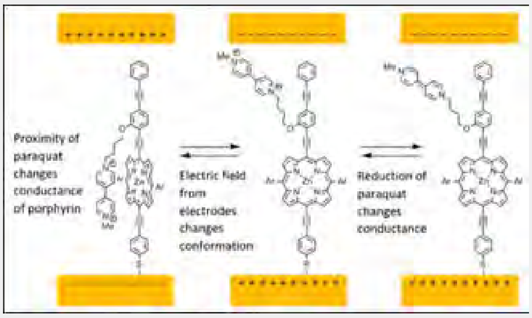
Dr Niladri Banerjee
Senior Lecturer
n.banerjee@imperial.ac.uk

Organic memristive devices for neuromorphic computing

Memristor is a programmable non-volatile memory resistor which remembers even without an external power. Their low-energy consumption and fast switching speeds are attractive for information storage. Interestingly, they can also emulate biological synapses and neurons for neuromorphic computing. This project will investigate asymmetric organic molecules such as porphyrin where an electric field-induced conformational change leads to a change in conductivity of the molecule. These molecular switches will be used to designed self-assembled monolayers and various memristive device architectures explored for applications. The project activities will be closely linked to the large consortium grant on Quantum Engineering of Energy-efficient Molecular Materials.

In this project you will:

- Perform solution processing, spray coating and ink-jet printing of asymmetric organic molecules
- Develop expertise in nano fabrication using standard optical and/or electron beam lithography.
- Learn low-noise electronic, thermal and heat capacity measurements.
- Advanced data analyses and simulation and modelling of experimental results



Dr Niladri Banerjee
Senior Lecturer
n.banerjee@imperial.ac.uk

Prof. Will Branford
Professor of Solid State Physics
w.branford@imperial.ac.uk

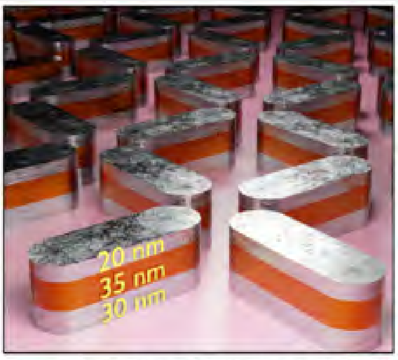
Artificial spin ice-based reprogrammable superconducting electronic devices

Geometrical frustration can be generated in an array of nanomagnets where several degenerate configurations exist and are important for microelectronic memory and logic devices. Incorporatinga superconducting layer underneath these spin ice lead to a vortex lattice inthe superconductor coupled to these nanomagnets with remarkably highdegeneracy and fully magnetic field reprogrammable geometric frustration.

This project will investigate the fundamental physics in these systems including the effect of nanomagnet dimensions, anisotropy on the vortex lattice, and possibility of generating highly degenerate field-free vortex lattices for computing applications.

In this project you will:

- Perform low noise low temperature electronic measurements
- Learn nanofabrication
- Perform Ferromagnetic resonance spectroscopy measurements
- Magnetic simulations
- Magnetometry and magnetic force microscopy



Nanomagnetic array with two magnetic layers

Prof. Will Branford **Prof. Riccardo Sapienza**

Professor of Solid State Physics Professor of Physics
w.branford@imperial.ac.uk r.sapienza@imperial.ac.uk

Dr Jack Gartside

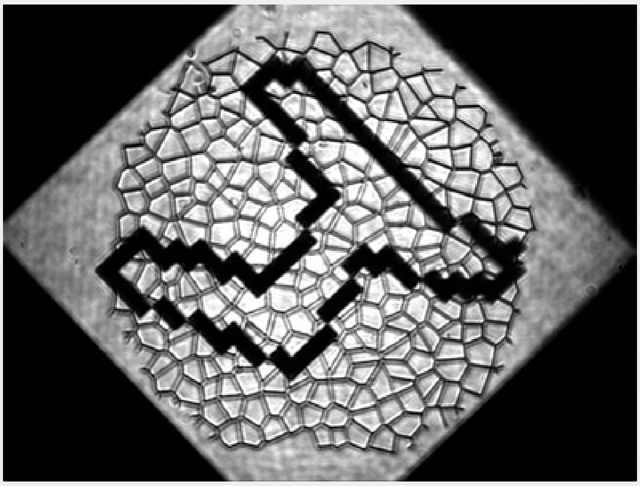
Research Fellow
j.carter-gartside13@imperial.ac.uk

Optical Neuromorphic Computing

Neuromorphic computing, beyond the traditional van Neumann architectures of our personal computers, is poised to revolutionise theway we perform calculations, inspired by how the human brain works,and with better performances at a much lower energy cost. You willimplement neural networks on random lasing networks which arecontrolled by laser illumination. The pattern of illumination can be controlled by a digital mirror device and the highly non-linear physics ofcompeting lasing modes controls the computation.

In this project you will learn the following skills and techniques:

- Optical spectroscopy measurements
- Graph theoretical simulation methods
- Neuromorphic computing methods, such as reservoirs and convolutional neural networks.
- Hyperspectral imaging



Prof. Will Branford

Professor of Solid State Physics
w.branford@imperial.ac.uk

Prof. Rupert Oulton

Professor of Nanophotonics
r.oulton@imperial.ac.uk

Dr Jack Gartside

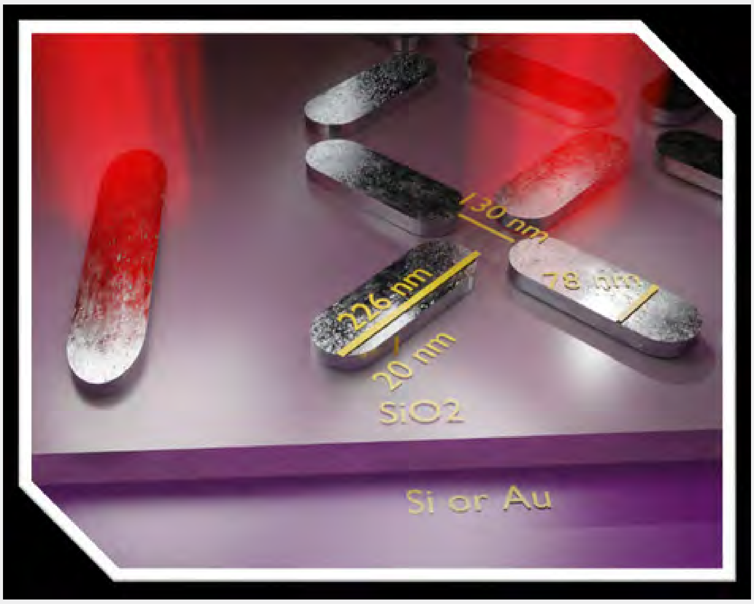
Research Fellow
j.carter-gartside13@imperial.ac.uk

Rewritable magnetic nanostructures

We have recently developed a method of writing any magnetic pattern we choose into magnetic nanostructured arrays that are usually calledArtificial Spin Ice using a continuous wave laser at very low power. Theaim of this project will be to understand the fundamental physics of thewriting by fabricating artificial spin Ice structures and studying them byultrafast and CW optical experiments. We will also explore thepossibilities for neuromorphic computing technology.

In this project you will learn the following skills and techniques:

- Nanofabrication
- Continuous-wave and ultrafast magneto-optic measurement
- Magneto-optic writing
- Magnetic simulations
- Magnetometry and magnetic force microscopy



Dr Joe Cotter

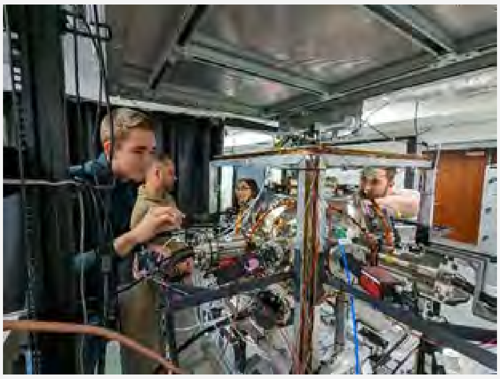
Advanced Research Fellow
Centre for Cold Matter
j.cotter@imperial.ac.uk

Atom interferometry for inertial sensing

Our atom interferometers use laser light to prepare the internal and motionalstates of a cloud of laser-cooled rubidium atoms. This device can beextremely sensitive - for example the instrument in our laboratory can sensechanges of a few billionths of the acceleration due to gravity.
The sensitivity and accuracy of such a device will enable navigation without the use of external signals such as Sonar or Satellite communications.

In this project you will:

- Join a team comprised of students, postdocs, and academics that is developing innovative quantum technologies.
- Laser-cool rubidium atoms to a few tens of microkelvin.
- Use the laser-cooled atoms to measure accelerations with high precision and accuracy.
- Advance current technology in collaboration with industry to build a more compact and reliable system that can be used in field trials.
- Test and characterise the performance of the system in field trials on the tube, ships and submarines.
- Become an expert in vacuum and laser science, optics and imaging, 3D modelling, computer automation and interfacing, numerical modelling, and statistics and data analysis.



Dr Jack Devlin

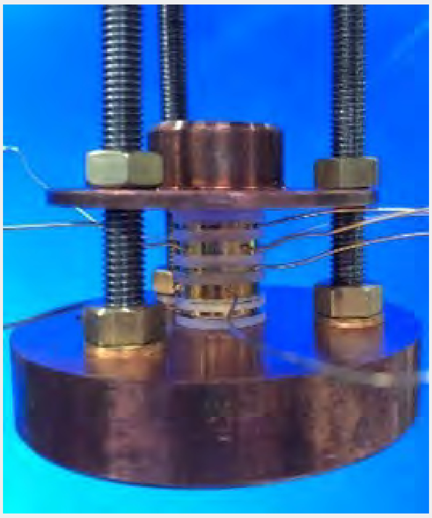
Royal Society University Research Fellow & Lecturer
Centre for Cold Matter
Ion Trapping
j.devlin11@imperial.ac.uk

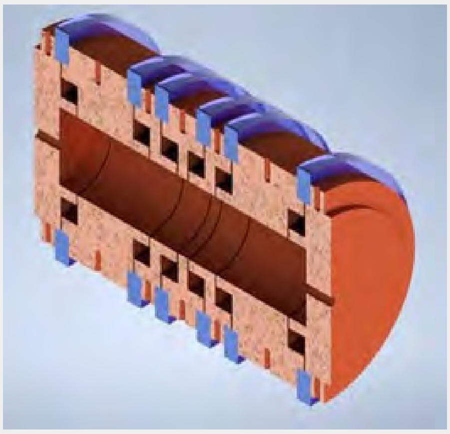
Astroparticle physics with a trapped electron quantum sensor

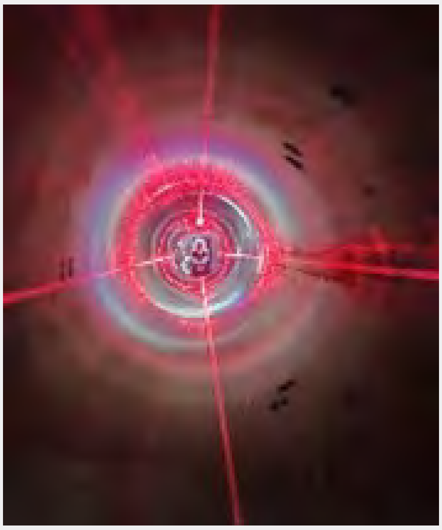
In this project you will use an electron in a Penning trap to do tabletopastroparticle physics, searching for hints of dark matter. The electron will act as a quantum sensor, and its quantum state will be monitored for changes caused by dark matter. These include both direct collisions with some types of dark matter and the absorption of single microwave photons from the decay of certain other types of dark matter particles like axions.

In this project you will:

- Design and assemble a Penning trap electrode stack that can be cooled to 4K
- Build ultra-sensitive detections systems to read out the trapped frequencies
- Make low noise electronics for use at cryogenic temperatures
- Learn all the skills of trapping individual particles including loading, cooling, trap optimisation and image current frequency detection
- Detect single microwave photons using a trapped electrons
- Search for hints of dark matter by measuring the electron heating rates







Dr Julie Euvrard

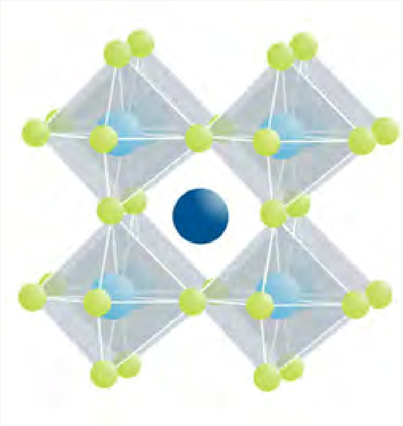
Lecturer in Experimental Solid State Physics
Echoes Lab
julie.euvrard@imperial.ac.uk

Towards Pb-free perovskites for solar energy applications

Halide perovskites appear as a promising family of materials for solar energy applications. Yet, this research success story relies on compounds containing lead (Pb), making the transition from lab to industrialisation and commercialisation uncertain. Efforts must be pursued to identify and optimise Pb-free perovskite materials with promising characteristics to act as solar absorber. Substituting Pb with less toxic elements comes at the cost of solar cell efficiency. This adverse evolution is associated with distortions in the crystal structure and higher defect density, directly impairing charge transport, electronic, and optoelectronic properties. In this project you will investigate the mechanisms underlying poor charge carrier mobility and strong recombination in this family of materials. You will leverage this fundamental understanding by exploring strategies to reduce or passivate defects and facilitate charge transport.

In this project you will:

- Fabricate Pb-free perovskite samples and devices, with a focus on double perovskites and vacancy-ordered double perovskites.
- Perform optical (UV-vis, PL…) and material (SEM, XRD…) characterisation to control the morphology and quality of the perovskite films.
- Master advanced electrical characterisation techniques to uncover charge transport and optoelectronic properties.
- Collaborate with researchers in the US (IBM) and in France (CNRS) to access unique Hall effect measurement capabilities.
- Join Echoes Lab and develop as a scientist within a Team of passionate and supportive researchers.



Prof. Matthew Foulkes

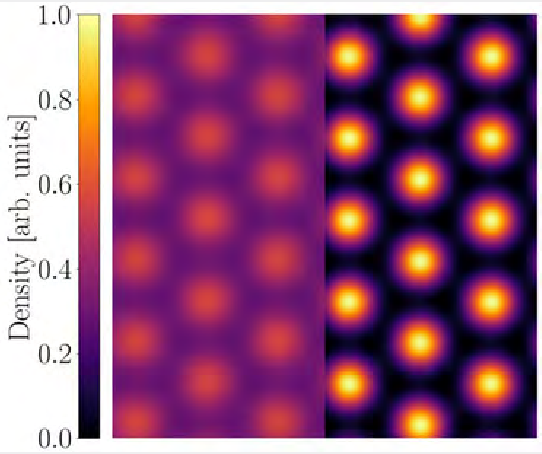
Professor of Physics
wmc.foulkes@imperial.ac.uk

Neural Quantum States

In 2020, working with scientists from DeepMind, we introduced FermiNet, a new way to solve the Schrödinger equation for systems of many interacting electrons. The antisymmetric many particle wavefunction is represented as a neural network, the parameters of which are optimized according to the variational principle without the use of externally generated data. We have recently used this approach to investigate the Wigner crystallization of the electron gas, superfluids, and positronic chemistry. It has proved to be remarkably successful and versatile.

In this project you will use neural wave functions to investigate oneor more of the following:

- Wigner crystallisation in two dimensions
- The quantum Hall effect in a two-dimensional electron gas
- Positron annihilation experiments, as used to assay defect concentrations in solids
- You will also design and implement new algorithms in Python and JAX



The crystalline order "discovered" by optimizing a neural wavefunction strengthens as the density of the Wigner crystal is lowered.

Dr Jack Gartside
Research Fellow
j.carter-gartside13@imperial.ac.uk

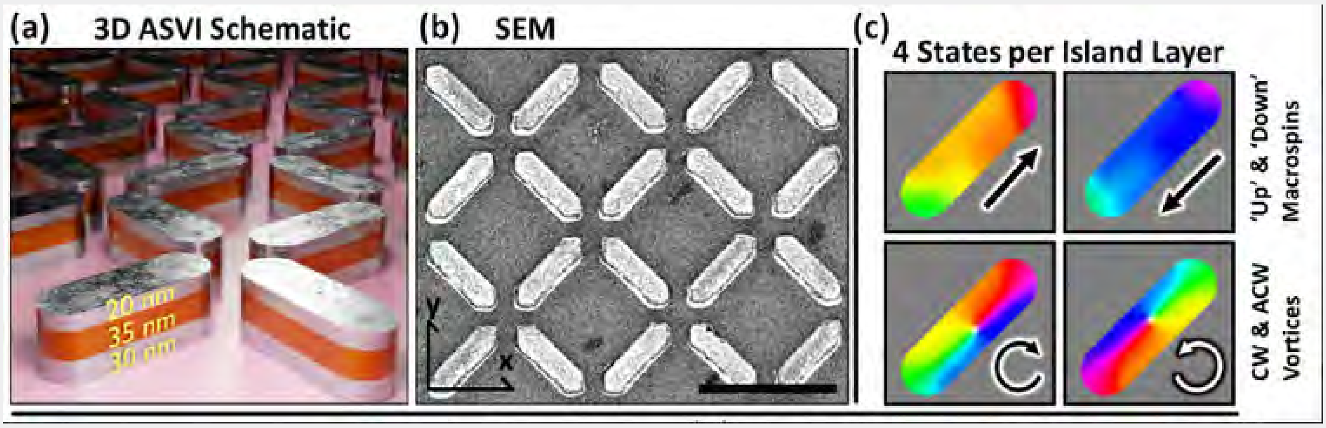
Prof. Will Branford
Professor of Solid State Physics
w.branford@imperial.ac.uk

3D Reconfigurable Magnonic Crystals

Magnonic crystals are materials that control the dispersion of GHz spin waves in ferromagnets. We have shown a multilayer architecture of nanomagnets great increases the coupling strength, and so the degree ofcontrol in the system. The project will explore the fundamental physics,including metamaterial properties and the role of topology and chirality,behind phenomena such as magnon frequency combs. Ferromagneticresonance spectroscopy experiments and simulations will be used tooptimise nanostructure design for computing applications.

In this project you will:

- Nanofabrication
- Ferromagnetic resonance spectroscopy measurements
- Magnetic simulations
- Magnetometry and magnetic force microscopy



Dr Jack Gartside

Research Fellow
j.carter-gartside13@imperial.ac.uk

Prof. Will Branford

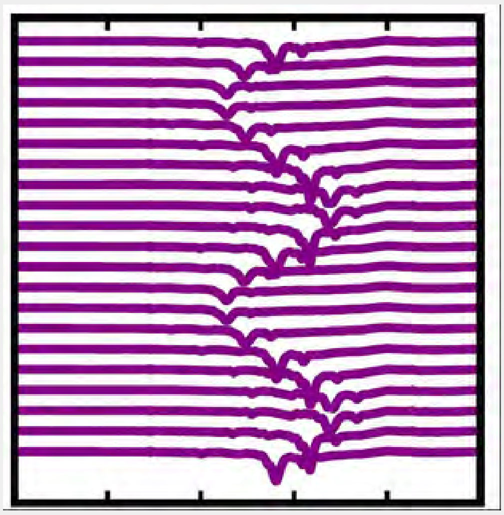
Professor of Solid State Physics
w.branford@imperial.ac.uk

Magnetic Neuromorphic Computing

Neuromorphic computing, beyond the traditional van Neumann architectures of our personal computers, is poised to revolutionise the way we perform calculations, inspired by how the human brain works, and with better performances at a much lower energy cost. You will implement neural networks in nanomagnetic arrays where the nanomagnets are both the memory elements and the logic processors, and the interaction weights between them are controlled by the exact magnetic configuration.

In this project you will learn the following skills and techniques:

- Nanofabrication
- Magnetic simulations
- Magnetometry and magnetic force microscopy
- Ferromagnetic Resonance Spectroscopy
- Neuromorphic computing methods

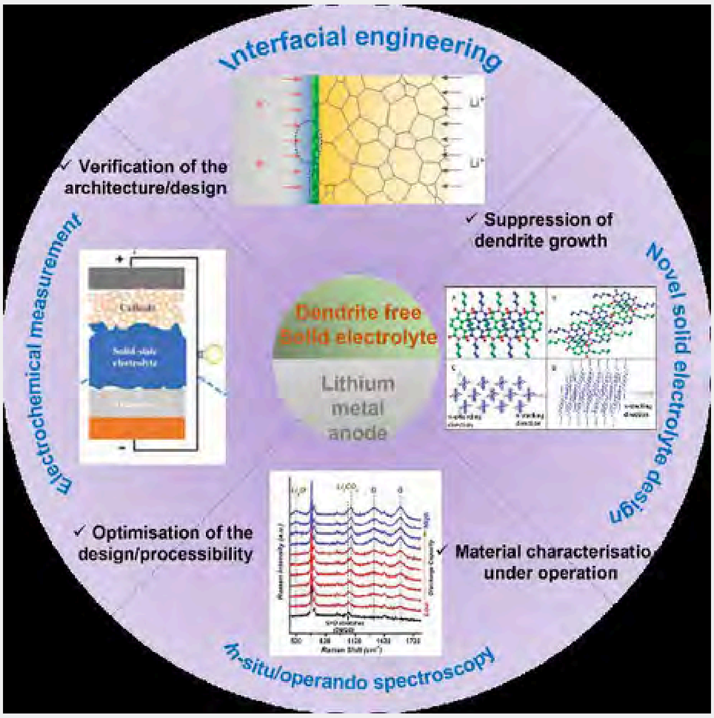


Prof. Ji-Seon Kim
Professor of Solid State Physics
ji-seon.kim@imperial.ac.uk

Dr Juyeon Park
SLB, Schlumberger
Cambridge Research Limited

Interface engineering for high performance energy storage applications

The energy storage device market is currently dominated by battery technology which is aligned with global net zero emission ambitions. High performance of the battery requires the optimisation of important parameterssuch as energy, power, cycle life, cost, and safety, which are strongly linkedto materials chemistry, interfacial engineering, and device physics challenges.Although lithium metal anode has attracted significant attention for solidstate battery applications owing to its high theoretical specific capacity, thekey issues related to undesirable lithium dendrite growth during operationstill hinder its full potential for commercialisation. In this project, we aim toaddress these important interface issues of energy storage devices. We willelucidate fundamental understanding of the interfacial properties by applyinginnovative interface engineering and by developing in-situ electrochemicaland energetics spectroscopic techniques.

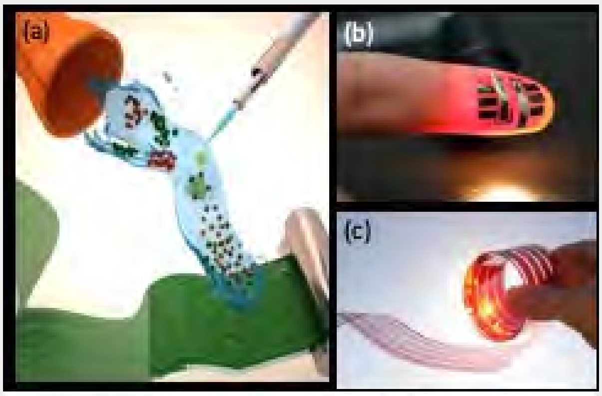


Prof. Ji-Seon Kim

Professor of Solid State Physics
ji-seon.kim@imperial.ac.uk

Single-Component Organic Photovoltaics and Photodetectors

Organic photovoltaics (OPVs) and photodetectors (OPDs) have attracted greatinterest in both the research and commercial market due to their applicabilityto low-weight and flexible devices, adjustable detection range by moleculardesign, non-toxic material-based devices, and the optimum absorptionproperties of organic semiconductors. In general, bulk-heterojunctions (BHJs) formed by blending two or more organic semiconductors together have been widely utilized as the photoactive layer in OPV/OPD devices to provide the energetic offset for efficient exciton dissociation. Although BHJ devices produce excellent device performance due to the large interfacial areas between different materials, in terms of commercialization, the use of two or more different materials as the photoactive layer has many limitations.They include complicated optimization procedures, low reproducibility of thefilm quality, and unavoidable broadband absorption due to multi-componentblend systems. We have recently demonstrated that these limitations couldbe overcome by using a single-component organic photoactive layer [1, 2]. Inthis project, we will utilise newly developed non-fullerene acceptors (NFAs)[3] as a single- component photoactive layer to fabricate high performanceOPV/OPD devices. Furthermore, we will elucidate the molecular origins ofelectronic states and interfacial energetics that are key to the OPV/OPDphotophysical processes such as charge generation, recombination, andextraction. In particular, we will identify the impact of the molecularstructures (e.g., planar vs twisted) and molecular properties (e.g., quadrupolemoment, intermolecular interaction, and packing) of NFAs on theseprocesses.



Schematics of printing flexible OPV/OPD devices (a), printed flexible OPD (b) and OPV modules (c).

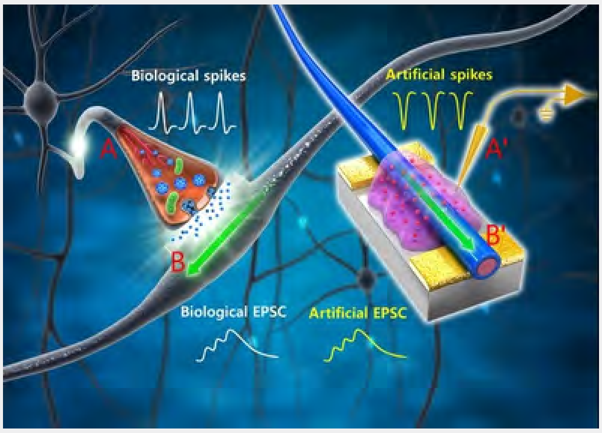
[1] Park et al., The State-of-the-Art Solution-Processed Single Component Organic Photodetectors Achieved by Strong Quenching of Intermolecular Emissive State and High Quadrupole Moment in Non-Fullerene Acceptors, Advanced Materials, 2306655 (2023), DOI: 10.1002/adma.202306655
[2] Luke et al., Key molecular perspectives for high stability in organic photovoltaics, Nature Reviews Materials, 8, 839–852 (2023), DOI: 10.1038/s41578-023-00606-5
[3] Fu et al., Molecular orientation-dependent energetic shifts in solution-processed non-fullerene acceptors and their impact on organic photovoltaic performance, Nature Communications 14, 1870 (2023). DOI: 10.1038/s41467-023-37234-0

Prof. Ji-Seon Kim

Professor of Solid State Physics
ji-seon.kim@imperial.ac.uk

Developing Organic Synaptic Transistors for Neuromorphic Circuits

Synaptic transistors provide the parallel storage and processing of data, ideal for running artificial intelligence algorithms when implemented into neuromorphic circuits compared to the von Neumann architectures used in current computer systems. Organic semiconductor devices such as organic transistors and chemiresistors, which benefit from solution processability, have been investigated regarding the impacts of the molecular design on device performance and the application of such devices as biosensors [1-4].However, most of these devices implement liquid electrolytes, restricting independent gating, reducing operation speed and decreasing feasibility for miniaturised integrated circuit fabrication. Such limitations can be overcome by implementing an all-solid-state architecture. In this project, we will explore this exciting possibility by fabricating, optimising and characterising organic synaptic transistors with a range of organic channel materials. In particular, we will develop accumulation-mode transistors to utilise their low-power operation. We will use various device fabrication methods, electrical characterisation regimes and optoelectronic and structural characterisation techniques to identify the electronic and ionic charge transport mechanisms which provide short- and long- term plasticity effects in OSTs. As such, the synaptic plasticity effects of OSTs will be measured and the key mechanisms of synaptic behaviour at the molecular level of organic semiconductors and their interactions with ions will be elucidated. With efficacious OSTs presented, the devices will be fabricated into basic neuromorphic circuits that demonstrate associative/Pavlovian learning.



(Source: https://www.science.org/doi/10.1126/sciadv.1501326)

[1]Tyrrell, J. E., Boutelle, M. G., Campbell, A. J., Measurement ofElectrophysiological Signals In Vitro Using High-Performance OrganicElectrochemical Transistors. Adv. Funct. Mater. 2021, 31, 2007086.

[2]Tyrrell, J. E., Petkos, K., Drakakis, E. M., Boutelle, M. G., Campbell, A. J.,Organic Electrochemical Transistor Common-Source Amplifier forElectrophysiological Measurements. Adv. Funct. Mater. 2021, 31,2103385.

[3]Tan, E., Kim, J., Stewart, K., Pitsalidis, C., Kwon, S., Siemons, N., Kim, J.,Jiang, Y., Frost, J. M., Pearce, D., Tyrrell, J. E., Nelson, J., Owens, R. M., Kim,Y.-H., Kim, J.-S., The Role of Long-Alkyl-Group Spacers in GlycolatedCopolymers for High-Performance Organic Electrochemical Transistors.Adv.Mater. 2022, 34, 2202574.

[4]Stewart, K., Pagano, K., Tan, E., Daboczi, M., Rimmele, M., Luke, J.,Eslava,S., Kim, J.-S., Understanding Effects of Alkyl Side-Chain Density onPolaronFormation Via Electrochemical Doping in Thiophene Polymers. Adv.Mater.

2023, 2211184.

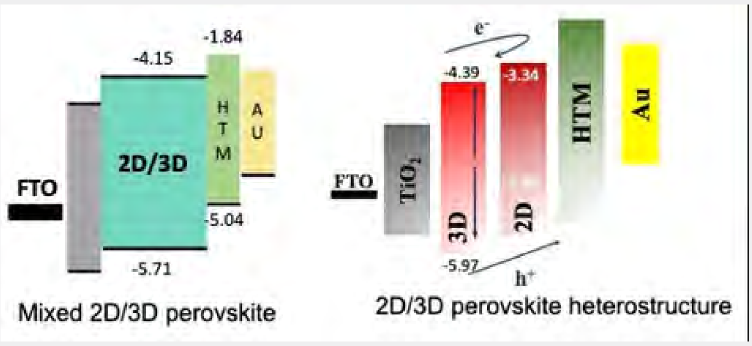
Prof. Ji-Seon Kim

Professor of Solid State Physics
ji-seon.kim@imperial.ac.uk

2D/3D Perovskites for Efficient Solar Cells

Recently, 2-dimensional (2D)/3D perovskite solar cells have attracted great research interest due to their potential to overcome the single-junction Shockley-Queisser theoretical efficiency limit, as well as to reduce the high trap state density and instability of 3D perovskite solar cells. In this project, we will first control the energy levels of perovskite layers via their dimensionality control (3D and 2D/3D) with varying composition and stoichiometry (applying different cations and anions in the 2D perovskite). We will then identify the nature of trap states in these dimensionality-controlled perovskite layers. The energy levels together with the trap state distribution will be investigated by using ambient photoemission spectroscopy (APS), which will be complemented by surface photovoltage (SPV) measurements to investigate the impact of cascaded energy levels andtrap states on photogenerated charge carriers. Finally, the impact of dimensionality controlled perovskites and their trap states on solar cell performance (efficiency and stability) will be investigated. The advanced spectroscopy techniques such as APS and SPV are relatively new and our expertise in this area will be crucial for the success of the project. The projectwill also include simulation of APS signals and/or one-dimensional drift-diffusion modelling of device performance and surface photovoltage.

[1] Henderson C, et. al., Charge transfer complex formation between organic interlayers drives light-soaking in large area perovskite solar cells, Energy and Environmental Science (2023), DOI: https://doi.org/10.1039/d3ee02571c [2] Chin, Y. -C., et al., Suppressing PEDOT:PSS Doping-Induced Interfacial Recombination Loss in Perovskite Solar Cells. ACS ENERGY LETTERS, 7(2), 560-568 (2022). DOI:10.1021/acsenergylett.1c02577



Schematic illustration of the dimensionally engineered 2D/3D perovskite thin film bandgap diagrams in mixed and heterostructure devices.

Dr Jongseok Lim

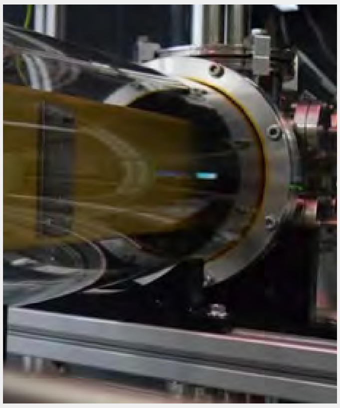
Ernest Rutherford Fellow
Centre for Cold Matter
j.lim@imperial.ac.uk

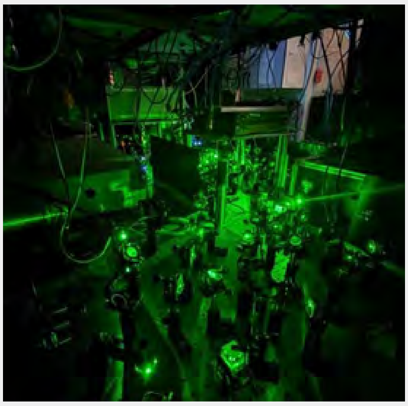
Testing fundamental physics with ultracold molecules

An array of laser-cooled heavy polar molecules can be used for precision tests of fundamental physics beyond the Standard Model of Particle Physics. The low-energy table-top experiments open a window to high-energy physics and allow us to explore new physics at energies beyond thereach of particle accelerators such as CERN.

In this project you will:

- Join a team comprised of students, postdocs, and academics developing innovative quantum technologies
- Learn how to use precisely controlled lasers to manipulate a beam of molecules and slow the molecules using radiation pressure
- Use a combination of magnetic and laser fields to trap and cool the molecules
- Arrange the molecules into a regular array by loading them into an optical lattice
- Implement a measurement protocol to search for small energy shifts induced by the electric dipole moment of the electron
- Become an expert in vacuum and laser science, optics and imaging, 3D modelling, computer automation and interfacing, numerical modelling, and statistics and data analysis





Prof. Jon Marangos Dr Mary Matthews

Lockyer Chair in Physics
j.marangos@imperial.ac.uk

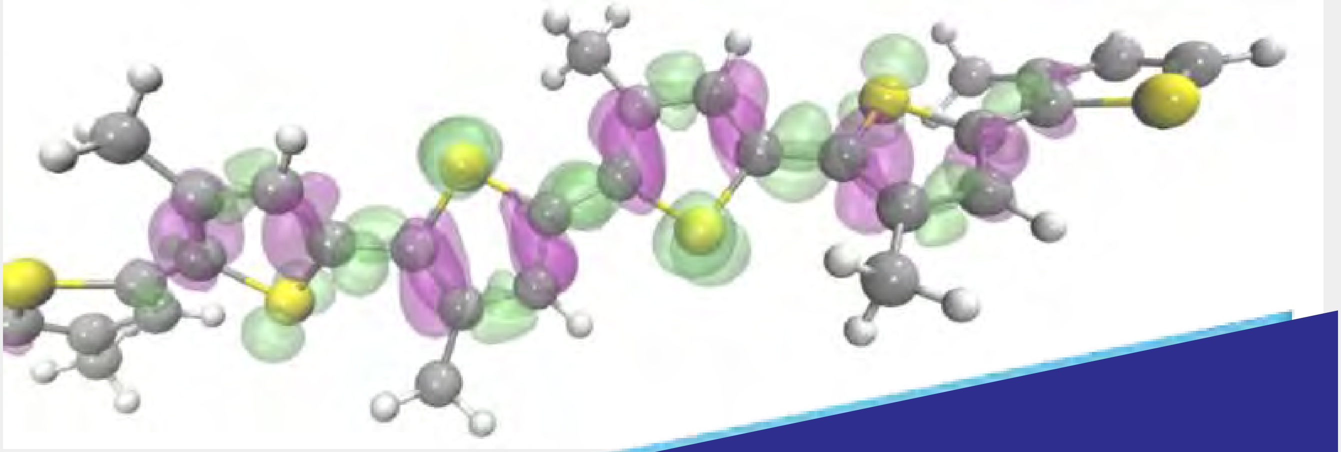
Lecturer in Ultrafast Science
m.mathews@imperial.ac.uk

Measuring ultrafast electronic dynamics in organic semiconductors and photoswitching materials

The project will apply time-resolved x-ray spectroscopy to the investigation of exciton dynamics, and the ultrafast evolution of charge separation, in organic semiconductors, thin film photo-switch and 2D materials. Recently we have measured initial exciton dynamics in an organic semiconductor polythiophene (P3HT) using time-resolved carbon K-edge x-ray spectroscopy. A promising new material for photovoltaics, Y6, will be probed at C K edge (290 eV), N K edge (410 eV) and F K edge (697 eV) sites using our laboratory based high harmonic source combined with x-ray free electron laser (XFEL) sources. These ultrafast X-ray measurements will allow the full reconstruction of the crucial early time exciton dynamics through probing at multiple atomic edges.

In this project you will:

- Work with collaborators at Imperial and Madrid to produce thin film format oganometallic photoswitches and Y6 samples
- Perform preliminary characterisation and x-ray absorption measurements at the Extreme Light Consortium (XLC) at Imperial College
- Use the XLC high harmonic generation attosecond supercontinuum source and dispersive wave pump pulses to make measurements with unprecedented < 5 fs temporal resolution
- Play a key role in preparation for XFEL beamtimes, leading beamtimes and analysing data
- Develop simulations working closely with theoretical collaborators to model the exciton dynamics and the time-dependent changes to the x-ray spectrum



Prof. Jenny Nelson

Professor of Physics
jenny.nelson@imperial.ac.uk

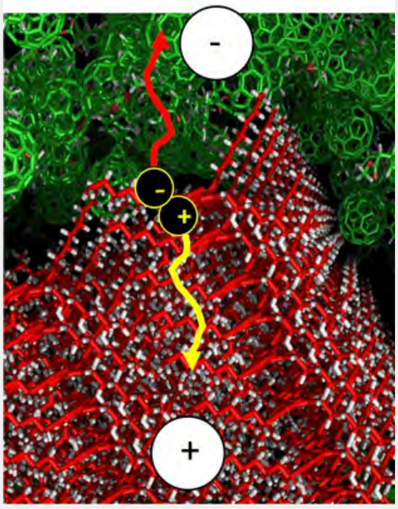
Modelling electronic processes in molecular systems for solar energy conversion

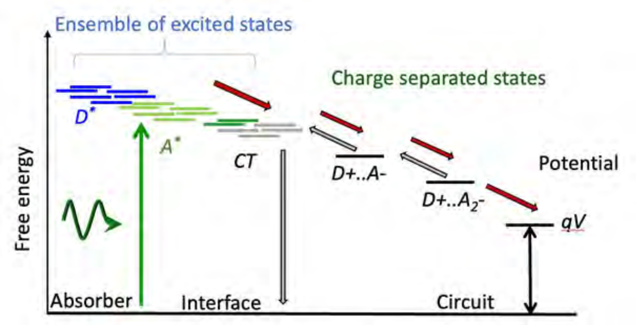
In molecular solar cells, solar photons are converted into electrochemicalpotential energy by a sequence of steps including photon absorption,exciton diffusion, charge separation, and polaron transport, in a molecularassembly. In high performance systems, electronic states are delocalisedover several molecules, and models that account for delocalisation areneeded to explain experimental results and design new materials. Thesame models can be applied to the first stages of solar energy conversionin natural photosynthesis. This project will develop a physics-basedmodel of photochemical solar energy conversion that takes account ofchemical and physical structure and use it to explain experimental dataand to optimise material and device designs.

In this project you will:

- Develop an existing model of the quantum dynamics of excitations in molecular systems to simulate the process of solar-to-photochemical energy conversion;
- Improve the model by applying it to experimental data, and use it to
- identify the factors limiting energy conversion efficiency;
- Propose and test ideas for how energy losses could be reduced;
- Compare equivalent processes in photovoltaic and photosynthetic systems;

Learn how to use computational chemistry methods





Prof. Jenny Nelson

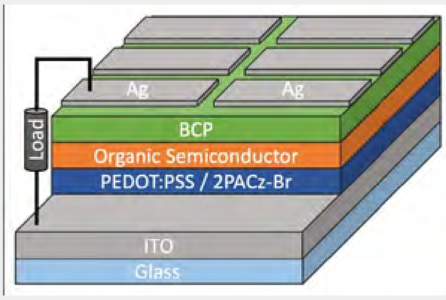
Professor of Physics
jenny.nelson@imperial.ac.uk

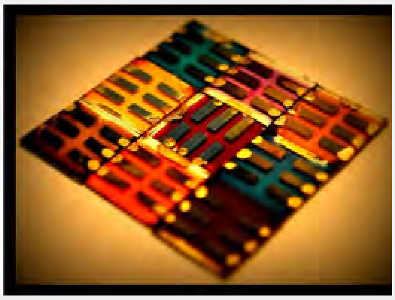
Device physics of single-component organic solar cells

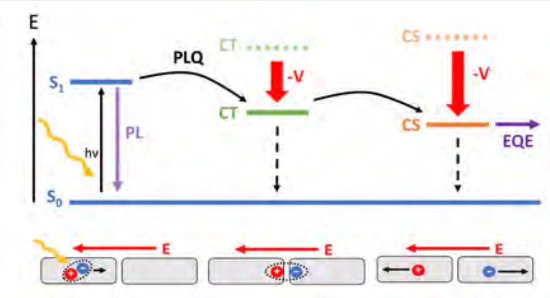
Organic semiconductors are promising materials for solar photovoltaic energy conversion that have achieved almost 20% power-conversion efficiency. Traditionally, two materials, a donor and an acceptor, were needed to achieve good charge-generation efficiency. Recently, photogeneration has been achieved in alternative ‘single component’ molecular materials, that contain different (electron-rich and electron-poor) units within the same structure. Such an approach offers improved structural control and stability, and potential improvements in energy efficiency. However, the mechanism of charge generation in such single-component systems is not yet understood. This project aims to establish how single-component molecular systems work, and to develop design rules for high performance materials.

In this project you will:

- Design, fabricate and measure single-component solar cells using different materials;
- Explore the effect of chemical structure on performance using optoelectronic, spectroscopic and structural measurements;
- Interpret your results with microscopic kinetic models and device models;
- Work with chemists and theorists to design and test materials for higher device performance.







Prof. Jasper van Thor Prof. Jon Marangos

Prof Jasper van Thor
Molecular Biophysics
j.vanthor@imperial.ac.uk

Lockyer Chair in Physics
Department of Physics
j.marangos@imperial.ac.uk

X-ray Free Electron Laser Science

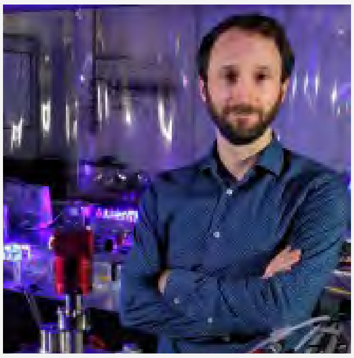
A fully funded 4-year PhD position is available in the group of Professor Jasper van Thor at Imperial College London. The PhD is supported by the STFC UK Hub for the physical sciences on XFELs (HPSX) and Imperial College. The project will involve all aspects of executing and analysing ultrafast X-ray crystallography experiments at X-ray Fee Electron Lasers

(XFELs). The project involves developing methods and experiments in order to increase the time resolution towards few-femtosecond and attosecond resolution. The PhD project will include experimental components involving sample environment, optics, diagnostics, beamline instrumentation and detector data processing, as well as computational aspects involving crystallographic data analysis and modelling. The project will be co-supervised by Professor Jon Marangos in the physics department. A part of the project will include work in the physics department on the configuration and use of a laser driven plasma hard X-ray source 'The Imperial College Laboratory for Ultrafast X-ray Diffraction (LUXD)'. The new LUXD facility will allow pump-probe femtosecond chemical crystallography.

Eligibility:

You will have either a physics, chemistry or biochemistry undergraduate degree with a 2:1 result or better. Additionally, a Masters degree with Merit or better in a relevant physics or chemistry topic will be preferred. Only students classified as Home (UK) for fees purposes are eligible to apply. The 4-year PhD studentship is jointly funded by STFC XFEL Physical Sciences Hub and Imperial College London Life Science Department. Applications should be emailed to Jasper van Thor and should include a CV and a cover letter with a personal statement. The CV should contain names and contact details for three references and details for courses taken and marks obtained.

For more details see also the Find A PhD advert.



Prof. Mike Tarbutt
Professor of Experimental Physics
Centre for Cold Matter
m.tarbutt@imperial.ac.uk

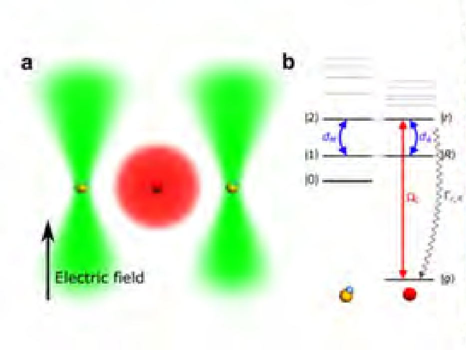
Dr Stefan Truppe
Senior Lecturer
Centre for Cold Matter
s.truppe@imperial.ac.uk

Quantum networks of atoms and molecules

An array of laser-cooled polar molecules interacting with Rydberg atoms isa promising hybrid system for scalable quantum computation. Quantum information is stored in long-lived hyperfine or rotational states of molecules which interact indirectly through resonant dipole-dipole interactions with Rydberg atoms.

In thisproject you will:

- Join a team comprised of students, postdocs, and academics developing innovative quantum technologies
- Learn how to use precisely controlled lasers to cool atoms and molecules to ultracold temperatures
- Load the particles into traps formed by tightly focussed laser beams(optical tweezers)
- Rearrange the atoms and molecules into regular arrays and study their coherent interactions
- Implement a two-qubit gate between the molecules mediated by their strong interaction with a highly polar Rydberg atom
- Become an expert in vacuum and laser science, optics and imaging, 3D modelling, computer automation and interfacing, numerical modelling,and statistics and data analysis



Prof. Mike Tarbutt

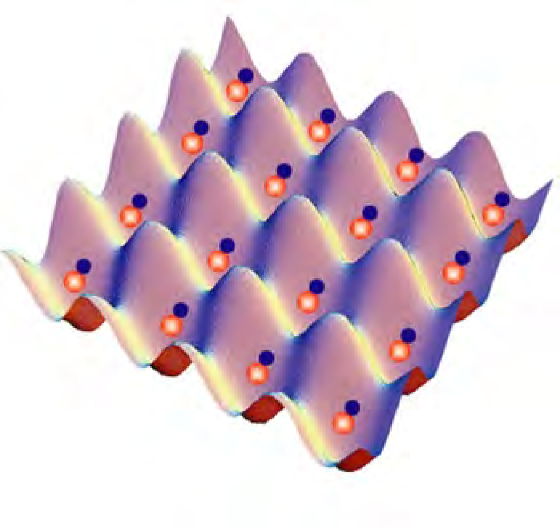
Professor of Experimental Physics
Centre for Cold Matter
m.tarbutt@imperial.ac.uk

Molecular lattice clock

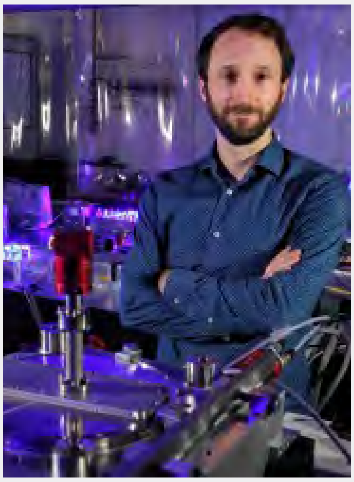
The aim of this project is to build a clock based on the vibrational frequency of ultracold molecules trapped in an optical lattice. The clockwill be used to test the idea that the fundamental constants may bevarying, as predicted by many extensions of the Standard Model. It willalso serve as a frequency standard in the infra-red.

In this project you will:

- Join a small team of students, postdocs and academic staff
- Learn practical skills in lasers, optics, vacuum science, and electronics
- Build computer control hardware and software
- Evaluate and control systematic uncertainties in frequency metrology
- Develop and apply data analysis and statistical methods
- Work with collaborators from other institutions



Ultracold laser-cooled molecules in an optical lattice



Dr Stefan Truppe

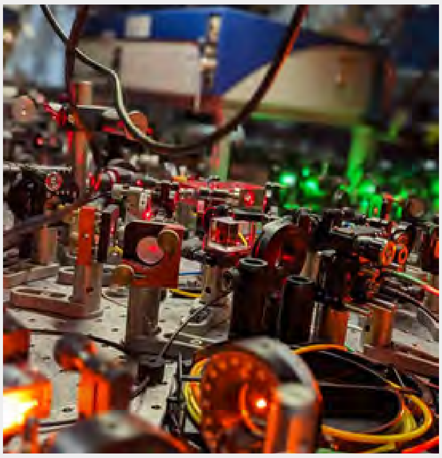
Senior Lecturer
Centre for Cold Matter
The Matter Community
s.truppe@imperial.ac.uk

Cooling atoms and molecules with deep ultraviolet lasers

Ultracold molecules are the next frontier in ultracold quantum science. Wedevelop new powerful lasers in the deep ultraviolet to manipulate stablegas-phase molecules and to cool them to ultracold temperatures in themicrokelvin regime. Molecules cooled to such low temperatures offer many new possibilities in quantum information, simulation, and computation and for precise tests of fundamental physics.

In this project you will:

- Design and build lasers to produce high-powercontinuous radiation in the deep UV
- Stabilise and precisely controlthe frequency of these lasers
- Produce gas-phase, polar molecules in a high vacuum environment and cool them using cryogenic helium
- Use radiation pressure to slow a molecular beam and trap the moleculesin a magneto-optical trap, where they can be cooled to microkelv in temperatures
- Study collisions in the quantum regime and perform precision measurements to test new physics
- Use thestrong dipolar interactions between the molecules to encode quantum information and simulation protocols



Frequently Asked Questions

How to apply?

Find out everything you need to know about your application journey on Imperial's Application website.

What if I am interested in a number of projects?

If you are interested in a number of projects, state your preferences in the personal statement section of the application.

What's the deadline for submitting applications?

We do not have a deadline but students who are seeking studentships should aim to apply as early as possible. We typically allocate the available studentships by the end of March for a start date in October.

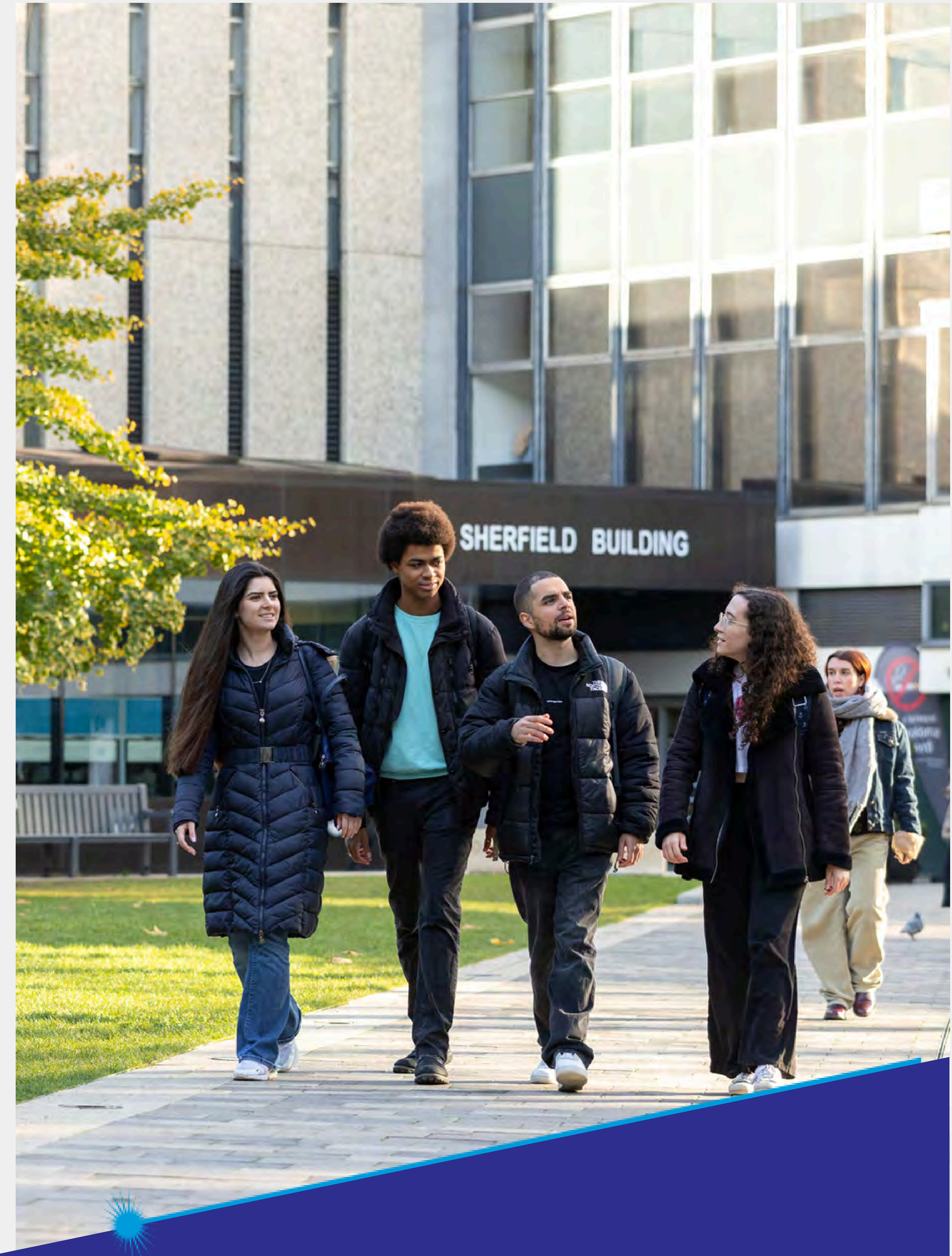
Can I apply for projects that are not fully funded?

Yes. The funding situation is very dynamic and we encourage you to mention your preference in the application. Scholarships are available for talented candidates.

Getting more information

For general information, please email Ms. Loli Sanchez on Loli.sanchez@imperial.ac.uk. For more information about research programmes and PG opportunities, please email Stefan Truppe s.truppe@imperial.ac.uk.

The Matter Research Community Website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