Title of Project	Division	1st Supervisor	Exp	Th	Com	Offered This Yr	Notes
Measurement of the quality of the laser focus in a scanning optical microscope	Biophotonics	Gail McConnell	70%	10%	20%		
Photonic materials and devices for Visible Light Communication (VLC)	IoP	Benoit Guilhabert	50%	20%	30%	5th	Mark Carmichael
Neurophotonic systems for interfacing with the retina	IoP	Keith Mathieson	40%	10%	50%		
Modelling non-linear processes in micro-waveguides	IoP	Michael Strain	0%	50%	50%		
Remote sensing of subsea light fields	Nanoscience	Alex Cunningham	0%	50%	50%		
Characterisation of irregular particles by optical microscopy and digital imaging	Nanoscience	Alex Cunningham	25%	25%	50%		
Differential polarisation imaging for environmental applications	Nanoscience	Alex Cunningham	33%	33%	34%		
Optical modes and multiple scattering	Nanoscience	Ben Hourahine	0%	50%	50%	5th	David Newton
Twisted nanostructures	Nanoscience	Ben Hourahine	0%	30%	70%		
Optical forces on nanoparticles	Nanoscience	Ben Hourahine	0%	60%	40%		
Statistical analysis of defect distributions in semiconductor thin films	Nanoscience	Carol Trager-Cowan	10%	40%	50%	5th	Ross Johnston
Image processing of electron channelling contrast patterns and electron channelling contrast images	Nanoscience	Carol Trager-Cowan	10%	30%	60%		
Surface fluorescence	Nanoscience	David Birch	70%	20%	10%		
Nanoparticle metrology	Nanoscience	David Birch	60%	20%	20%		
Tele-spectroscopy	Nanoscience	David McKee	70%	10%	20%		
Time series analysis of ocean colour remote sensing data from the North Sea	Nanoscience	David McKee	0%	20%	80%		
Spectroscopic Studies of Pheomelanin: Spectra, Kinetics, Modulators	Nanoscience	Jens Sutter	65%	25%	10%		
Luminescence Hysteresis	Nanoscience	Kevin O'Donnell	50%	10%	40%		
Eu-doped GaN	Nanoscience	Kevin O'Donnell	60%	15%	25%		
Predicting Solvation Thermodynamics of Bioactive Molecules	Nanoscience	Maxim Fedorov	0%	30%	70%		
Molecular Mechanisms of Biological Adaptation to Extreme Ionic Environments	Nanoscience	Maxim Fedorov	50%	10%	40%		
Ionic liquids at charged interfaces: applications for electrochemical energy storage	Nanoscience	Maxim Fedorov	0%	50%	50%		
Development of molecular-scale computer models for enhanced oil recovery	Nanoscience	Maxim Fedorov	0%	50%	50%		
Modelling of wettability of mineral surface by water and oil	Nanoscience	Maxim Fedorov	0%	50%	50%		
Effects of salts on surfactant solutions	Nanoscience	Maxim Fedorov	0%	50%	50%		
Predicting small molecule binding sites on protein surfaces	Nanoscience	Maxim Fedorov	70%	10%	20%		
Uncovering the early stages of protein folding	Nanoscience	Neil Hunt	75%	10%	15%	5th	Andrew Farrell
A Physical Investigation of Protein-drug Binding	Nanoscience	Neil Hunt	75%	15%	10%	5th	Elaine Adair
The Physics of DNA	Nanoscience	Neil Hunt	75%	15%	10%		

Thermal modelling of a gravitational ribbon-sensor	Nanoscience	Nick Lockerbie	30%	30%	40%		
Gravitational ribbon-sensor modelling.	Nanoscience	Nick Lockerbie	30%	30%	40%		
Testing for gravitational coupling to Entropy.	Nanoscience	Nick Lockerbie	50%	50%	0%		
Intrinsic Fluorophores in Sensing Applications	Nanoscience	Olaf Rolinski	80%	10%	10%		
Unusual fluorescence decays	Nanoscience	Olaf Rolinski	30%	10%	60%		
Modelling semiconductor nanostructures using a Schrödinger-Poisson-current solver	Nanoscience	Paul Edwards	0%	20%	80%		
Noise and system response of CCD spectrographs for luminescence spectroscopy	Nanoscience	Paul Edwards	50%	25%	25%		
Effects of electron irradiation on photoluminescence spectra of thin film Cu(InGa)Se2	Nanoscience	Rob Martin	60%	20%	20%		
Electroluminescence spectroscopy and electrical characterisation of light-emitting diodes	Nanoscience	Rob Martin	70%	0%	30%		
Laser Selective Excitation Studies of Nd3+ doped mixed garnets	Nanoscience	Tom Han	85%	10%	5%	5th	Stacey Mitchell
Stimulated Raman spectroscopy (SRS) of Organic liquids	Nanoscience	Tom Han	85%	10%	5%		
Spectrocopic Studies of Rare-earth ions doped in LiNbO3	Nanoscience	Tom Han	85%	10%	5%		
Optical Second Harmonic Generation in Urea	Nanoscience	Tom Han	85%	10%	5%		
Noble Metal Quantum Dots	Nanoscience	Yu Chen	95%	5%	0%	5th	Callum Runciman
Optical Properties of Nanoparticles	Nanoscience	Yu Chen	80%	10%	10%		
Observing beam propagation by fluorescence (b)	Optics	Aidan Arnold	70%	20%	10%		
Observing beam propagation by fluorescence	Optics	Aidan Arnold	70%	20%	10%		
Chirp management of LEDs (experimental and computational)	Optics	Nigel Langford	75%	0%	25%	5th	Gregor McDowall
Non-resonant optical cavities	Optics	Nigel Langford	20%	0%	80%		
Control of Quantum Cascade chirped laser pulses via dispersion management (BSc) Computational and Experimental	Optics	Nigel Langford	20%	0%	80%		
Optical pumping of molecular gas lasers by QC Lasers (computational)	Optics	Nigel Langford	20%	0%	80%		
Thermal management of pulsed QC Lasers (computational)	Optics	Nigel Langford	0%	0%	100%		
Single-shot, 3D reconstruction of the spatial profile of a laser beam	Optics	Paul Griffin	60%	20%	20%	5th	Matteo Demelas
Automated optimisation of optical fibre coupling using microprocessor control	Optics	Paul Griffin	80%	5%	15%		
Magnetic Field Stabilization with an Arduino Microprocessor	Optics	Stefan Kuhr	40%	10%	50%	5th	Nick Bruce
Holographic Atom Traps	Optics	Stefan Kuhr	45%	10%	45%		
Beam quality of broad-area lasers	Optics	Thorsten Ackemann	70%	10%	20%		
Spin and polarization properties of optically pumped vertical-cavity gain structures	Optics	Thorsten Ackemann	70%	15%	15%		

Polarization and feedback dynamics of VCSELs	Optics	Thorsten Ackemann	75%	10%	15%		
Numerical Modelling and Design of a High Power Magnetron	Plasmas	Alan Young	0%	40%	60%		
Stochastic particle heating of charged particles by plasma waves	Plasmas	Bengt Eliasson	0%	50%	50%		
Simulation of electromagnetic waves in magnetized plasmas	Plasmas	Bengt Eliasson	0%	30%	70%		
Beam-driven Plasma Wakefield Acceleration (PWFA)	Plasmas	Bernhard Hidding	40%	20%	40%		
MonteCarlo Simulation and cooling performance of the MICE Step V laboratory experiment	Plasmas	David Speirs	0%	30%	70%		
Laser Wakefield Acceleration and Betatron Gamma Ray Radiation	Plasmas	Dino Jaroszynski	0%	30%	70%	5th	Adam Ross
Phase-contrast X-ray imaging using an X-ray source based on a laser-plasma accelerator	Plasmas	Dino Jaroszynski	60%	20%	20%	5th	Craig Murdoch
Medical Radio-isotope Production using a Laser-Plasma Wakefield Accelerator	Plasmas	Dino Jaroszynski	25%	25%	50%	5th	Gemma King
Radiation Reaction	Plasmas	Dino Jaroszynski	0%	70%	30%		
Non-linear Optics in Plasma: Raman Amplification and Frequency Mixing	Plasmas	Dino Jaroszynski	0%	50%	50%		
Electron Beam Transport and Diagnostics	Plasmas	Dino Jaroszynski	0%	50%	50%		
Capillary Discharge Waveguides for Laser-Plasma Interactions	Plasmas	Dino Jaroszynski	80%	10%	10%		
Radiotherapy using Beams from Laser-plasma Accelerators	Plasmas	Dino Jaroszynski	70%	10%	20%		
Radiation Reaction	Plasmas	Dino Jaroszynski	0%	70%	30%		
Capillary Discharge Waveguides for Laser-Plasma Interactions	Plasmas	Dino Jaroszynski	80%	10%	10%		
Laser-Wakefield Plasma Accelerated electron optimization for Very High Energy Electron (VHEE) cancer treatment	Plasmas	Dino Jaroszynski	15%	25%	60%		
Radiotherapy using Beams from Laser-plasma Accelerators	Plasmas	Dino Jaroszynski	80%	10%	10%		
Design of a Brewster window for a W-band gyro-TWA	Plasmas	Liang Zhang	20%	30%	50%		
Excitation of Heavy Atomic Species for ITER	Plasmas	Nigel Badnell	0%	30%	70%		
Atomic Processes for Astrophysical Plasmas	Plasmas	Nigel Badnell	0%	30%	70%		
Design study on plasma optics	Plasmas	Paul McKenna	0%	20%	80%	5th	Jonathan Jarrett
Modelling laser-driven plasma expansion and ion acceleration dynamics	Plasmas	Paul McKenna	0%	20%	80%	5th	Alan Brown
Induced relativistic optical transparency in intense laser-solid interactions	Plasmas	Paul McKenna	0%	20%	80%		
High energy ion acceleration in intense laser-plasma interactions	Plasmas	Paul McKenna	0%	20%	80%		
High-Power Microwave Sources	Plasmas	Phil MacInnes	0%	35%	65%		
Design and measurement of a mode converter for a microwave amplifier	Plasmas	Wenlong He	25%	25%	50%		
Numerical simulation of laser interaction with dense magnetized plasma	Plasmas	Zheng-Ming Sheng	0%	30%	70%		
Theoretical and numerical studies of laser pulse compression in underdense plasma	Plasmas	Zheng-Ming Sheng	0%	30%	70%		

Nonlinear Propagation of Extreme Intense Laser Beams in Plasma	Plasmas	Zheng-Ming Sheng	0%	20%	80%		
Spiral Bandwidth Control in Optical Parametric Oscillators	Theory	Alison Yao	0%	30%	70%	5th	Samuel Anderson
Orbital Angular Momentum in Vectorial Kerr Cavities	Theory	Alison Yao	0%	30%	70%		
Dynamics of impurity atom coupled to a quantum gas	Theory	Andrew Daley	0%	40%	60%	5th	Karen Wallace
Transport dynamics of quantum gases in optical potentials	Theory	Andrew Daley	0%	40%	60%		
Computational modelling of X-ray Free electron Lasers	Theory	Brian McNeil	0%	25%	75%	5th	Matthew Brown, Scott Thomas
Resonant Electron Beam-light Interactions	Theory	Brian McNeil	0%	50%	50%	5th	Martyn Hunter
The theory of X-ray Free electron Lasers	Theory	Brian McNeil	0%	80%	20%		
The scientific applications of X-ray Free Electron Lasers	Theory	Brian McNeil	20%	50%	30%		
Quantum measurement in the Jaynes-Cummings model	Theory	Daniel Oi	0%	50%	50%		
Satellite free-space optics for quantum communication	Theory	Daniel Oi	0%	50%	50%		
Ancilla-driven quantum dynamics	Theory	Daniel Oi	0%	90%	10%		
Surface Fields in Layered Nano Particles	Theory	Francesco Papoff	0%	40%	60%		
Resonances in clouds of cold atoms	Theory	Francesco Papoff	0%	50%	50%		
Fluctuations and Noise in Cold Atoms	Theory	Francesco Papoff	0%	50%	50%		
Interaction of Spatial Optical Solitons	Theory	Gian-Luca Oppo	10%	40%	50%	5th	James Denholm, Philip Doyle
Self-structuring and Optomechanics of Cold Atoms	Theory	Gian-Luca Oppo	10%	40%	50%	5th	Mathias Weisen
Dynamics of Coupled Laser Systems	Theory	Gian-Luca Oppo	10%	40%	50%		
Simulations of Spin-Polarized Vertical-Cavity Surface-Emitting Lasers	Theory	Gian-Luca Oppo	10%	40%	50%		
BEC simulations	Theory	Gordon Robb	0%	50%	50%	5th	Steven Lennox
Cold atom-light interactions	Theory	Gordon Robb	0%	30%	70%		
Interactive Physics Simulations (PwT project)	Theory	Gordon Robb	0%	20%	80%		
BEC-light interactions	Theory	Gordon Robb	0%	30%	70%		
Ghost imaging and the Klyshko approach	Theory	John Jeffers	0%	60%	40%	5th	Leon Chan
State Comparison Amplification of Schrodinger Cats	Theory	John Jeffers	0%	60%	40%		
Exotic quantum operations with light	Theory	John Jeffers	0%	75%	25%		
Quantum Optical Computational Toolbox	Theory	John Jeffers	0%	30%	70%		
Quantifying quantum steering via semidefinite programming	Theory	Marco Piani	0%	50%	50%	5th	Benjamin Ross

department of physics at the university of strathclyde

DEPARTMENT OF PHYSICS

Fourth Year Research Projects

2014/15

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Health and Safety

Undergraduate students need to undergo appropriate safety training for their projects. The University Occupational Health & Safety Arrangements state:

16.4 Supervision of Students

- Departments recognise that most undergraduate students are initially untrained in matters of health and safety, therefore, Academics will provide information, instruction, training and "such supervision as is necessary", for all aspects of coursework, to ensure, so far as is reasonably practicable, the health and safety of both postgraduate and undergraduate students;

- Coursework will cover, practical work, project work, fieldwork, work placements and any other aspect required of students by their courses;

- Departments will record the means of delivery of the health and safety programme for each course, each year;

- Academic Supervisors will determine the appropriate level of supervision, based on an assessment of risks of the research or teaching activity etc. and documented training received by students; Academic Supervisors will personally provide necessary supervision, unless others are identified by the relevant risk assessment.

An Undergraduate safety induction training record is required to be completed for each project student. Please ensure that the training is completed and the form returned to Lynn Gilmour before the project work begins. (see Appendix 1)

With thanks,

Mr Ron Weston

Nanoscience Division

Predicting Solvation Thermodynamics of Bioactive Molecules

Project Supervisors: (1) Prof Maxim V. Fedorov, (2) Dr Neil Hunt & Dr David Palmer

Project Description:

The project will study solvation thermodynamics of bioactive molecules by novel computer modelling methods.

One of the main causes of the unacceptable attrition rate in drug discovery is the failure of molecules to reach the market place because they have the wrong physico-chemical properties to allow them to be orally administered to patients. Indeed, as many as 40% of all drug failures on the market have been attributed to these problems.

Experimental high-throughput measurements of physico-chemical properties of bioactive molecules (solubility, pKa, logP, etc) are traditionally used to screen candidate drug molecules. However, such experiments are expensive, time-consuming and can only be applied to molecules that have already been synthesized. An alternative approach is to use computer simulations to calculate the properties of putative drug molecules.

Recently we developed a highly efficient method for predicting solvation thermodynamics parameters of bioactive molecules in a view of potential medical and environmental applications. The method is based on a molecular theory of solutions, Reference Interaction Sites Model (RISM). The student will have the opportunity to be involved into large-scale computational screening of thermodynamic properties of drug-like molecules and agrochemicals by this new method.

Reference: *Kerns, E. H. & Di, L. (2008), Drug-like properties: concepts, structure design and methods: from ADME to toxicity optimization*, *Academic Press*;

Additional references will be provided.

Ratio of effort: Exp/Theo/Comp	**Exp:**	**0%**
	Theo:	**30%**
	Comp:	**70%**

Suitability: MPhys, BSc

Additional comments: *Suitable for Masters-level students with good computer skills and an interest in chemical/molecular physics or biophysics. This is an excellent opportunity for students to get experience in novel state-of-the-art methods of molecular modelling.*

Safety Training Requirements: *none*

Molecular Mechanisms of Biological Adaptation to Extreme Ionic Environments

Project Supervisors: (1) Prof Maxim V. Fedorov, (2) Dr Neil Hunt & Dr David S. Palmer

Project Description:

The project will study molecular mechanisms of protein resistance to extreme ionic environments by use of different methods of experimental and computational molecular biophysics.

Among different types of life there is one that exists under conditions considered for a long time as a dead zone. These living (micro) organisms are called "extremophiles". They feel comfortable at such extreme conditions as high (>70° C) temperatures (*thermophile*), extreme pH (*alkaliphile, acidophile*), high salinity (*halophile*) etc.

In the current project we will study molecular structures of enzymes from *halophilic bacteria* that inhabit hypersaline environments such as those found in the Dead Sea and saltern evaporation ponds. It was found that such aggressive media where 'normal' organisms cannot survive are the optimum living conditions for the halophilic species. During the billions years of evolution, the halophilic organisms developed *molecular mechanisms* of adaptation to highly concentrated salt environments. However, these mechanisms are still poorly understood. There are several hypotheses for the main mechanisms of halophilic proteins resistance to extreme ionic envirnments: (i) accumulation of negative charges on the protein surface; (ii) minimization of the solvent accessible surface area.

The main goal of the study will be to explore correlations between the surface charge and the surface area of different mutants of halophilic proteins compared to their homologous counterparts from 'normal' organisms. The project will involve experimental spectroscopic studies of polypeptides/proteins and homologous molecular modelling of proteins and structural analysis of the protein structures.

Key References: *Gross M. "Life on the Edge: Amazing Creatures Thriving in Extreme Environments"*, *New YorK: Plenum (1998)*; *Lesk, A. M. "Introduction to protein architecture", Oxford (2001); SWISS-MODEL Protein Modelling Environment (http://swissmodel.expasy.org); additional references will be provided.*

Ratio of effort: Exp/Theo/Comp	**Exp:**	**up to 50%**
	Theo:	**10%**
	Comp:	**40-70%**

Suitability: MPhys, BSc

Additional comments: *Suitable for students at all levels with good computer skills and an interest in molecular biophysics. The student will get experience in modern state-of-the-art tools of protein structural analysis and bioinformatics applications in molecular biophysics.*

Safety Training Requirements: *none*

Ionic Liquids at Charged Interfaces: Applications for Electrochemical Energy Storage

Project Supervisors: (1) Prof. Maxim V. Fedorov, (2) Dr Yu Chen

Project Description:

The project is focused on the theoretical modelling of ionic liquids (IL) and electrified interfaces (ES). Ionic liquids are strongly believed to replace traditional electrolytes in high efficiency electrochemical devices for energy storage and transformation (e.g supercapacitors), due to their superior physicochemical properties, especially very low volatility and high electrochemical stability.

High-resolution modelling of the structure of ILs near the electrode surface is crucial for the understanding of electrochemical processes in RTILs. The results of the project would serve as a basis for understanding and rationalising the structure–potential and structure–property dependence of the electrified interface between ionic liquids and charged surface.

The main task of the project is to apply methods of Quantum Mechanics and Molecular Mechanics methods to investigate ILs at ES. The student will get experience with High Performance Computing (HPC) applications in chemical physics and theoretical/computational description of IL-based supercapacitors and batteries. The computational part of the project will be done with use of the ARCHIE-WeST HPC facilities (www.archie-west.ac.uk).

Key Reference (if applicable): M.V. Fedorov and A.A. Kornyshev (2014). Ionic liquids at electrified interfaces. // *Chemical Reviews,* **114**(5), 2978.

Ratio of effort: Exp/Theo/Comp	**Exp:**	**0 %**
	Theo:	**50 %**
	Comp:	**50 %**

Suitability: MPhys, BSc, BSc (Phys with Teaching), BSc (Maths Physics)

Additional comments: Solid background in theoretical physics and statistical mechanics is strongly required. Some experience with computations and/or data analysis would be a plus.

Safety Training Requirements: None

Development of Molecular-scale Computer Models for Enhanced Oil Recovery

Project Supervisors: (1) Prof Maxim V. Fedorov, (2) Dr Neil Hunt

Project Description:

The project is a part of ongoing collaboration with Schlumberger and it is focused on development of advanced molecular-scale models for enhanced oil recovery (EOR). Waterflooding is widely applied to boost declining oil reservoir pressure and sweep additional oil into production wells. Success in waterflooding is a key element to improved oil recovery.

In this project we intend to develop new computational model based on Molecular Dynamics for predicting and understanding characteristics of aqueous brines used for waterflooding in oil/gas reservoirs and complex mixtures of these brines with organic compounds. To facilitate this, a number of fundamental phenomena need to be understood by use of large-scale supercomputer simulations such as thermodynamics of ion solvation in brines; physico-chemical properties of brines at high temperature and pressure; the role of ions and counter-ions such as naturally occurring in sea water and ion effects on structural and thermodynamic properties of organic (bio)molecules.

The student will get experience with High Performance Computing (HPC) applications in chemical physics and use of HPC in development of advanced EORs. The computational part of the project will be done with use of the ARCHIE-WeST HPC facilities (www.archie-west.ac.uk).

Key Reference (if applicable): (book) Israelachvili, J.N., 2011. Intermolecular and surface forces. Academic Press, Burlington, MA. (book) Frenkel, D., Smit, B., 2002. Understanding molecular simulation. Academic Press.

Ratio of effort: Exp/Theo/Comp	**Exp:**	**0 %**
	Theo:	**50 %**
	Comp:	**50 %**

Suitability: MPhys, BSc, BSc (Phys with Teaching), BSc (Maths Physics)

Additional comments: Solid background in theoretical physics and statistical mechanics is strongly required. Some experience with computations and/or data analysis would be a plus.

Safety Training Requirements: None

Modelling of Wettability of Mineral Surface by Water and Oil

Project Supervisors: (1) Prof. Maxim V. Fedorov, (2) Dr Yu Chen

Project Description:

The project is a part of ongoing collaboration with Schlumberger and it is focused on development of advanced molecular-scale models for understanding wettability of mineral (calcite) surface by water and hydrocarbons. Waterflooding is widely applied to boost declining reservoir pressure and sweep additional oil into producing wells. Success in waterflooding is a key element of Enhanced Oil Recovery (EOR) techniques. Specific interactions between crude oil/water/rock can lead to large variations in the displacement efficiency of water floods. The rock wettability by reservoir fluids affects not only the release of heavy ends of crude oil, but also the attachment of fine solids, e.g. clays, to the liberated mineral surface. Fundamental understanding of the wettability of mineral solids from oil reservoir could substantially enhance the efficiency of oil recovery.

In this project we intend to develop new computational model based on Molecular Dynamics for predicting and understanding interfacial properties of mineral-water-hydrocarbon systems. We aim to rationalize the wettability mechanism of the mineral surface by atomistic simulations of the rock/oil and rock/water interfaces.

The student will get experience with High Performance Computing (HPC) applications in chemical physics and theoretical/computational description of mineral/water and mineral/oil systems important for the oil & gas sector. The computational part of the project will be done with use of the ARCHIE-WeST HPC facilities (www.archie-west.ac.uk).

Key Reference (if applicable): (book) Israelachvili, J.N., 2011. Intermolecular and surface forces. Academic Press, Burlington, MA. (book) Frenkel, D., Smit, B., 2002. Understanding molecular simulation. Academic Press.

Ratio of effort: Exp/Theo/Comp	**Exp:**	**0 %**
	Theo:	**50 %**
	Comp:	**50 %**

Suitability: MPhys, BSc, BSc (Phys with Teaching), BSc (Maths Physics)

Additional comments: Solid background in theoretical physics and statistical mechanics is strongly required. Some experience with computations and/or data analysis would be a plus.

Safety Training Requirements: None

Effects of Salts on Surfactant Solutions

Project Supervisors: (1) Prof. Maxim Fedorov, (2) Dr Neil Hunt

Project Description:

The project is focused on molecular-scale simulations of effects of ions on the stability of surfactant solutions. Aqueous surfactant solutions are widely used in many industries; however, we are particularly interested in surfactants used for enhanced oil recovery (EOR).

In this project we will use Molecular Dynamics simulations for understanding molecular-scale effects of dissolved inorganic salts on stability of aqueous surfactant solutions. We plan to use large-scale supercomputer simulations to investigate thermodynamics of ion and surfactant solvation in water; physico-chemical properties of surfactant/salt solutions at high temperature and pressure; the role of ions and counter-ions such as naturally occurring in sea water and ion effects on the phase diagram of surfactant solutions.

The student will get experience with High Performance Computing (HPC) applications in chemical physics and use of HPC in development of advanced EORs. The computational part of the project will be done with use of the ARCHIE-WeST HPC facilities (www.archie-west.ac.uk).

Key Reference (if applicable): (book) Israelachvili, J.N., 2011. Intermolecular and surface forces. Academic Press, Burlington, MA.

(book) Frenkel, D., Smit, B., 2002. Understanding molecular simulation. Academic Press.

Ratio of effort: Exp/Theo/Comp	**Exp:**	**0 %**
	Theo:	**50 %**
	Comp:	**50 %**

Suitability: MPhys, BSc, BSc (Phys with Teaching), BSc (Maths Physics)

Additional comments: Solid background in theoretical physics and statistical mechanics is strongly required. Some experience with computations and/or data analysis would be a plus.

Safety Training Requirements: None

Predicting Small Molecule Binding Sites on Protein Surfaces

Project Supervisors: (1) Prof. Maxim Fedorov, (2) Dr David Palmer

Project Description:

Binding of small molecules (ligands) by proteins plays very important role in biology. In fact, protein-ligan binding is the main mechanism of regulation of complicated in vivo and in vitro biochemical reactions. Therefore, protein-ligand binding studies play very important role in many areas of biotechnology and drug development & design.

However, direct experiments on protein-ligand systems are laborious and expensive; moreover, experimental measurements do not provide direct information about molecular-scale mechanisms of binding. In addition, for many important protein systems (e.g. membrane proteins) direct experiments are hardly possible these days due to problems with protein purification and stabilization. Therefore, molecular modeling plays important role in these studies as a complimentary tool to experimental techniques.

The main goal of the project is to apply advanced modeling techniques developed by Fedorov & Palmer together with their co-workers to the problem of predicting small molecule binding sites for a selected set of proteins.

The core of the method is the so-called 3D Reference Interaction Site Model (3D-RISM) that allows one to calculate 3D distributions of different small molecules (as well as water) near the protein surface. If successful, the expected results of the projects may have important applications in pharmacology and biotechnology areas.

Key References: *D.S. Palmer, A.I. Frolov, E.L. Ratkova and M.V. Fedorov (2011). Towards a Universal Model to Calculate the Solvation Thermodynamics of Druglike Molecules: The Importance of New Experimental Databases. // Molecular Pharmaceuticals, 8, 1423-1429. Lesk, A. M. "Introduction to protein architecture", Oxford (2001); SWISS-MODEL Protein Modelling Environment (http://swissmodel.expasy.org);* Additional references will be provided.

Ratio of effort: Exp/Theo/Comp	**Exp:**	**70%**
	Theo:	**10%**
	Comp:	**20%**

Suitability: MPhys, BSc, BSc (Phys with Teaching), BSc (Maths Physics)

Additional comments: Some knowledge of programming/scripting languages and Linux (Unix) OS would be a plus.

Safety Training Requirements:

Uncovering the Early Stages of Protein Folding

Project Supervisors: (1) Dr Neil Hunt, (2) Prof. Maxim Fedorov

Project Description:

The aim of this project is to use state of the art ultrafast laser based techniques to examine physical aspects of the topical subject of protein folding.

Proteins are of fundamental importance in biology as they play key roles in the life of every living organism. Proteins can be described as linear polymers of amino acids and their properties are determined by the structure of this polymer chain. Proteins tend to adopt only a limited number of spatial arrangements, the most common of which are the α-helix, a coil-like structure, the planar β-sheet motif and the random coil. Besides the obvious importance of folding in determining the properties of proteins, in recent years it has emerged that serious diseases, such as Alzheimer's, Diabetes and Creutzfeldt-Jakob disease, are associated with incorrect (mis-folded) protein conformations. The mechanism by which a protein undergoes changes in structure is therefore of great interest.

So far, the physics of protein folding are not fully understood. There is a general consensus that the final, fully folded, form of the protein is reached *via* a series of intermediate structures that exist for very short periods of time (10^{-12}-10^{-3}s) This project will examine these intermediate structures using a combination of Fourier transform infrared (FTIR) absorption spectroscopy and ultrafast 2D-IR spectroscopy. By examining short chain polypeptide models, we will build up a library of IR spectra under a range of conditions. The project will then progress to studies of isotopically-labelled peptides in order to gain site-specific information relating to the structure, dynamics and, ultimately, folding processes of these model proteins. If successful, there is scope to expand the project to larger protein systems.

Key Reference (if applicable): N.T.Hunt, "*2D-IR spectroscopy: ultrafast insights into biomolecule structure and function*", Chem. Soc. Rev. 38, 1837-1848 (2009) doi: 10.1039/b819181f

Ratio of effort: Exp/Theo/Comp	**Exp:**	**75 %**
	Theo:	**10 %**
	Comp:	**15 %**

Suitability: MPhys

Additional comments: Suitable for Masters-level students with an interest in biophysics or chemical physics. The project will be multidisciplinary in nature and will require the student to be proactive in tackling associated new skills and subject matter.

Safety Training Requirements: Chemical and Laser Safety

A Physical Investigation of Protein-drug Binding

Project Supervisors: (1) Dr Neil Hunt, (2) Dr Daniel Shaw

Project Description:

This project will use physical methods such as infrared and ultraviolet absorption spectroscopy to investigate the interactions between a drug molecule and the protein that it targets. The drug in question is currently used clinically to treat patients but a long course of treatment is required, which can lead to resistance. The aim of this project is to understand the physics of the binding between drug and protein by examining the structural interactions and hydrogen bonding that underpin drug activity and ultimately to discover ways of improving the effectiveness of future drug candidates.

If the project is successful later stages may progress to using ultrafast laser spectroscopy techniques to examine drug binding in real time.

The project lies at the boundary between physics and the life sciences and is an excellent opportunity to experience multidisciplinary research in the lab and to learn the skills that are required for this increasingly common type of study. The project will suit a motivated and ambitious student interested in taking part in a challenging project.

Key Reference (if applicable):

Ratio of Experiment/Theory/Computation:	**Exp:**	**75 %**
	Theo:	**15 %**
	Comp:	**10 %**

Suitability: MPhys

Additional comments: A background in biology (or chemistry) is not required but would be an advantage.

Safety Training Requirements: Laser and Chemical Safety

Surface Fluorescence

Project Supervisors: (1) Prof. David Birch, (2) Dr Jens Sutter

Project Description:

Surface fluorescence remains one of the most challenging aspects of fluorescence spectroscopy and yet one of the most useful. It enables the non-destructive analysis of important functional materials, such as semiconductors and polymers, as well as natural products such as fruit and vegetables. The difficulty often lies in contamination of the measured spectra with scattered excitation light. In this project the basics of surface fluorescence techniques will be learned and used to investigate bespoke polymer films dyed with fluorescent molecule as well as some natural products. Fluorescence is a very sensitive technique with even single molecules now being detectable. Progress towards the limit on sensitivity and techniques to separate overlapping fluorescence emission spectra will be developed.

Key Reference: Principles of Fluorescence Spectroscopy by JR Lakowicz, 3rd edition, 2006, Springer.

Ratio of effort: Exp/Theo/Comp	**Exp:**	**70%**
	Theo:	**20%**
	Comp:	**10%**

Suitability: MPhys, BSc, BSc Maths and Physics, BSc Physics with Teaching

Additional comments:

Safety Training Requirements: Chemical handling.

Intrinsic Fluorophores in Sensing Applications

Project Supervisors: (1) Dr Olaf Rolinski, (2) Dr Yu Chen

Project Description:

Fluorescent aminoacids, tryptophan (Trp), tyrosine (Tyr) and phenylalanine (Phe) occur in most proteins and are involved in a large number of bioactivities. Their fluorescence responses, usually altered by this activity or an analyte, provide valuable information on the events occurring in nanometre scale. For example, binding ligands to proteins is usually reflected by shifts in the absorption and fluorescence spectra, changes in quantum yield and alterations in fluorescence decay kinetics.

The aim of the project is to investigate the spectroscopic properties of the number of dyes, including fluorescent aminoacids, and determine their excited-state kinetics. Student will have an opportunity to become familiar with some aspects of photophysics, sensing, fluorescence, time-resolved spectroscopy and state-of-the-art SNOM instrumentation.

Reference: http://www.photobiology.info/Visser-Rolinski.html Relevant research papers will be provided

Ratio of Experiment/Theory/Computation: **Exp: 80 %**
Theo: 10 %
Comp: 10 %

Suitable for: MPhys, BSc

Additional Comments: Project is a part of the current research of the Photophysics Group

Safety Training Requirements: Laser Safety Training

Unusual Fluorescence Decays

Project Supervisors: (1) Dr Olaf Rolinski, (2) Dr Yu Chen

Project Description:

Fluorescence decay measurements allow detection of interactions between fluorophores and their surroundings in nm scale and are broadly used in fluorescence sensing. The fluorescence decay following a δ-pulse excitation, is usually an exponential function, ~$\exp[-t/\tau_0]$, where the fluorescence lifetime τ_0 is determined by all factors leading to de-excitation.

However, some fluorescent molecules do not show exponential decays, and the analysis based on multi-exponential model, is not fully conclusive.

The aim of the project is to study the alternative to exponential model of fluorescence kinetics and research its applicability to certain molecules showing unusual behaviour. The project includes work on both synthetic and experimental data. Student will be involved in some aspects of fluorescence sensing, time-resolved spectroscopy, molecular dynamics and in developing new methods of revealing molecular information from fluorescence lifetime experiments.

Reference: http://www.photobiology.info/Visser-Rolinski.html Relevant research papers will be provided

Ratio of Experiment/Theory/Computation: **Exp: 30 %**
Theo: 10 %
Comp: 60 %

Suitable for: MPhys, BSc

Additional Comments: Project is a part of the current research of the Photophysics Group

Safety Training Requirements: Laser Safety Training

Noble Metal Quantum Dots

Project Supervisors: (1) Dr Yu Chen, (2) Dr Olaf Rolinski

Project Description:

Nanoscale noble metal particles have unique properties different from bulk. Indeed, small metal nanoclusters of sizes comparable to the Fermi wavelength of electrons (ca. 0.7 nm), no longer possess metallic properties, but have molecule-like behaviour including size-dependent luminescence [1] and discrete electronic states [2]. Recent advances in this area have seen the development of a variety of syntheses that produced a new class of fluorescent noble-metal quantum dots such as Au and Ag nanoclusters [3]. These nanosized emitters have great potentials in biological imaging and sensing because of their small sizes, tunable optical properties and low toxicity. This project intends to develop protein encapsulated gold quantum dots and explore their applications in biological sensing using optical spectroscopies.

Key Reference (if applicable):

J. Zheng, C. W. Zhang and R. M. Dickson, *Phys. Rev. Lett.* **93**, 077402 (2004).

S. Chen, R. S. Ingram, M. J. Hostetler, J. J. Pietron, R. W. Murray, T. G. Schaaff, J. T. Khoury, M. M. Alvarez and R. L. Whetten, *Science* **280**, 2098 (1998).

R. Jin, H. Qian, Z. Wu, Y. Zhu, M. Zhu. A. Mohanty and N. Garg, *J. Phys. Chem. Lett.* **1**, 2903 (2010).

Ratio of effort: Exp/Theo/Comp	**Exp:**	**95%**
	Theo:	**5%**
	Comp:	**0%**

Suitability: MPhys, BSc

Safety Training Requirements: laser safety

Remote Sensing of Subsea Light Fields

Project Supervisors: (1) Prof. Alex Cunningham, (2) Dr David McKee

Project Description:

Sunlight which is scattered back from the ocean can be measured from space using radiometers mounted on polar orbiting satellites. The resulting signals can be processed to give information on the optical properties of the water column. These properties are often used to estimate the concentrations of phytoplankton and other materials in the surface layer of the ocean. An alternative possibility, which will be explored in this project, is to use optical properties recovered from remote sensing signals to estimate the spectral distribution of light under water and its rate of decrease as a function of depth. This information can provide useful indicators of the functional state of marine ecosystems, and their vulnerability to anthropogenic disturbance and climate change. The project will involve downloading satellite data from the NASA Global archive and developing special processing methods using existing software packages supplemented by code written by the student.

Key Reference: Mitchell C, Cunningham A and McKee D (2014) Remote sensing of particulate absorption coefficients and their biogeochemical interpretation: A case study in the Irish Sea. Remote Sensing of Environment 152: 74–82

Ratio of effort: Exp/Theo/Comp	**Exp:**	**0%**
	Theo:	**50%**
	Comp:	**50%**

Suitability: MPhys, BSc, BSc Maths and Physics, BSc Physics with Teaching

Additional comments: Owing to the idiosyncrasies of different software packages, this project has quite a steep learning curve.

Safety Training Requirements: General lab safety only

Characterisation of Irregular Particles by Optical Microscopy and Digital Imaging

Project Supervisors: (1) Prof. Alex Cunningham, (2) Dr David McKee

Project Description:

Microscopic particles in the aquatic environment are responsible for processes ranging from primary production to the remineralisation of organic material, and their function is at least partly determined by their size and shape. The object of this project is to acquire digital images of small particles (typically 10 μm to 100 μm in size) by means of optical microscopy. The particles will initially be latex calibration beads and pollen grains, but once the basic procedures have been established they will include phytoplankton and other natural materials sampled from the marine environment. The student will be required to write MATLAB routines which are capable of counting and sizing the particles in the first instance, and subsequently of carrying out the automated classification of different particle types. For this to work, both the processing routines and the sample illumination techniques will have to be optimised. Consequently, an ability to handle small samples and make fine adjustments to optical equipment will be necessary alongside an interest in digital image processing.

Potential applications include microbiology and marine and atmospheric optics, where a description of natural particle mixtures is required for modelling optical properties.

Key Reference:

http://www.mathworks.co.uk/products/image

http://plankt.oxfordjournals.org/content/25/6/669.full

Ratio of effort: Exp/Theo/Comp	**Exp:**	**25%**
	Theo:	**25%**
	Comp:	**50%**

Suitability: MPhys, BSc, BSc Maths and Physics, BSc Physics with Teaching

Additional comments: Requires patience in handling microscopes and preparing samples.

Safety Training Requirements: General lab safety only.

Differential Polarisation Imaging for Environmental Applications

Project Supervisors: (1) Prof. Alex Cunningham, (2) Dr David McKee

Project Description:

Direct sunlight is randomly polarised, but the process of scattering in the environment induces a variety of polarisation states. The degree of polarisation depends on the nature of the scattering surface and on the viewing and illumination angles. The state of polarisation can be concisely described using the four-element Stokes vector. This is constructed by measuring the total energy incident on a sensor, and the fractions which pass through vertical, horizontal and circular polarisers. The aim of the present project is to collect digital images under these different polarisation conditions and to write software to produce processed images which are combinations of Stokes vector elements. The ability of such images to identify specific features in the environment (such as water surfaces and particular types of vegetation) and to differentiate between targets of similar colour but with different reflective properties will be tested in the laboratory and outdoors. Note that the development and calibration of the optical hardware for quantifying polarisation states, which will be undertaken by the student, is likely to be challenging.

Key Reference:

Jerry E. Solomon 1981 Polarization imaging. Applied Optics, Vol. 20, Issue 9, pp. 1537-1544

Ratio of effort: Exp/Theo/Comp	**Exp:**	**33%**
	Theo:	**33%**
	Comp:	**33%**

Suitability: MPhys, BSc, BSc Maths and Physics, BSc Physics with Teaching

Additional comments: The hardware development involved in this project may be quite demanding.

Safety Training Requirements: General lab safety only.

Thermal Modelling of a Gravitational Ribbon Sensor

Project Supervisors: (1) Dr Nicholas Lockerbie, (2) Dr Wayne McRae

Project Description:

Gravity gradiometers measure the change in the Earth's gravitational field over the length of a sensing element or elements. Some common methods used for practical gradiometers include matched accelerometers connected in a differential configuration, or measuring the deflection of a very precise torsion balance. Because gravity is by its very nature a weak force, and the subtle changes in the force are many times smaller than the dominant uniform field on Earth, great care must be taken in the development of any commercial gravity gradiometer.

This project covers modelling the temperature response of the ribbon gravity gradiometer sensor and determining methods to improve thermal performance. This work will include theoretial and modelling using FEA software as well as experimental work to validate the modelled results. The student should be willing to learn to use FEA modelling software.

Key Reference:

http://www.gravitec.co.nz/publications.html (Gravity Gradiometer Publications)

Ratio of effort: Exp/Theo/Comp	**Exp:**	**30%**
	Theo:	**30%**
	Comp:	**40%**

Suitability: BSc, BSc Maths and Physics

Additional comments: The student should be willing to learn CAD and FEA modelling techniques and should be familiar with Matlab.

Safety Training Requirements: None

Gravitational Ribbon-Sensor Modelling

Project Supervisors: (1) Dr Nicholas Lockerbie, (2) Dr Wayne McRae

Project Description:

Gravity gradiometers measure the change in the Earth's gravitational field over the length of a sensing element or elements. Some common methods used for practical gradiometers include matched accelerometers connected in a differential configuration, or measuring the deflection of a very precise torsion balance. Because gravity is by its very nature a weak force, and the subtle changes in the force are many times smaller than the dominant uniform field on Earth, great care must be taken in the development of any commercial gravity gradiometer.

The design of the ribbon sensing element has a significant effect on the performance of the sensor. The focus of the project is to optimise and test designs, including FEA modelling of response to gravity loading. Successful designs will be manufactured and tested in the lab to measure performance relative to sensor requirements. The student should be willing to learn to use FEA modelling software.

Key Reference:

http://www.gravitec.co.nz/publications.html (Gravity Gradiometer Publications)

Ratio of effort: Exp/Theo/Comp	**Exp:**	**30%**
	Theo:	**30%**
	Comp:	**40%**

Suitability: BSc, BSc Maths and Physics

Additional comments: The student should be willing to learn CAD and FEA modelling techniques and should be familiar with Matlab.

Safety Training Requirements: None

Laser Selective Excitation Studies of Nd^{3+} Doped Mixed Garnets

Supervisors (1) Dr Thomas Han, (2) TBA

Project Description

(This project can accommodate 2 students each studying a different aspect of the garnet host.)

When trivalent rare-earth ions are introduced into a crystal lattice substituting for divalent cation some form of charge compensation is required for the crystal to maintained charge neutrality. A wide variety of symmetry configurations can be produced depending on the charge compensator(s) and the rare-earth ion(s) in the host lattice. Selective laser excitation technique can be used to determine the site distribution and symmetry of the various centres in the crystal. The aim of this project is to investigate the spectroscopic properties of garnet crystals doped with different concentrations of rare-earth ion. This project is a continuation of part of a Phd investigation of Nd^{3+} doped in a series of mixed garnets. The aim is to investigation the effect of local environment disordering has on the optical properties of the active ions. The main effect is inhomogeneous broadening of the spectral linewidth which has the potential for shorter pulse generation. This project involves a detail LSE study of a specially selected subset of mixed garnets aiming to resolve the inhomogeneously broadened spectral lines and to investigate 'new' defect centres. The project involves the use of technique such as optical absorption, laser spectroscopy and fluorescence decay measurements.

Key Reference (if applicable):

L. A. Riseberg , R. M. Brown , and W. C. Holton, Applied Physics Letters 23 , 127 (1973); doi: 10.1063/1.1654830

Ratio of effort: Exp/Theo/Comp	**Exp:**	**85%**
	Theo:	**10%**
	Comp:	**5%**

Suitability: MPhys and BSc

Additional comments:

Garnet is a well-studied laser gain material and there are plenty of literatures on the properties of rare-earth ion doped garnets. However, aspects of this project require patient and lots of laboratory time. You should be interested in experimental work and will be working with lasers.

Safety Training Requirements: General laboratory and Laser safety

Stimulated Raman Spectroscopy (SRS) of Organic Liquids

Project Supervisors: (1) Dr Thomas Han, (2) Dr David McKee

Project Description:

Raman scattering is an inelastic collision between a photo and a molecule (or particle). Because of energy conservation, the inelastic collision results in absorption of the photon and generation of another photon at different wavelengths. The shift of photon wavelength can be a positive or negative value, which leads to a Stokes or an anti-Stokes transition, respectively. At a high power of stimulated photon intensity, stimulated-raman scattering (SRS) can produce a new type of wavelength tunable laser. Raman lasers have been extensively studied in active media of solids, liquids and gases. The key objectives of this project are to study the SRS of a raman active organic liquid such as DMSO or acetone and investigate the efficient, stability and tunability of such a system.

Key Reference (if applicable):

F.G. Yang, Z.Y. You, Z.J. Zhu, Y. Wang, 1 J.F. Li, C.Y. Tu, Laser Phys. Lett. **7**, (2010) 14.

Y.S. Cheng, J.G. Yang, M.H. Chan, Chin.Phys. Lett. **23**, (2006) 135.

Ratio of effort: Exp/Theo/Comp	**Exp:**	**85%**
	Theo:	**10%**
	Comp:	**5%**

Suitability: MPhys, BSc

Additional comments:

This is a relatively speculative project that positive results may be difficult to obtain but other researchers have shown promising results. Aspects of this project require patient and lots of laboratory time. You should be interested in experimental work and will be working with lasers and chemicals.

Safety Training Requirements: General laboratory and Laser safety

Spectroscopic Studies of Rare-earth ions Doped in $LiNbO_3$.

Supervisors (1) Dr Thomas Han, (2): TBA

Project Description

(This project can accommodate 2 students each studying a different rare-earth ion.)

When trivalent rare-earth ions are introduced into a crystal lattice substituting for divalent cation some form of charge compensation is required for the crystal to maintained charge neutrality. A wide variety of symmetry configurations can be produced depending on the charge compensator(s) and the rare-earth ion(s) in the host lattice. This project involves detail optical spectroscopic studies of rare-earth ions doped in a ferroelectric crystal host, namely, $LiNbO_3$, aiming to investigation the effect of local environment has on the optical properties of the active ions and to investigate 'new' defect centres. The main technique used is laser-selective-excitation (LSE) spectroscopy; it is a power technique in the study of rare-earth ions such as Nd^{3+} or Er^{3+} and in the investigation of trace elements. This project is a continuation of part of a Phd investigation of rare-earth ions doped in $LiNbO_3$. The project involves the use of technique such as optical absorption, laser spectroscopy and fluorescence decay measurements.

Key Reference (if applicable):

D. M. Gill, L. McCaughan, and J. C. Wright, Phys. Rev. B 53, 2334 (1996).

Ratio of effort: Exp/Theo/Comp	**Exp:**	**85%**
	Theo:	**10%**
	Comp:	**5%**

Suitability: MPhys and BSc

Additional comments:

$LiNbO_3$ is a well-studied material and there are plenty of literatures on the properties of this material doping with rare-earth ions. However, aspects of this project require patient and lots of laboratory time. You should be interested in experimental work and will be working with lasers.

Safety Training Requirements: General laboratory and Laser safety

Optical Modes and Multiple Scattering

Project supervisors: (1) Dr Ben Hourahine (2) Dr Francesco Papoff

Project Description:

It has recently been shown that the optical properties of most nano-particles can be understood as arising from the modes of the particle. These are, like the standing acoustic waves of an organ pipe or the wavefunctions of a quantum mechanical particle in a box, distinct solutions of the appropriate wave equations (here, Maxwell's equations). However, if a second particle is brought close by, how does this affect these modes?

Light will then "bounce" between these two particles (multiple scattering), leading to a new set of optical modes which describe the whole composite system. This project will theoretically and computationally study the transition between the isolated and coupled modes of two glass particles as they approach each other.

Key Reference (if applicable):

F. Papoff, B. Hourahine, Geometrical Mie theory for resonances in nanoparticles of any shape, Optics Express, 19, 21432 (2011)

Ratio of Experiment/Theory/Computation: **Exp = 0%, Theo = 50%, Comp = 50%**

Suitability: MPhys, BSc

Twisted Nanostructures

Project supervisors: (1) Dr Ben Hourahine (2) Prof. Maxim Fedorov

Project Description:

In addition to the familiar arrays of atoms in crystals, there are several other types of large ordered arrangements of atoms which occur in nature which are not periodic. For example there are many structures that are fundamentally helical in nature, these include carbon nanotubes, screw-dislocated nanowires, the tails and capsids of many viruses, amyloid fibrils, and perhaps most famous, DNA. Traditionally these are investigated by either using large clusters of atoms to describe segments of the helical structure, or as a crystal with a large number of atoms in its unit cell to include a complete twist of the helix. Both of these approaches require the simulation of very many atoms, even though the fundamental repeat unit of the structure is often much smaller.

This project applies the recently developed idea of simulating this fundamental repeat unit (the so called 'objective' cell) to study twisted nanostructures. Potential systems to be studied in this project are helical carbon nanotubes, twisted semiconductor nanowires or the DNA helix.

Key Reference (if applicable):

D.-B. Zhang, M. Hua, and T. Dumitrica, J. Chem. Phys. 128, 084104 (2008).

Ratio of Experiment/Theory/Computation: **Exp = 0%, Theo = 30%, Comp = 70%**

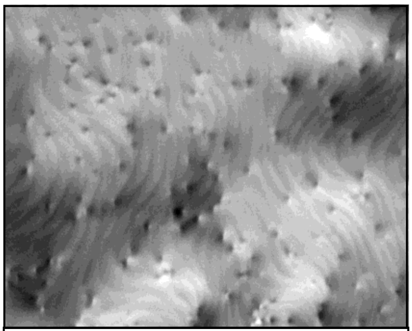
Suitability: MPhys, BSc

Statistical Analysis of Defect Distributions in Semiconductor Thin Films

Project Supervisors: (1) Dr Carol Trager-Cowan, (2) Dr Paul Edwards

Project Description:

Today's scanning electron microscopes allow the properties of materials and devices to be interrogated on the nanoscale. The technique of electron channelling contrast imaging (ECCI), in the scanning electron microscope, can reveal defects such as dislocations in nitride semiconductor thin films (i.e., the "black spots" in the image opposite) when a sample is suitably positioned in the microscope. The acquisition of electron channelling contrast patterns allows the precise position of a sample to be determined. Nitride-based optoelectronic devices are commercially available, e.g., UV/blue laser diodes, UV/visible LEDs and white LEDs; however, the presence of dislocations can limit the performance of these devices.



1 µm ECC image from GaN film

Here at Strathclyde, experiments, computer simulations of electron channelling contrast and image processing software are under development to study defects in nitride semiconductors. This project will involve applying statistical analysis methods to determine the distribution of defects, for example to determine if the dislocation distribution is random or if significant clustering of dislocations occurs. Such studies will provide information on how dislocations form and move during the growth of nitride thin films.

Key Reference (if applicable):

C. Trager-Cowan, F. Sweeney, P. W. Trimby, A. P. Day, A. Gholinia,, N. -H. Schmidt, P. J. Parbrook, A. J. Wilkinson and I. M. Watson, "Electron backscatter diffraction and electron channelling contrast imaging of tilt and dislocations in nitride thin films", *Phys. Rev. B* **75**, 085301 (2007).

Ratio of effort: Exp/Theo/Comp	**Exp:**	**10%**
	Theo:	**40%**
	Comp:	**50%**

Suitability: ALL MPhys, BSc, BSc (Phys with Teaching), BSc (Maths Physics)

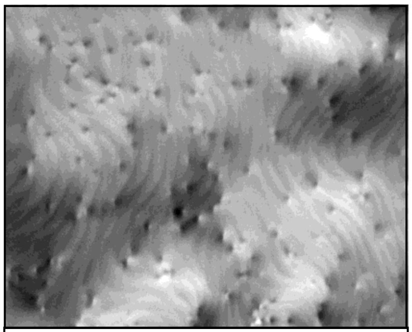
Safety Training Requirements: N/A

Image Processing of Electron Channelling Contrast Patterns and Electron Channelling Contrast Images

Project Supervisors: (1) Dr Carol Trager-Cowan, (2) Dr Paul Edwards

Project Description:

Today's scanning electron microscopes allow the properties of materials and devices to be interrogated on the nanoscale. The technique of electron channelling contrast imaging (ECCI), in the scanning electron microscope, can reveal defects such as dislocations in nitride semiconductor thin films (i.e., the "black spots" in the image opposite) when a sample is suitably positioned in the microscope. The acquisition of electron channelling contrast patterns allows the precise position of a sample to be determined. Nitride-based optoelectronic devices are commercially available, e.g., UV/blue laser diodes, UV/visible LEDs and white LEDs; however, the presence of dislocations can limit the performance of these devices.



ECC image from GaN film

Here at Strathclyde experiments, computer simulations of electron channelling contrast and image processing software are under development to study defects in nitride semiconductors. This project will involve image processing of electron channelling contrast patterns and electron channelling contrast images to extract the maximum information from acquired images. Using image processing packages such as ImageJ, students will investigate both spatial domain and frequency domain processing to, for example, identify grain boundaries in electron channelling contrast images or Kikuchi lines in electron channelling contrast images.

Key Reference (if applicable):

C. Trager-Cowan, F. Sweeney, P. W. Trimby, A. P. Day, A. Gholinia,, N. -H. Schmidt, P. J. Parbrook, A. J. Wilkinson and I. M. Watson, "**Electron backscatter diffraction and electron channelling contrast imaging of tilt and dislocations in nitride thin films**", *Phys. Rev. B* **75**, 085301 (2007).

Ratio of effort: Exp/Theo/Comp	**Exp:**	**10%**
	Theo:	**30%**
	Comp:	**60%**

Suitability: MPhys, BSc, BSc (Phys with Teaching), BSc (Maths Physics)

Safety Training Requirements: N/A

Modelling Semiconductor Nanostructures using a Schrödinger-Poisson-Current Solver

Project Supervisors: (1) Dr Paul Edwards, (2) Prof Rob Martin

Project Description:

This project will involve the use of a Schrödinger-Poisson-current solver to simulate the properties of nanostructures based on III-nitride semiconducting materials. Use will be made of existing code such as *nextnano* (http://www.nextnano.com), and the initial part of the project will involve the student familiarising themselves with this software. This will then be used to model low-dimensional structures such as quantum wells (QWs), quantum dots (QDs) and nanowires, progressing to more complex structures such as full light-emitting diode (LED) devices. The results will be used to aid the interpretation of experimental results from optical and electrical characterisation techniques, and in particular will be combined with Monte Carlo electron trajectory simulations to model the generation and transport of charge carriers in a device under electron beam irradiation.

Key Reference: S. Birner at al. “nextnano: General purpose 3-D simulations” (2007) *IEEE Trans. Electron Devices* **54** 2137 doi:0.1109/TED.2007.902871

Ratio of effort: Exp/Theo/Comp	**Exp:**	**0%**
	Theo:	**20%**
	Comp:	**80%**

Suitability: MPhys, BSc

Safety Training Requirements: None

Noise and System Response of CCD Spectrographs for Luminescence Spectroscopy

Project Supervisors: (1) Dr Paul Edwards, (2) Prof. Robert Martin

Project Description:

Charge-coupled device (CCD) detectors have transformed many areas of scientific research, allowing optical spectra to be collected rapidly and with high signal-to-noise ratios. This project will examine limiting factors in the signal-to-noise ratio of luminescence spectroscopy measurements carried out using CCD spectrographs. The response of such systems is a strong function of both wavelength and polarization, and the project will investigate these aspects both theoretically and through experimental measurements. CCD noise will be quantified with the aim of determining which factors dominate under typical measurement conditions (e.g. during the acquisition of a cathodoluminescence hyperspectral image). The relative influence of shot noise (Poissonian) and read-out noise (Gaussian) will be compared for different sensors: not only conventional CCDs but also electron-multiplying (EMCCD) and image-intensified (ICCD) variants. The project may also be broadened to include the implications of the noise distribution for the pre-treatment of data prior to the application of multivariate statistical analysis methods.

Key Reference:

M. Lesser, "Charge coupled device (CCD) image sensors", in High Performance Silicon Imaging, edited by Daniel Durini, Woodhead Publishing, 2014, Pages 78-97, 10.1533/9780857097521.1.78

P. R. Edwards, L. Krishnan Jagadamma, J. Bruckbauer, C. Liu, P. Shields, D. Allsopp, T. Wang, R. W. Martin (2012) *Microscopy and Microanalysis* **18** 1212–1219 10.1017/S1431927612013475

Ratio of effort: Exp/Theo/Comp

Exp: **50%**
Theo: **25%**
Comp: **25%**

Suitability: MPhys, BSc, BSc Maths and Physics, BSc Physics with Teaching

Additional comments:

Safety Training Requirements:

Optics Division

Non Resonant Optical Cavities

Project Supervisors: (1) Dr Nigel Langford, (2) Dr Alison Yao

Project Description:

Optical spectroscopy is a simple way of detecting pollutants in the atmosphere. In most cases the interaction between the absorbing species and the light is described by Beer's Law (I = Ioexp(-aL)) where L is the interaction length and a is the absorption coefficient. In many cases a is small and so to achieve a detectable change in I requires a long interaction length. One way of doing this is to contain the light in a non-resonant optical cavity whereby the mirrors of the cavity are arranged to allow the light to make multiple bounces. This project will involve modelling of the cavity by use of traditional beam tracing methods (ABCD Matrix approach) as well as using Huygens' Integral approach. The modelling will be done using MatLab.

Key Reference (if applicable):

1. H. Kogelnik and T. Li, "Laser beams and resonators", Am J. Phys., Vol. 5, No. 10, pp.1550–67 (1966).
2. Kogelnik, H. and Li, T., Laser Beams and Resonators, Applied Optics, Vol. 5, pp. 1551-1552, 1966.
3. McManus, J. B., Kebabian P. L., & Zahniser M. S. Astigmatic mirror multipass absorption cells for long-path-length spectroscopy, Applied Optics, Vol. 33, pp.3336, 1995.
4. Arnaud, J.A. and Kogelnik, H., Gaussian Light Beams with General Astigmatism, Vol. 8, Issue 8, pp. 1687-1693, 1969.

Ratio of effort: Exp/Theo/Comp	**Exp:**	**20 %**
	Theo:	**0%**
	Comp:	**80 %**

Suitability: MPhys, BSc Physics, BSc Physics with Teaching, BSc Maths and Physics

Safety Training Requirements: Laser Safety

Control of Quantum Cascade Laser Chirped Pulses by Dispersion Management

Project Supervisors: (1) Dr Nigel Langford, (2) Prof. Geoff Duxbury

Project Description:

A chirp is a change in frequency with time. In a laser the cavity length of the laser sets the optical frequency and by changing the cavity length a chirp can be induced. In a quantum cascade laser it is possible to change the cavity length by heating the laser and chirped pulse quantum cascade lasers have proven to be an invaluable source for optical spectroscopy. The chirp is determined by the way in which the laser is heated and as a consequence the user has little control over the chirp. The aim of this project is to see whether dispersion management approaches developed for ultra-short pulse generation can be applied to the output from a quantum cascade laser. In this case you will investigate the use of diffraction grating based dispersion management techniques to control the chirp from a quantum cascade laser. This work will primarily be a modelling project and will use MatLab.

Key Reference (if applicable):

1. Nonlinear Fiber Optics, G. P. Agrawal, Academic Press 1989 Chapter 6.

Ratio of effort: Exp/Theo/Comp	**Exp:**	**20 %**
	Theo:	**0%**
	Comp:	**80 %**

Suitability: BSc Physics, BSc Physics with Teaching, BSc Maths and Physics

Safety Training Requirements: Laser Safety

Quantum Cascade Laser Pumped Molecular Lasers

Project Supervisors: (1) Dr Nigel Langford, (2) Prof. Geoff Duxbury

Project Description:

The use of high power laser diodes at 800 nm as a pump source for solid state lasers resulted in a revival and revolution in solid-state laser technology. Molecular gas lasers offer operation in the mid infrared a key region for LIDAR applications. These lasers are normally optically excited by use of CO2 lasers that are large and bulky. The development of mid infrared quantum cascade lasers, which operate in the same wavelength region as CO2 lasers, opens up the potential for optical pumping of molecular gas lasers. This project is to investigate the potential of quantum cascade lasers for optical pumping of molecular lasers,

Key Reference (if applicable):

1. B I Vasil'ev, Cho Cheon Whan, Quantum Electronics **30**, 1105, 2000.

Ratio of effort: Exp/Theo/Comp	**Exp:**	**20 %**
	Theo:	**%**
	Comp:	**80 %**

Suitability: MPhys, BSc Physics, BSc Physics with Teaching, BSc Maths and Physics

Safety Training Requirements: Laser Safety

Chirp Management of LEDs

Project Supervisors: (1) Dr Nigel Langford, (2) Dr Thomas Han

Project Description:

High power LEDs are now routinely used in a variety of applications such as bike lights. The aim of this project is to investigate how output wavelength of a high power LED changes when a current pulse is applied to the LED. Once this is understood then there will be a study to see if it is possible to control this change in wavelength by use of the dispersive properties of optical fibres and diffraction gratings.

Key Reference:

E. B. Treacy, "Optical pulse compression with diffraction gratings," IEEE Journal of Quantum Electronics, vol. Qe5, pp. 454–458, 1969.

J. MCMULLEN, "Analysis of compression of frequency chirped optical pulses by a strongly dispersive grating pair," Applied Optics, vol. 18, pp. 737–741, 1979.

Ratio of effort: Exp/Theo/Comp	**Exp:**	**75%**
	Theo:	**0%**
	Comp:	**25%**

Suitability: BSc

Additional comments: You will need to have a good working knowledge of Matlab or C.

Safety Training Requirements: Laser / High power light source

Thermal Management of Pulsed Quantum Cascade Lasers

Project Supervisors: (1) Dr Nigel Langford, (2) Prof. Thorsten Ackemann

Project Description:

A common method of operating lasers is in a pulsed mode. For semiconductor lasers this is done by applying a current pulse to the laser. When a current pulse is applied the laser is heated and as a result the wavelength of the laser changes in time. This change in wavelength is known as a frequency-chirp. The aim of this project is to look at the temperature variation in a pulsed quantum cascade lasers with a view to controlling the frequency chirp. The project will be computational in nature.

Key Reference: Dynamics of thermo-optical properties of semiconductor lasers E. Kowalczyk*, L. Ornoch, Z. Gniazdowski, B. Mroziewicz High-Power Diode Laser Technology and Applications V, edited by Mark S. Zediker, Proc. of SPIE Vol. 6456, 64561G, (2007) · 0277-786X/07/$18 · doi: 10.1117/12.700548

Ratio of effort: Exp/Theo/Comp	**Exp:**	**0%**
	Theo:	**0%**
	Comp:	**100%**

Suitability: BSc, BSc Maths and Physics

Additional comments: You will need to have a good working knowledge of Matlab or C.

Safety Training Requirements: VDU

Beam Quality of Broad-area Diode Lasers

Project Supervisors: (1) Prof. Thorsten Ackemann, (2) Dr Michael Strain

Project Description:

Power scaling of semiconductor laser diodes and maintaining at the same time a high beam quality is a notoriously difficult challenge, since increasing the emission aperture leads to numerous instabilities limiting the brightness of a broad-area laser (BAL) [2].

Recently, a novel approach to control the beam quality of edge-emitting BALs maintaining their attractive monolithic compactness was proposed [1]. The suggestion is to implement a two-dimensional spatial modulation- *simultaneously transverse and parallel to the cavity axis* – of the gain characteristics, i.e. of the imaginary part of the susceptibility, by a modulation of the current injection. Similar to the case of photonic crystals (relying on a modulation of the real part of the susceptibility), the modulation is predicted to lead to a modification of spatial dispersion curves, in particular to a spatial filtering and a highly directional gain along the optical axis. As a result, *noise triggered by inhomogeneities or dynamically generated via instabilities* is quenched.

The project will set up a probe station to measure beam quality of BALs and perform measurements of samples processed at the University of Glasgow.

Key Reference: [1] R. Herrero et al., Beam shaping in spatially modulated broad-areasemiconductor amplifiers, Opt Lett. 37, 5253 (2012); [2] Crump et al., Experimental and theoretical analysis of the dominant lateral waveguiding mechanism in 975 nm high power broad area diode lasers. Semicond. Sci. Technol. **27** (2012) 045001

Ratio of effort: Exp/Theo/Comp	**Exp:**	**70%**
	Theo:	**10%**
	Comp:	**20%**

Suitability: MPhys, BSc

Additional comments: The student is required to attend PH445 and PH453 to obtain the necessary background.

Safety Training Requirements: laser

Characterization of Optically pumped Quantum Well and Quantum Dot Vertical-cavity Structures

Project Supervisors: (1) Prof. Thorsten Ackemann, (2) Dr Antonio Hurtado

Project Description:

The research field of spintronics aims at utilizing the carrier spin for applications in addition to the number of carriers as usual in electronics and semiconductor photonics. However, electrical injection of spin polarized carriers is still limited to cryogenic temperatures or low temperatures in combination with a large magnetic field. At room temperature, optical pumping provides a convenient alternative to electrical injection since carrier spin and photon spin are coupled by angular momentum selection rules. III-V semiconductor gain media in vertical-cavity structures possess the necessary isotropy in the plane of the gain medium to investigate spin dependent effects. Most work centred on relatively low gain structures in vertical-cavity surface-emitting lasers (VCSEL) with quantum well gain media.

This project will look at high gain quantum well samples for external-cavity use (VECSELs) and VCSEL structures containing quantum dots, zero dimensional semiconductors with quantum confinement in all directions. The measurements will start with analyzing the polarization properties of the photoluminescence in dependence on the polarization ellipticity of the optical pump field. Polarization dependent gain will be measured afterwards via a tunable laser. The final aim of the project is to achieve lasing.

Key Reference (if applicable):

Bhattacharya et al., Quantum dot polarized light sources, Semicond. Sci. Technol. 26 (2011) 014002

Hoevel et al., Appl. Phys. Lett. 92, 041118 (2008)

Ratio of effort: Exp/Theo/Comp	**Exp:**	**70%**
	Theo:	**15%**
	Comp:	**15%**

Suitability: MPhys BSc

Additional comments: The student is required to attend PH445 and PH453 to obtain the necessary background.

Safety Training Requirements: Laser safety

Observing Beam Propagation by Fluorescence

Project Supervisors: (1) Dr Aidan Arnold, (2) Dr Paul Griffin

Project Description:

You will make a thorough investigation of the Beer-Lambert Law (and its generalisation) by imaging the fluorescence (spontaneous emission) of rubidium atoms in a vapour cell to detect the local intensity of laser beams propagating through the cell. Key variables include the beam initial intensity, beam shape, and cell temperature. Possible extensions are the investigation of multiple beam interference, and dynamically scanned beams. The project requires a student with good experimental and analysis skills.

Key Reference: N. Radwell, M. A. Boukhet, and S. Franke-Arnold, Opt. Express **21**, 22215 (2013).

Ratio of effort: Exp/Theo/Comp	**Exp:**	**70%**
	Theo:	**20%**
	Comp:	**10%**

Suitability: MPhys

Additional comments: Lab JA3.04A,

Safety Training Requirements: Laser safety training required.

Automated Optimisation of Optical Fibre Coupling using Microprocessor Control

Project Supervisors: (1) Dr Paul Griffin, (2) Dr Aidan Arnold

Project Description:

Coupling light into an optical fibre can be a slow and tedious process. The ultimate aim is optimisation of a multiparameter problem with potentially a number of local maxima. However, this type of problem is ideally suited for solving by a computer using either parameter rastering or genetic algorithm techniques.

For the automatic optimization of coupling a laser beam into a single-mode optical fiber, a suitable algorithm on a microcontroller should be implemented that controls low-priced gear motors, via a microprocessor circuit, which then adjust a mirror mount for alignment of the laser beam on maximum fiber transmission adjust. This project is intended to be incorporated into a atom-optics experiment allowing for continuous optimization and, by eliminating the long-term daily adjustment effort, reducing the complexity of our experiments.

Key Reference:

G. Brooker, "*Modern Classical* Optics", Oxford University Press

Ratio of effort: Exp/Theo/Comp	Exp:	80%
	Theo:	5%
	Comp:	15%

Suitability: MPhys, BSc, BSc Maths and Physics,

Additional comments: The ideal student will have an interest in electronics and computer control, as well as an eagerness to work in a fundamental research laboratory.

Safety Training Requirements: Laser safety

Single-shot, 3D Reconstruction of the Spatial Profile of a Laser Beam

Project Supervisors: (1) Dr Paul Griffin, (2) Prof. Erling Riis

Project Description:

Recording the full spatial profile of a laser beam is a slow process, involving measuring 2D scans of the intensity at numerous planes along the beam axis. In this project we instead propose to instead measure the full 3D laser parameters in a single shot by passing the laser beam through an atomic vapour. By monitoring the light scattered when passing a near-resonant laser beam through an atomic medium, which is a strong function of both frequency and intensity, we can observe a non-linear projection of the laser intensity. Using knowledge of the physics of light-matter interactions, as well as computer processing techniques, such as the inverse Abel transform, this project will produce a 3D image of the spatial profile of the beam. Higher-order laser modes and spatial interference patterns will also be examined as the project evolves.

Key Reference: Atomic Physics, Christopher J. Foot, Oxford University Press

Ratio of effort: Exp/Theo/Comp	**Exp:**	**60 %**
	Theo:	**20 %**
	Comp:	**20 %**

Suitability: MPhys, BSc, BSc Maths and Physics

Additional comments: The success of this project will require a student with strong experimental experimental skills, and the ability to rigorously collect and analyse data.

Safety Training Requirements: Laser safety

Magnetic Field Stabilization with an Arduino Microprocessor

Project Supervisors: (1) Prof. Dr Stefan Kuhr, (2) Dr Elmar Haller

Project Description:

Experiments with ultracold atoms require an accurate control of magnetic fields in the lab. An external magnetic field can induce unwanted field gradients and time dependent forces on the atoms. The goal of this project is to develop a magnetic field stabilization based on a microprocessor unit, which can respond to time and position dependent perturbations. The project includes the design and construction of magnetic field sensors, coils, current drivers and a PID regulator. The student will learn about the simulation and measurements of magnetic fields, the design of electronics and the programming of microprocessors and lab devices (C, C++, Matlab, Labview).

Ratio of effort: Exp/Theo/Comp	**Exp:**	**60%**
	Theo:	**5%**
	Comp:	**35%**

Suitability: MPhys, BSc, BSc Maths and Physics,

Additional comments: The student should be familiar with basic electronics and programming (languages: C, C++, Matlab, Labview).

Safety Training Requirements: None.

Ghost Imaging and the Klyshko approach

Project Supervisors: (1) Dr John Jeffers, (2) Dr Alison Yao

Project Description:

Ghost imaging is the imaging of objects using light that has not interacted with them. This is not impossible, it relies on correlations between two beams of light.

There are two main types of ghost imaging, classical and quantum. The quantum type uses entangled twin beams. The Klyshko approach, in which one beam is described in a time-reversed fashion and the detector in this arm is thought of as a *source* of photons that travel backwards in time, provides an elegant description of the phenomenon.

This project will explore whether such an approach can be simply applied in classical ghost imaging, where the correlations are normally thermal.

Key Reference:

Ryan S. Bennink, Sean J. Bentley, and Robert W. Boyd (2002). *Physical Review Letters* **89**: 113601.

E.-K. Tan, J. Jeffers, S.M. Barnett and D.T. Pegg
Retrodictive states and two-photon quantum imaging
Eur. Phys. J. D 22, 495, 2003

http://en.wikipedia.org/wiki/Ghost_imaging

Ratio of effort: Exp/Theo/Comp

Exp:	**0%**
Theo:	**60%**
Comp:	**40%**

Suitability: MPhys, BSc, BSc Maths and Physics

Additional comments: Students should have passed well (~70%) third year quantum physics. Attendance at Quantum Optics and/or Quantum Information Classes would be desirable.

Safety Training Requirements: N/A

State Comparison Amplification of Schrodinger Cats

Project Supervisors: (1) Dr John Jeffers, (2) Dr Marco Piani

Project Description:

The state comparison amplifier is a simple means of producing a higher amplitude coherent state from a lower one. The device uses only beam splitters, detectors and a laser.

Quantum optical Schrodinger cats are superpositions of different coherent states of light, and are notoriously fragile. Their possible applications in quantum information render them extremely useful, despite them being a difficult-to-produce quantum resource.

This project will describe the possible means of increasing the amplitude of Schrodinger cats, rendering them less susceptible to loss.

Key Reference:

Quantum Optical State Comparison Amplifier, E Eleftheriadou, SM Barnett, J Jeffers, Physical Review Letters 111 (21), 213601, (2013)

Ratio of effort: Exp/Theo/Comp

Exp:	**0%**
Theo:	**60%**
Comp:	**40%**

Suitability: MPhys, BSc, BSc Maths and Physics

Additional comments: Students should have passed well (~70%) third year quantum physics. Attendance at Quantum Optics and/or Quantum Information Classes would be desirable.

Safety Training Requirements: N/A

Cold Atom-Light Interactions

Project Supervisors: (1) Dr Gordon Robb, (2) Dr Brian McNeil

Project Description:

It is now possible to cool atoms down to temperatures close to absolute zero. At these temperatures, the interaction between light and atoms can change dramatically; with the optical forces acting on the atoms can play a significant effect.

The project will involve analysing and simulating interactions between optical beams and a gas of cold atoms, in particular considering cases where the light-atom interaction is nonlinear, offering new possibilities for e.g. optical pattern formation, light amplification and atomic self-organisation.

Key Reference: E. Tesio, G.R.M. Robb, T. Ackemann, W.J. Firth, and G.-L. Oppo, Phys. Rev. A 86, 031801(R) (2012)

Ratio of effort: Exp/Theo/Comp		
	Exp:	**0%**
	Theo:	**30%**
	Comp:	**70%**

Suitability: MPhys BSc

BEC-Light Interactions

Project Supervisors: (1) Dr Gordon Robb, (2) Prof. Gian-Luca Oppo

Project Description:

When a gas of atoms is cooled to a temperature < ~1μK , it can stop behaving as a cloud of classical particles and instead behave as a "matter wave" or Bose-Einstein Condensate (BEC), whose behaviour is governed by the laws of quantum mechanics. BECs were first realised experimentally in 1995 and the only one in Scotland is here at Strathclyde.

The wave nature of the BEC can have a dramatic effect on how the atoms interact with light. This project will involve theory and simulation of nonlinear interaction involving a BEC and light.

Key Reference: S. Inouye, A.P. Chikkatur, D.M. Stamper-Kurn, J. Stenger, D.E. Pritchard, and W. Ketterle: Science 285, 571-574 (1999)

Ratio of effort: Exp/Theo/Comp	**Exp:**	**0%**
	Theo:	**30%**
	Comp:	**70%**

Suitability: MPhys, BSc

Safety Training Requirements: N/A

Interactive Physics Simulations

Project Supervisors: (1) Dr Gordon Robb, (2) Dr Nigel Langford

Project Description:

Many interactive Physics simulations have been developed over the years in a variety of different languages e.g. JAVA, Adobe Flash, Shockwave etc.

However, for several reasons many existing simulations have now become obsolete, e.g.

- Most modern browsers do not run JAVA easily, as it is perceived as a security risk
- Many existing simulations cannot run on tablets or mobile phones

The project will involve developing one or more interactive Physics simulations using HTML5, which allows them to be run on modern browsers and on mobile devices. Recent examples of such simulations and teaching activities which use them can be found in [1].

The physics topic and the exact method of developing the simulation can be adjusted to suit the student's degree programme and level of previous programming experience.

Key Reference: https://phet.colorado.edu

Ratio of effort: Exp/Theo/Comp	**Exp:**	**0**	**%**
	Theo:	**20**	**%**
	Comp:	**80**	**%**

Suitability: MPhys, BSc, BSc Maths and Physics, BSc Physics with Teaching

Additional comments:

Safety Training Requirements: N/A

Quantum Measurement in the Jaynes-Cummings Model

Project Supervisors: (1) Dr Daniel Oi, (2) Dr John Jeffers

Project Description:

Measurement plays a vital role in quantum information theory. Non-destructive measurement of optical fields is challenging to implement. One method is to couple a two-level atom to a cavity mode and through the interaction extract information from the field via the atomic state. Due to bosonic enhancement, the resulting measurement operators can be complicated and this project will investigate the resulting cavity dynamics.

Key Reference:

Nondemolition measurement of the vacuum state or its complement, D.K.L. Oi, V. Potoček, J. Jeffers, Physical Review Letters **110**, 210504 (2013)

Ratio of effort: Exp/Theo/Comp	**Exp:**	**0%**
	Theo:	**50%**
	Comp:	**50%**

Suitability: MPhys, BSc, BSc Maths and Physics, BSc Physics with Teaching

Additional comments:

Safety Training Requirements:

Satellite Free-space Optics for Quantum Communication

Project Supervisors: (1) Dr Daniel Oi, (2) Dr Paul Griffin

Project Description:

CubeSats are a promising platform for quantum key distribution systems in low Earth orbit. However, their small size, mass, and power restricts the equipment it is able to carry so innovative solutions are required. A key issue is the diffraction limited spot size of single photon transmission between satellite and the ground. The project would model the optical channel from a CubeSat to a receiving station in order to characterize losses and the effect of beam shape, pointing jitter, and atmospheric turbulence.

Key Reference:

Quantum optics for space platforms, W. Morong, A. Ling, D. Oi, Optics and Photonics News **23** p.42 (2012) http://quantumlah.org/media/story/2012_OPN_Alexfeature.pdf

Ratio of effort: Exp/Theo/Comp	**Exp:**	**0%**
	Theo:	**50%**
	Comp:	**50%**

Suitability: MPhys, BSc, BSc Maths and Physics, BSc Physics with Teaching

Additional comments:

Safety Training Requirements:

Ancilla-driven Quantum Dynamics

Project Supervisors: (1) Dr Daniel Oi, (2) Dr Marco Piani

Project Description:

The ability to perform information processing tasks using quantum systems depends on the resources available. In the Ancilla Driven Quantum Computation model, the main resource is a single two-qubit unitary interaction that can drive evolution of a system via coupling to an ancilla. By suitable preparation and measurement of the ancilla, different effects can be applied to the system, but this depends on the form of the interaction. This project would investigate the relationship between the form of the unitary and what can be achieved.

Key Reference:

Ancilla-driven universal quantum computation, J. Anders, D.K.L. Oi, E. Kashefi, D.E. Browne, E. Andersson, Physical Review A **82**, 020301 (2010)

Ratio of effort: Exp/Theo/Comp	**Exp:**	**0%**
	Theo:	**90%**
	Comp:	**10%**

Suitability: MPhys, BSc, BSc Maths and Physics, BSc Physics with Teaching

Additional comments:

Safety Training Requirements:

Spiral Bandwidth Control in Optical Parametric Oscillators

Project Supervisors: (1) Dr Alison M Yao, (2) Prof. Gian-Luca Oppo

Project Description:

Optical parametric oscillators (OPOs) consist of a nonlinear crystal placed inside an optical cavity. The crystal converts a pump photon into two lower-frequency photons via a process known as spontaneous parametric down conversion (SPDC), while the cavity amplifies the down-converted beams by resonating either one (singly resonant) or both (doubly resonant) of the output beams. Doubly resonant optical parametric oscillators have been shown to produce signal and idler output beams that can have different amounts of orbital angular momentum (OAM). The range of OAM found in the output is known as the spiral bandwidth (SB) [1].

For quantum communication purposes, it is desirable to maximise the SB. In SPDC alone, the SB can be increased by changing the ratio of the pump width to the signal/idler width. In current OPO models, however, it is not possible to change this ratio as there is no control over the signal/idler size. The aim of this project is to incorporate curved mirrors into the simulations of OPO cavities [2]. By changing the radius of curvature of these mirrors the size of the signal/idler beam on the nonlinear crystal can be controlled. In this way we hope to develop a means of controlling the SB in widely used devices for the generation of entangled photons.

Key Reference (if applicable):

[1] A. M. Yao, "*Angular momentum decomposition of entangled photons with an arbitrary pump*", New J. Phys. **13,** 053048 (2011).

[2] M. Santagiustina, E. Hernandez-Garcıa, M. San-Miguel, A. J. Scroggie and G.-L. Oppo, *Phys. Rev. E* **65**, 036610 (2002).

Ratio of effort: Exp/Theo/Comp	**Exp:**	**0%**
	Theo:	**30%**
	Comp:	**70%**

Suitability: MPhys BSc (Maths Physics)

Additional comments: The project requires skills in mathematical and computational techniques.

Safety Training Requirements: None

Orbital Angular Momentum in Vectorial Kerr Cavities

Project Supervisors: (1) Dr Alison M Yao, (2) Prof. Gian-Luca Oppo

Project Description:

Spontaneous breaking of spatial or temporal symmetries is the mechanism at the base of many physical phenomena in particle (Higgs boson), solid-state (magnetic orientation) and soft matter (liquid crystals) physics. In optics, the spontaneous breaking of the translational and rotational symmetries in the plane perpendicular to the direction of light propagation leads to pattern formation in the shape of hexagons, stripes, rhomboids and honeycombs. In this project we consider an extension of the theory of spatial pattern formation in a nonlinear cavity to account for the vector nature of the fields [1].

We investigate the effect of orbital angular momentum on the propagating beams and the effect of intra-cavity polarizing elements. The coupling of nonlinearity, diffraction and optical angular momentum leads to the formation of exotic structures with counterintuitive correlations between the two components of the vector field. Numerical codes for the integration of these equations have already been developed so the project will focus on the generation and analysis of the data, its physical meaning and the relevance to applications in photonics and quantum technologies.

Key Reference (if applicable):

[1] R. Gallego, M. San Miguel and R. Toral, "*Self-similar domain growth, localized structures, and labyrinthine patterns in vectorial Kerr resonators*", Phys. Rev. E **61**, 2241 (2000).

Ratio of effort: Exp/Theo/Comp	**Exp:**	**0%**
	Theo:	**30%**
	Comp:	**70%**

Suitability: MPhys BSc (Maths Physics)

Additional comments: The project requires skills in mathematical and computational techniques.

Safety Training Requirements: None

Transport Dynamics of Quantum Gases in Optical Potentials

Project Supervisors: (1) Prof. Andrew Daley, (2) Dr Alexandre Tacla

Project Description:

Quantum gases are engineered quantum systems, typically consisting of millions of atoms, which can be precisely manipulated by optical potentials to study quantum effects in a large many-body scale. These are highly controllable systems that can be trapped in arbitrary geometries and have their interactions tuned to study exotic quantum states of matter, such as the quantum phase transition between an insulator and a superfluid, and to possibly develop groundbreaking technologies, such as quantum computers. Such remarkable achievements have demonstrated our strong theoretical understanding of atomic systems on a microscopic level and our ability to numerically simulate the quantum many-body dynamics with high accuracy.

This project investigates non-equilibrium transport dynamics of quantum gases in one-dimensional optical lattice potentials. The goal is to investigate the flow of atoms through the lattice and passing through barriers, including impurity atoms. The student will learn techniques to treat the many-body dynamics in different levels of approximation, ranging from a simplified mean-field description in terms of the discrete nonlinear Schrödinger equation, to powerful numerical techniques, such as time-dependent Density Matrix Renormalization Group, which allow for virtually exact calculations of the many-body dynamics in many interesting regimes. This project is directly related to existing experiments, including some in the photonics group in this department.

Key References:

[1] I. Bloch, *Ultracold quantum gases in optical lattices*. Nature Physics **1**, 23 (2005).

[2] A. J. Daley, P. Zoller, and B. Trauzettel, *Andreev-like reflections with cold atoms*. Physical Review Letters **100**, 110404 (2008).

Ratio of effort: Exp/Theo/Comp	**Exp:**	**0%**
	Theo:	**40%**
	Comp:	**60%**

Suitability: MPhys, BSc, BSc Maths and Physics, BSc Physics with Teaching

Additional comments: The student should be interested in working with numerical techniques and comfortable working with computers. Specific numerical methods will be covered over the course of the project as required.

Safety Training Requirements: No special safety training requirements.

Dynamics of Impurity Atom Coupled to a Quantum Gas

Project Supervisors: (1) Prof. Andrew Daley, (2) Dr S. McEndoo

Project Description:

Cold atomic systems provide an exciting and varied landscape of tools and materials for investigating and manipulating quantum systems in precise ways. From macroscopic quantum objects such as Bose-Einstein condensates to the manipulation of single atoms, we now have a large range of experimental and theoretical systems at our disposal. By investigating such systems, we can study fundamental physics at close quarters, while providing new ideas and methods for manipulating information at a quantum level.

Because we can consider both the wave and particle natures of atoms, we can use a quantum gas to take the role of the electric field and recreate optical phenomena using atoms alone. For example, when an atom in an excited state is coupled to quantum gas, the atom is able to undergo spontaneous emission, but instead of emitting a photon as it drops to the ground state, the atom creates an excitation in the quantum gas.

In addition to being able to recreate spontaneous emission as it is in the photonic case, by using quantum gases we can move into new regimes, taking advantage of the different properties of the quantum gas, and the gas-atom coupling.

In this project we look at how the properties of the atoms and the quantum gas can affect the dynamics of the system and can be used to engineer particular states of the atom. A large component of this project will involve numerical simulation of these systems including, if appropriate, methods such as time-dependent DMRG. We will also take a theoretical approach parallel to the numerical approach, particularly for interesting cases where there is an analytical solution. This project is directly related to existing experiments, including some in the photonics group in this department.

Key References:

I. Bloch, Nature Physics **1**, 23 - 30 (2005)

A. J. Daley, P. O. Fedichev, and P. Zoller, Phys. Rev. A **69**, 022306 (2004).

Ratio of effort: Exp/Theo/Comp	**Exp:**	**0%**
	Theo:	**40%**
	Comp:	**60%**

Suitability: MPhys, BSc, BSc Maths and Physics, BSc Physics with Teaching

Additional comments: The student should be interested in working with numerical techniques and comfortable working with computers. Specific numerical methods will be covered over the course of the project as required.

Safety Training Requirements: No special safety training requirements

Quantifying Quantum Steering by Semidefinite Programming

Project Supervisors: (1) Dr Marco Piani, (2) Dr Daniel Oi

Project Description:

Quantum steering corresponds to the “spooky action at a distance” between quantum systems allowed by quantum entanglement and disliked by Einstein. Entanglement corresponds to stronger-than-classical correlations which result when two systems become so tightly intertwined that their shared properties dominate over their individual ones. In steering, the measurement of one system affects the other system in ways that go beyond classical intuition and are key in the development of future revolutionary quantum technologies. The project regards recently proposed ways to quantify steering that make use of an optimization technique known as semidefinite programming. The student will learn about steering and semidefinite programming, and use analytical and numerical tools to quantify steering in relevant examples of quantum states.

Key References:

P. Skrzypczyk, M. Navascues, and D. Cavalcanti, *Quantifying Einstein-Podolsky-Rosen steering*, Phys. Rev. Lett. 112, 180404 (2014)

M. Piani and J. Watrous, *Einstein-Podolsky-Rosen steering provides the advantage in entanglement-assisted subchannel discrimination with one-way measurements*, **arXiv:1406.0530**

Ratio of effort: Exp/Theo/Comp	**Exp:**	**0%**
	Theo:	**50%**
	Comp:	**50%**

Suitability: MPhys, BSc, BSc Maths and Physics,

Additional comments: The student should be familiar with basic concepts of quantum physics and with the use of Matlab.

Safety Training Requirements: None, except you should not be afraid of spooky things.

Surface Fields in Layered Nano Particles

Project Supervisors: (1) Dr Francesco Papoff, (2) Dr Ben Hourahine

Project Description:

Nano and micro particles have remarkable optical properties: at some wavelengths they can massively enhance the local electromagnetic field close to the particle (the near field) while also acting as optical cavities with exceptionally high Q factors. A very effective way to control the wavelength at which these effects appear is by adding layers of different materials. In this project, we aim to develop a new theory to calculate the responses of layered particle when illuminated by light sources that are close to the particle surface.

Key Reference (if applicable):

1)F. Papoff, B. Hourahine,Geometrical Mie theory for resonances in nanoparticles of any shape, Optics Express, 19, 21432 (2011)

2)B Hourahine, F. Papoff, The geometrical nature of optical resonances: from a sphere to fused dimer nanoparticles, Meas. Sci. Technol. 23, 084002 (2012)

Ratio of Experiment/Theory/Computation: **Exp: 0%**
Theo: 40%
Comp: 60%

Suitability: MPhys, BSc

Safety Training Requirements: None

Resonances in Clouds of Cold Atoms

Project supervisors: (1) Dr Francesco Papoff (2) Dr Gordon Robb and Dr Ben Hourahine

Project Description:

Spherical clouds of cold atoms and Bose-Einstein condensate have electromagnetic resonances that are similar to the Mie resonances of spherical dielectric particles. In most experiments, however, the atomic clouds are more similar to elongated cigars than to spheres. In this project we will develop a theory for bodies with axially symmetric density that will apply to these experiments and we will consider whether the scattering of light from these clouds can become an effective diagnostic tool to measure the density of the cloud.

Ratio of Experiment/Theory/Computation:	**Exp**	**0%**
	Theo	**50%**
	Comp	**50%**

Suitability: MPhys, BSc

Fluctuations and Noise in Cold Atoms

Project supervisors: (1) Dr Francesco Papoff (2) Dr Gordon Robb

Project Description:

Noise plays a crucial role in all physical systems and in many cases it is not an hindrance, but an essential ingredient for the observation of processes as important as laser emission, for instance. In this project we will investigate theoretically and numerically the nature of small noisy fluctuations present in cold atoms interacting with coherent light, a very important system where it is possible to observe collective phenomena, linear and non-linear behaviour and many types of instabilities. In particular, we will find how noisy perturbations affect the the collective behaviour of cold atoms and explore regimes where they are be amplified.

Key Reference (if applicable): http://sbfel3.ucsb.edu/www/vl_fel.html

F. Papoff, G. D'Alessandro, G.-L. Oppo, Phys. Rev. Lett. 100, 123905, 1-4, (2008)

F. Papoff, G.R.M Robb, Phys. Rev. Lett. 108, 113902 (2012)

Ratio of Experiment/Theory/Computation: **Exp = 0%,**
Theo = 50%,
Comp = 50%

Suitability: PH450 MPhys BSc

Additional Comments:

Safety Training Requirements:

Dynamics of Coupled Laser Systems

Project Supervisors: (1) Prof. Gian-Luca Oppo, (2) Prof. Thorsten Ackemann

Project Description:

It is well known that coupled lasers can synchronise by locking their phases when the coupling strength is large enough. Two typical examples of coupled laser systems are lasers injecting each other and closely placed laser waveguides. This project investigates and compares the dynamics of these two systems before and after the locking threshold when increasing the coupling parameter. The dynamical roles of relaxation oscillations and semiconductor features are analysed by using simple laser models that can be numerically integrated by using Matlab.

In the second part of the project, we remove the losses due to the spontaneous emission of photons and obtain equations that are (surprisingly) reversible in time. The research will focus on the coexistence of conservative and dissipative dynamics [1] that can lead to unexpected oscillations of the coupled laser output. Coupled lasers, laser arrays and laser networks [2] find natural applications in optical communications and in the processing of optical information.

Key Reference (if applicable):

[1] D. H. Henderson, PhD Thesis "Reversibility and intensity dependent dissipations in lasers" (University of Strathclyde, 2000)

[2] M. Nixon et al., "Controlling synchronization in large laser networks", Phys. Rev. Lett. **108**, 214101 (2012)

Ratio of effort: Exp/Theo/Comp	**Exp:**	**10 %**
	Theo:	**40 %**
	Comp:	**50 %**

Suitability: MPhys, BSc (including Maths Physics)

Additional comments: The "experimental" part is related to the understanding of experimental results and their comparison with numerical simulations.

Safety Training Requirements: None

Interaction of Spatial Optical Solitons

Project Supervisors: (1) Prof. Gian-Luca Oppo, (2) Prof. William Firth

Project Description:

Spatial optical solitons are beams of light in which nonlinearity counter-balances diffraction, leading to robust single-hump structures that propagate without change of form. In the case of light propagating through a medium, the simplest spatial soliton is due to self-focusing and Kerr nonlinearity, that is, a refractive index which changes in proportion to the intensity of the light. More general schemes where dissipation and driving and/or feedback are included can also support stable soliton-like solutions with lots of intriguing and new properties. Among these, localized bright spots in driven-optical cavities have received a great deal of attention because of their experimental realisability in semiconductor lasers and potential applications in information processing. These are usually referred to as laser cavity solitons (LCS). In this project we study the interaction of two LCS belonging to separate families, one tall and narrow and the other one short and fat. This is a very peculiar situation that can arise in semiconductor lasers with saturable absorption and optical feedback. The numerical codes are already in operation and produce 2D and 3D movies of static and dynamic interactions.

Key Reference (if applicable):

T. Ackemann, W. J. Firth and G-L Oppo, "Fundamentals and Applications of Spatial Dissipative Solitons", Adv. At. Mol. Opt. Phys. 57, 323 (2009)

Ratio of effort: Exp/Theo/Comp	**Exp:**	**10%**
	Theo:	**40%**
	Comp:	**50%**

Suitability: **MPhys, BSc (Maths Physics)**

Additional comments: The "experimental" part is related to the understanding of experimental results and their comparison with numerical simulations.

Safety Training Requirements: None

Simulations of Spin-Polarized Vertical-Cavity Surface-Emitting Lasers

Project Supervisors: (1) Prof. Gian-Luca Oppo, (2) Prof. Thorsten Ackemann

Project Description:

Spin-polarized vertical-cavity surface-emitting lasers (known as VCSELs) offer the exciting prospect of output polarization control through the injection of spin-polarized electrons. Such capabilities could lead to many new applications in the field of spectroscopy, communications and information processing. In this project we simulate the rate equations that describe the right- and left-circularly polarized complex fields and the carrier densities, as originally introduced in [1], to detect and describe the instabilities leading to self-sustained oscillations [2]. The numerical integration is made via MATLAB while the output is characterized by power and optical spectra. We look at the description of Vertical External Cavity devices, bifurcation diagrams, high frequency oscillations and possible transitions to chaotic motion for spin-polarized lasers. The effects of an injected signal and modulations of losses or cavity parameters are also investigated.

Key Reference (if applicable):

[1] G. P. Puccioni, M. V. Tratnik, J. E. Sipe and G.-L. Oppo, “Low instability threshold in a laser operating in both states of polarization**”** Optics Letters **12**, 242 (1987)

[2] R. Al-Seyab, D. Alexandropoulos, I. D. Henning, and M. J. Adams, “Instabilities in Spin-Polarized Vertical-Cavity Surface-Emitting Lasers**”** IEEE Photonics Journal **3**, 799 (2011)

Ratio of effort: Exp/Theo/Comp	**Exp:**	**10 %**
	Theo:	**40 %**
	Comp:	**50 %**

Suitability: MPhys, BSc

Additional comments: Good performance in the course PH254 Computational Physics is recommended. The “experimental” part is related to the understanding of experimental results and their comparison with numerical simulations.

Safety Training Requirements: None

Self-structuring and Optomechanics of Cold Atoms

Project Supervisors: (1) Prof. Gian-Luca Oppo, (2) Dr Gordon Robb

Project Description:

The rapidly developing field of optomechanics aims at the combined control of optical and mechanical degrees of freedom of light interacting with an atomic medium. The spontaneous emergence of regular spatial structures (hexagons) due to optomechanical forces has been observed recently by retro-reflecting a laser beam through a cloud of cold Rubidium atoms [1]. Turing patterns (from Alan Turing of Enigma fame) have been studied before in nonlinear optics but this is the first evidence of an atomic displacement mechanism (self-structuring) operating in conjunction with the focusing of light in small peaks [1].

Theoretical and simulation approaches have been developed at Strathclyde to describe the optomechanical forces due to a laser beam interacting with cold atoms [1,2]. The project focuses on the generation and comparison of data (read colourful pictures) from these codes simulating different physical configurations of the experiment: large temperature, changes in the frequency and intensity of the input beam, use of a cavity configuration instead of a single mirror reflector, inclusion of spontaneous emission, excitation of spatial solitons, and, possibly, operation with two input laser beams.

Key Reference (if applicable):

[1] G. Labeyrie et al., "Optomechanical self-structuring in a cold atomic gas", Nature Photonics **8**, 321 (2014) and Supplementary Material

[2] E.Tesio et al., "Kinetic Theory for Transverse Optomechanical Instabilities", Phys. Rev. Lett. **112**, 043901 (2014)

Ratio of effort: Exp/Theo/Comp	**Exp:**	**10 %**
	Theo:	**40 %**
	Comp:	**50 %**

Suitability: **MPhys, BSc (including Maths Physics)**

Additional comments: The "experimental" part is related to the understanding of experimental results and their comparison with numerical simulations.

Safety Training Requirements: None

Computational Modelling of X-ray Free Electron Lasers

Project Supervisors: (1): Dr Brian McNeil, (2) Dr Gordon Robb

Project Description:

X-ray Free-Electron Lasers (XFELs), such as the LCLS at SLAC in California [1] and SACLA at Spring-8 in Japan, use high energy electron bunches, produced by particle accelerators, to generate intense pulses of X-rays within a long magnet called an undulator [2].

The spatial and temporal resolution available from the high brightness ultra-violet to x-ray pulses generated by these XFELs, is making feasible the observation and ultimately the potential to control ultra-fast, optionally non-linear processes in all forms of matter. With the ability to probe correlated electronic processes within atoms at short timescales, to measure how electrons and nuclei re-organise themselves, either individually within atoms due to external stimulus, during molecular bond making and breaking, or while undergoing subtle catalytic or biological processes, we can begin to unravel how all matter functions at this fundamental level.

The supervisor of this project Dr Brian McNeil works closely with the UK's Accelerator Science and Technology Centre, along with international collaborators in this field. In the UK he is closely involved with the proposed CLARA facility based at Daresbury near Warrington [3]. Previously, good project students have obtained a summer studentship working there.

Starting from the basic working equations that describe the FEL process, the student will gain an understanding of how an XFEL works. You will then use numerical methods to solve the simplest case. This will involve solving equations describing the electron trajectories through the combined undulator and light fields, while simultaneously solving the equation that describes how the light field is driven by the electrons. Initially a code like MATLAB can be used. The student may wish to then use a lower-level language like Fortran, C or Java (your choice), to solve the same or extended equations describing further effects (e.g. harmonic light generation) and then present the solutions in a meaningful way using available plotting packages.

The skills that you will learn are generic to a working theoretical/computational physicist and will prepare you well for a future career in this field. A good student should be able to take the analysis further and begin looking at more advanced topics. This will be like performing 'numerical experiments'. From these, it may be possible to predict new effects that can enhance or extend current XFEL performance.

Key Reference (if applicable):

[1] https://portal.slac.stanford.edu/sites/lcls_public/Pages/Default.aspx
[2] B.W.J. McNeil & N.R.Thompson, 'X-ray free-electron lasers', Nature Photonics, **4**, 814, 2010
[3] http://www.stfc.ac.uk/ASTeC/Programmes/38749.aspx

Ratio of effort: Exp/Theo/Comp	**Exp:**	**0%**
	Theo:	**25%**
	Comp:	**75%**

Suitability: **MPhys, BSc, BSc (Maths Physics)**

Safety Training Requirements: Normal office/computer user induction. No special requirements

Resonant Electron Beam-light Interactions

Project Supervisors: (1) Dr Brian McNeil, (2) Dr Gordon Robb

Project Description:

Electron motion can be driven by the electromagnetic field of light. But accelerated electrons can also be the source of electromagnetic radiation. These mutual interactions can be applied to create coherent sources of high power radiation from mm wavelengths into the hard x-ray. Such light sources use different methods to achieve this, such as the Cyclotron Resonance Maser and the Free Electron Laser. The light-electron interactions may also be used to accelerate electrons possibly to very high (relativistic) energies.

You will develop a mathematical model of both the radiation source and acceleration processes and then solve the resulting equations numerically. A good student can expect to use their model to research new physical processes that may occur and possibly make a new and useful contribution to the field.

Key Reference (if applicable):

Free-Electron Lasers: The Next Generation by Davide Castelvecchi New Scientist, January 21, 2006

See also: www.4gls.sc.uk, www-ssrl.slac.stanford.edu/lcls/, xfel.desy.de/

Ratio of effort: Exp/Theo/Comp	**Exp:**	**0%**
	Theo:	**50%**
	Comp:	**50%**

Suitability: MPhys BSc

Additional comments: Students will require or will be expected to develop a working knowledge of a computer

language (such as Fortran or MATLAB.) and have a good proficiency at mathematics.

Safety Training Requirements: None

Plasmas Division

Laser Wakefield Acceleration and Betatron Gamma Ray Radiation

Project Supervisors: (1) Prof. Dino Jaroszynski, (2) Dr M Ranaul Islam

Project Description:

The student will carry out analytical and numerical work on laser plasma wakefield acceleration. This is a method of accelerating electrons using plasma waves. The attraction of this method, being investigated experimentally and theoretically at Strathclyde University, lies in the propagation of intense laser pulses in under-dense Plasma, which can accelerate energetic electron beams up to 1 GeV by utilizing the huge longitudinal electrostatic fields produced by displaced electrons. These forces create a bubble-like ion structure, and the transverse restoring force in such ionic-background leads to acceleration and the emission of intense femtosecond duration gamma-ray betatron radiation. The emphasis of this project will be on controlled acceleration, investigating ways to obtain high energy X-rays, and studying the efficiency, which can be comparable with conventional accelerators. These new types of radiation sources could be used to probe the structure of matter on unprecedented length and time scales. The student will use particle-in-cell (PIC) codes such as VORPAL and OSIRIS. The project forms part of the ALPHA-X project at Strathclyde University.

Reference : (1)PhD thesis http://alexandria.tue.nl/extra2/200212656.pdf (2) http://phys.strath.ac.uk/alpha-x (3) Mangles, S. P. D. et al. Electron acceleration from the breaking of relativistic plasma waves. Nature 431, 535538 (2004).

Ratio of Experiment/Theory/Computation: **Exp: 0 %**
Theo: 30 %
Comp: 70 %

Suitable for: MPhys

Additional Comments: This is challenging project requiring good mathematical and numerical skills. Anyone interested in this project should contact the supervisors in advance.

Safety Training Requirements: Contact the project Supervisor for further advice

Radiation Reaction

Project Supervisors: (1) Prof. Dino Jaroszynski, (2) Dr Adam Noble

Project Description:

This project is an opportunity to investigate the interaction of a charged particle with its own radiation field. As well as being vital for the development of new technologies at the cutting edge of scientific discovery, this is a problem of fundamental importance in classical and quantum electrodynamics. Indeed, it is one of the classic unsolved problems in physics.

The Lorentz-Dirac equation, which describes radiation reaction, exhibits unexpected behaviour, such as unbounded accelerations and particles responding to a force before it acts. You will explore the origins of these pathologies and some of the attempts to eliminate them, as well as applying the equation to some of the latest accelerator designs and interactions of electrons with the electromagnetic fields that will be available from a new generation of powerful laser sources, such as that being constructed at the EU Extreme Light Infrastructure.

Reference:

J.D. Jackson, Classical Electrodynamics, 3rd ed. New York : Wiley, 1999. Main Library: D537.6 JAC;
E. Poisson, An introduction to the Lorentz-Dirac equation, arXiv: gr-qc/9912045.

Ratio of Experiment/Theory/Computation:	**Exp:**	**0 %**
	Theo:	**70 %**
	Comp:	**30 %**

Suitable for: MPhys and BSc

Additional Comments: This challenging project will be of interest to someone with strong mathematical skills, who enjoys exploring technical and conceptual questions. Anyone interested in pursuing this project should contact the supervisors beforehand

Safety Training Requirements: Contact the project Supervisor for further advice

Non-linear Optics in Plasma: Raman Amplification and Frequency Mixing

Project Supervisors: (1) Prof. Dino Jaroszynski, (2) Dr Bernhard Ersfeld

Project Description:

This project offers the opportunity to investigate, both theoretically and numerically, non-linear interactions between (transverse) electromagnetic waves through a (longitudinal) plasma wave. It has been suggested to use such a process, stimulated Raman scattering, to amplify a seed pulse by extracting energy from an intense pump pulse to provide a new type of light amplifier to reach petawatts, exawatts and beyond. Plasma as a non-linear optical medium for intense laser pulses has additional interest when optical pulses are sufficiently intense to drive electrons (and holes or positrons) to relativistic energies, and thus to generate astrophysical conditions in the laboratory.

The investigation may build on an existing code for the hydrodynamic simulation of plasma taking into account a variable number of carrier species, such as electron-positron plasmas, and electrons and ions, or holes in the case of a semiconductor plasma.

Reference: William L. Kruer: The physics of laser plasma interactions, Addison-Wesley, Redwood City, Calif. c1988. Main Library: D 530.44 KRU (or other textbooks on laser-plasma interaction)

Ratio of Experiment/Theory/Computation:	**Exp:**	**0 %**
	Theo:	**50 %**
	Comp:	**50 %**

Suitable for: MPhys, BSc (Maths Physics)

Additional Comments: Knowledge in the following areas would be advantageous: wave propagation, Fourier theory; computer programming (C or similar). Anyone interested in taking up this project should contact the supervisors beforehand.

Safety Training Requirements: Contact the project Supervisor for further advice

Electron Beam Transport and Diagnostics

Project Supervisors: (1) Prof. Dino Jaroszynski, (2) Dr Enrico Brunetti

Project Description:

Laser-driven particle accelerators are compact sources of high quality electron beams with potential applications to fields such as medicine, biology and material science. Since many applications require the transport and focusing of a beam over long distances, a good quality transport system is essential. This project consists of the theoretical study of the transport of an electron beam through magnetic devices, with particular emphasis on properties such as transverse emittance and bunch length.

Reference: Wiedemann, Particle Accelerator Physics, Springer, 2007 Jackson, Classical Electrodynamics, Wiley, 1999 Esarey, Schroeder and Leemans, Physics of laser-driven plasma-based electron accelerators, Rev. Mod. Phys. 81, 1229–1285 (2009)

Ratio of Experiment/Theory/Computation: **Exp: 0 %**
Theo: 50 %
Comp: 50 %

Suitable for: MPhys, BSc (Maths Physics)

Additional Comments: Knowledge in the following areas would be advantageous: wave propagation, Fourier theory; computer programming (C or similar). Anyone interested in taking up this project should contact the supervisors beforehand.

Safety Training Requirements: Contact the project Supervisor for further advice

Capillary Discharge Waveguides for Laser-Plasma Interactions

Project Supervisors: (1) Dr Mark Wiggins, (2) Prof. Dino Jaroszynski

Project Description:

The project will be part of the ALPHA-X project to harness plasma using high power lasers as radiation and particle sources. In a plasma medium, the laser can drive plasma waves that are then used as a non-linear optical medium to parametrically amplify laser pulses, or to provide extremely high electrostatic forces to accelerate charged particles.

In the project, the formation of stable plasma in capillary discharge waveguides will be investigated. These capillaries act as waveguides for laser pulses when filled with plasma, thus forming the medium for amplification and acceleration.

The project involves the evaluation and characterisation of both straight and undulated plasma waveguides, including determination of the plasma density. The guiding of relatively low intensity femtosecond laser pulses through these capillaries will be investigated. It will involve a balance between experimental and theoretical analysis and provide valuable hands-on experience with high-voltage pulsed power supplies, plasma diagnostics and femtosecond laser systems in the TOPS laser laboratory. It is the intention that these capillaries will be used in the current laser-driven wakefield accelerator experiments at Strathclyde. The student will have the opportunity to be involved in a ground breaking project.

Key Reference (if applicable): Relevant papers will be provided

Ratio of effort: Exp/Theo/Comp	**Exp:**	**80%**
	Theo:	**10%**
	Comp:	**10%**

Suitability: MPhys, BSc, BSc (Phys with Teaching), BSc (Maths Physics)

Additional comments: student supervised at all times during Class 4 laser use

Safety Training Requirements: laser

Phase-Contrast X-ray Imaging using an X-ray Source Based on a Laser-Plasma Accelerator

Project Supervisors: (1) Prof. Dino Jaroszynski, (2) Dr Silvia Cipiccia

Project Description:

X-rays are powerful tools used by scientists and industrialists in a wide range of applications. £1b synchrotrons and free-electron lasers (FELs) are the most commonly used x-ray source. They provide brilliant beams of x-ray photons with energies up to several 10's keV energy. They are used by a huge community because they provide the only way to study the structure of matter on small spatial scales, which makes them extremely valuable. At Strathclyde, in the ALPHA-X project, we are investigating new methods of using high power lasers and plasma as brilliant sources of hard x-ray beams. Radiation is emitted when electrons oscillate in the high electrostatic fields of the plasma. These sources could potentially enable synchrotrons and FELs to be placed at universities. An important part of this work is applying the x-ray sources in x-ray imaging. The proposed project will investigate the feasibility of using laser-plasma x-ray sources for imaging.

For weakly absorbing matter, which is the case at high photon energy, the contrast of an image can be very poor. To increase the contrast of an image the real part of the refractive index can be taken advantage of: the x-ray beams are refracted in the object to create an interference pattern which makes otherwise invisible matter visible. The student will investigate x-ray phase contrast imaging both experimentally and theoretically. One goal will be to produce a tomographic imaging.

Key Reference (if applicable): see http://phys.strath.ac.uk/alpha-x, Mangles, et al.

Nature **431**, 535538 (2004), Cipiccia, et al. Nature Physics **7**, 867 (2011).

Ratio of effort: Exp/Theo/Comp	**Exp:**	**40%**
	Theo:	**20%**
	Comp:	**40%**

Suitability: MPhys, BSc, BSc (Phys with Teaching), BSc (Maths Physics)

Additional comments: This is a very challenging project, using experimental, computational and theoretical methods, and will require the student to gain an understanding in plasma physics, acceleration of particles, radiation production and its application in imaging.

Safety Training Requirements: Consult supervisors

Medical Radio-isotope Production using a Laser-Plasma Wakefield Accelerator

Project Supervisors: (1) Prof. Dino Jaroszynski, (2) Dr Silvia Cipiccia/Dr Mark Wiggins

Project Description:

Laser-plasma wakefield accelerators (LWFAs) are very compact laser-drive accelerators that have the potential to replace conventional accelerators in many applications. Reactors are usually used to produce medical radio-isotopes, but their imminent decommissioning is threatening a world-wide shortage. Cyclotrons can be used but these are expensive. This project will explore how a LWFA can be used to produce radio-isotopes.

Positron emission tomography (PET) has been developed around the positron-emitting isotopes of biologically important elements, carbon, oxygen and nitrogen (^{11}C, ^{15}O, and ^{13}N), which enable PET imaging to characterise the biodistributions of a wide range of small molecules. However, the very short half-lives of these radionuclides (20 min for ^{11}C, 2 min for ^{15}O, and 10 min for ^{13}N) preclude their use for the study of prolonged biological processes involving, for example, protein and peptide interactions with their cellular targets. The radio-coppers have attracted considerable attention because they include isotopes which, due to their emission properties, offer themselves as agents of both diagnostic imaging (^{60}Cu, ^{61}Cu, ^{62}Cu and ^{64}Cu) and in vivo targeted radiation therapy (^{64}Cu and ^{67}Cu).

A monoenergetic, high energy electron beam from the ALPHA-X LWFA will be used to demonstrate the production of medical radioisotopes through γ-np photonuclear reactions. High-energy photons will be produced via bremsstrahlung from the LWFA electron beam and a target of natural zinc irradiated with the bremsstrahlung photons to produce the medical isotope ^{62}Cu from ^{64}Zn. The radioisotopes are suitable for chemical separation and subsequent use in medical imaging. With a pulse repetition frequency of 1 Hz, an energy of 130 MeV we expect 5 pC per shot, a peak activity of 18 kBq is measured for ^{62}Cu. Monte Carlo simulations will be used to model the interactions. Favourable scaling towards single patient doses for future high repetition rate LWFAs will be explored.

Ratio of effort: Exp/Theo/Comp	**Exp:**	**25%**
	Theo:	**25%**
	Comp:	**50%**

Suitability: MPhys, BSc, BSc (Phys with Teaching), BSc (Maths Physics)

Radiotherapy using Beams from Laser-plasma Accelerators

Project Supervisors: (1) Professor Dino Jaroszynski, (2) Xue Yang/ Silvia Cipiccia

Project Description:

Gamma rays are the most common form of radiation used in radio-therapy to treat cancer. However, another option exist: particle beams are also very effective forms of treatment. Heavy particles such as protons and carbon ions have the advantage that they deposit their dose in a very localised region in the body and thus can be used to destroy tumours while sparing healthy tissue. Unfortunately, accelerating these heavier particles is very expensive, with costs exceeding £300m for a facility. 20 MeV electrons from radiotherapy accelerators are often used for treating superficial tumours located within a few centimetres of the skin. However, by increasing the energy of the electrons to more than 100 MeV, beams can penetrate the whole body and become an effective form of radiotherapy. In this project we will utilise electron beams from a laser-plasma wakefield accelerator at Strathclyde (part of the ALPHA-X project) to study their therapeutic effect. Very High Energy Electrons (100 MeV – 250 MeV) have the potential of becoming an alternative radiotherapy method for cancer treatment because of their unique dosimetry properties compared with X-ray photons [1]. In this project, the student will be involved in a radiobiology experiment in which the VHEE beams generated from a Laser Wakefield Accelerator are transported and used to irradiate human lung cancer cells placed in a water phantom. The dose deposition measurements will be carried out using gafchromic film and an ion chamber. The electron beam transport and dose deposition in the water phantom will be simulated using numerical tools (e.g. GEANTE4, FLUKA [3-4] etc.).

[1] DesRosiers, C., et al., 150-250 MeV electron beams in radiation therapy. Physics in Medicine and Biology, 2000. 45(7): p. 1781-1805.

[2] A Subiel et al *Dosimetry of very high energy electrons (VHEE) for radiotherapy applications: using radiochromic film measurements and Monte Carlo simulations* Phys. Med. Biol. 59 5811 (2014) doi:10.1088/0031-9155/59/19/5811

[2]http://phys.strath.ac.uk/alpha-x

[3]Ferrari, A., et al., FLUKA: a multi-particle transport code. CERN 2005-10, INFN/TC_05/11, SLAC-R-773, 2005

[4]FLUKA. http://www.fluka.org/fluka.php

Ratio of Experiment/Theory/Computation: **Exp: 70 %**
Theo: 10 %
Comp: 20 %

Suitable for: MPhys, BSc

Safety Training Requirements: Contact the project Supervisor for further advice

Induced Relativistic Optical Transparency in Intense Laser-Solid Interactions

Project Supervisors: (1): Prof. Paul McKenna, (2) Dr Ross Gray

Project Description:

By focusing petawatt-scale pulses of laser light to intensities exceeding 10^{20} Wcm^{-2}, novel states of matter are created, involving highly relativistic plasma. The propagation of light in such plasma results in nonlinear effects analogous to those studied with conventional nonlinear optics, including for example self-focusing, self-modulation and harmonic generation. Laser light cannot normally propagate above a critical density at which the oscillating plasma frequency is equal to the laser frequency. However, at ultra-high intensities the quiver motion of the electrons in the laser field becomes relativistic and electron mass is increased by the Lorentz factor, γ. As a consequence of the increased relativistic inertia of the electrons the plasma frequency changes, increasing the critical density, leading to induced relativistic optical transparency, so that light can propagate through what would otherwise be over-dense or opaque plasma.

The objective of this project is to investigate the onset of relativistic optical transparency in dense plasmas irradiated by ultra-intense laser pulses. This involves simulating the response of the plasma electrons and ions to the fields created at the focus of the laser pulse, using a particle-in-cell code running on a high performance computer.

Ratio of effort: Exp/Theo/Comp	**Exp:**	**%**
	Theo:	**20%**
	Comp:	**80%**

Suitability: BSc, BSc (Phys with Teaching), BSc (Maths Physics)

Design Study on Plasma Optics

Project Supervisors: (1) Prof. Paul McKenna, (2): Dr Ross Gray

Project Description:

The conventional approach to focusing light, based on the use of solid state optical media, has not fundamentally changed over the centuries, but is rapidly becoming a key limiting factor for the further development of ultraintense laser science. The main reason for this is that there is a limit to the energy density which solid state optical media can withstand before it is damaged. The traditional way to circumvent this is to increase the size of the focusing optic as the laser energy is increased, so that the overall energy density is below the critical value. However, the optics used on the highest power lasers are now more than a meter in diameter and are very expensive. Radical new approaches are required for the production of compact high intensity laser drivers for application.

The project aims to explore the feasibility of developing new types of optical systems based on ultrafast plasma processes –*plasma optics*. Due to their ability to sustain extremely large amplitude electromagnetic fields, plasma optical components are inherently compact, and the ultrafast evolution of the optical properties of laser-excited plasma enables other properties of the laser pulse to be tailored. The project involves designing new plasma optical components using optical design programmes and plasma simulation codes.

Ratio of effort: Exp/Theo/Comp	**Exp:**	**%**
	Theo:	**20 %**
	Comp:	**80 %**

Suitability: BSc, BSc (Phys with Teaching), BSc (Maths Physics)

Modelling Laser-driven Plasma Expansion and Ion Acceleration Dynamics

Project Supervisors: (1) Prof. Paul McKenna, (2) Dr. Ross Gray

Project Description:

The interaction of intense laser pulses with matter is opening up new frontiers in physics via the production of extreme pressures, temperatures and intense electric and magnetic fields. This is leading to the use of high power laser radiation for exploring the properties of hot dense matter, the production of high energy particles and radiation, and the development of schemes to generate energy by inertial confinement fusion. The possibility of using high power lasers to generate high-quality beams of energetic ions is attracting global interest. In particular, laser-based ion acceleration schemes may lead to compact and relatively low-cost sources which can be used in science, medicine and industry.

The project involves modelling the acceleration of ions in electrostatic fields formed on the surface of thin foil solid targets which are irradiated by ultra-intense laser pulses. Specifically, it involves writing a code using Matlab to model the dynamics of the evolving electrostatic field and how that maps into the spatial-intensity profile of the beam of ions accelerated. The code will be applied to analysis existing experimental data obtained using a number of high power laser facilities. It will provide the student with a background in the physics of high power laser-based sources of ions, diagnostic techniques and in simulation and modelling.

Key Reference:

Ratio of effort: Exp/Theo/Comp	**Exp:**	**0%**
	Theo:	**20%**
	Comp:	**80%**

Suitability: BSc, BSc Maths and Physics, BSc Physics with Teaching

Additional comments:

Safety Training Requirements:

Numerical Simulation of Laser Interaction with Dense Magnetized Plasma

Project Supervisors: (1) Prof. Zheng-Ming Sheng, (2) Prof. Paul McKenna

Project Description:

Plasma as the fourth state of matter is pervasive in space, laboratory, and also in our life. It is formed when bounded electrons are released from atoms (such as by the high electric fields of a laser pulse) to become free electrons so that the system is made of free electrons and ions. The plasma as a medium exhibits distinct electric and magnetic properties, different from those in normal gas and solid targets. Recently with the development of chirped pulse amplification (CPA) technology, one can produce ultrashort and high intensity laser pulses. Such laser pulses can find wide applications including charged particle acceleration, high power X-ray radiation, advanced laser fusion, and the creation of high energy density matter etc.

In intense laser solid interaction, it is found that free electrons at the solid surface can be driven into oscillation with relativistic high speeds by the incident laser pulse. As a result, high harmonics of the laser pulse will be produced. In the meanwhile, some quasi-static magnetic fields up to 100MG will be produced around the solid surface. Such magnetic field cannot be measured directly. But this magnetic field may change the high harmonics generation, which may provide an indirect measurement of the magnetic field. The aim of this project is to investigate how the magnetic field at the solid surface can change the spectrum and efficiency of high harmonics generation.

Key Reference:

1. R. Lichters, J. Meyer-ter-Vehn, & A. Pukhov, Phys. Plasmas 3, 3425 (1996).
2. H.-C. Wu, Z.-M. Sheng et al., Phys. Rev. E 75, 016407 (2007).
3. U. Wagner et al., Phys. Rev. E 70, 026401 (2004).
4. M. Tatarakis et al., Nature (London) 398, 489 (2002).

Ratio of effort: Exp/Theo/Comp	**Exp:**	**0%**
	Theo:	**30%**
	Comp:	**70%**

Suitability: MPhys, BSc, BSc Maths and Physics, BSc Physics with Teaching

Additional comments: For different degree levels, the project will be carried out at different depths such as one-dimensional model, two-dimensional model, for laser pulses at different laser intensities, etc.

Safety Training Requirements: No

Theoretical and Numerical Studies of Laser Pulse Compression in Underdense Plasma

Project Supervisors: (1) Prof. Zheng-Ming Sheng, (2) Prof. Dino Jaroszynski

Project Description:

Plasma as the fourth state of matter is pervasive in space, laboratory, and also in our life. It is formed when bounded electrons are released from atoms (such as by high electric fields of a laser pulse) to become free electrons so that the system is made of free electrons and ions. The plasma as a medium exhibits distinct electric and magnetic properties, different from those in normal gas and solid targets. Recently with the development of chirped pulse amplification (CPA) technology, one can produce ultrashort and high intensity laser pulses. Such laser pulses can find wide applications including charged particle acceleration, high power X-ray radiation, advanced laser fusion, and the creation of high energy density matter etc.

Currently, typical high power laser pulse duration is about 40-50fs. For some applications, one needs to the laser pulse duration can be further reduced to less than 30fs. It is found that the plasma as a nonlinear medium can be used to compress the high intensity laser pulse. The main task of this project is to find suitable plasma parameters to compress the laser pulse duration.

Key Reference:

1. H. Y. Wang et al., Phys. Rev. Lett. 107, 265002 (2011).

2. O. Shorokhov et al., Phys. Rev. Lett. 91, 265002 (2003).

3. Z. M. Sheng et al., Phys. Rev. E 62, 7258 (2000).

Ratio of effort: Exp/Theo/Comp	**Exp:**	**0%**
	Theo:	**30%**
	Comp:	**70%**

Suitability: MPhys, BSc, BSc Maths and Physics, BSc Physics with Teaching

Additional comments: For different degree levels, the project will be carried out at different depths such as one-dimensional model, two-dimensional model, for laser pulses at different laser intensities, etc.

Safety Training Requirements: No

Nonlinear Propagation of Extreme Intense Laser Beams in Plasma

Project Supervisors: (1) Prof. Zheng-Ming Sheng, (2) TBC

Project Description:
Plasma as the fourth state of matter is pervasive in space, laboratory, and also in our life. It is formed when bounded electrons are released from atoms (such as by high electric fields of a laser pulse) to become free electrons so that the system is made of free electrons and ions. The plasma as a medium exhibits distinct electric and magnetic properties, different from those in normal gas and solid targets. Recently with the development of chirped pulse amplification (CPA) technology, one can produce ultrashort and high intensity laser pulses. Such laser pulses can find wide applications including charged particle acceleration, high power X-ray radiation, advanced laser fusion, and the creation of high energy density matter etc.

Currently, the Extreme Light Infrastructure (ELI) is under construction in Europe (http://www.eli-laser.eu/). Future ELI laser beams may reach peak power of 10-100PW (1PW=10^15 W). For a number of applications, it is interesting and necessary to investigate how such laser beams propagate in plasma. It is expected that nonlinear effects such as the relativistic electron motion and ponderomotive force play key roles for the laser propagation. In some cases, even the radiation reaction can play a role. The main task of this project is to investigate theoretically and numerically how such lasers will propagate based upon the envelop equation for laser beam derived with the paraxial approximation.

Key References:

1. W.-M. Wang, Z.-M. Sheng et al., Appl. Phys. Lett. 101, 184104 (2012).
2. Z.-M. Sheng et al., Phys. Rev. E 64, 066409 (2001).
3. M. Chen et al., Plasma Phys. Control. Fusion 53, 014004 (2011).

Ratio of effort: Exp/Theo/Comp

Exp:	**0%**
Theo:	**20%**
Comp:	**80%**

Suitability: MPhys

Additional comments: I have a model and code developed. The student is required to extend this work. It is preferable that the student is interested in programming.

Safety Training Requirements: No

Beam-driven Plasma Wakefield Acceleration (PWFA)

Project Supervisors: (1) Prof. Bernhard Hidding, (2) Prof. Dino Jaroszynski

Project Description:

Electron beams can drive plasma waves for generation and acceleration of highest brightness electron beams, which is strongly desired for advanced free-electron lasers. Suitable electron beam drivers can be produced by conventional accelerators such as SLAC as well as by laser wakefield acceleration. PWFA is a highly trending field and will be studied in by means of particle-in-cell simulations as well as in experiments in which the electron bunch output from laser-plasma-accelerators in Strathclyde will be used for the first time for PWFA. One special additional feature is the development of the underdense photocathode (aka Trojan horse) concept [1-2].

Key Reference (if applicable): [1] B. Hidding, G. Pretzler, J.B. Rosenzweig, T. Königstein, D. Schiller, D.L. Bruhwiler, *Ultracold Electron Bunch Generation via Plasma Photocathode Emission and Acceleration in a Beam-driven Plasma Blowout*, Physical Review Letters 108, 035001, 2012 (4 pages) [2] *Hybrid modeling of relativistic underdense plasma photocathode injectors*

Y. Xi, B. Hidding, D. Bruhwiler, G. Pretzler, and J. B. Rosenzweig, PRSTAB 16, Issue 3, 031303 (2013)

Ratio of effort: Exp/Theo/Comp	**Exp:**	**40%**
	Theo:	**20%**
	Comp:	**40%**

Suitability: MPhys, BSc, BSc (Phys with Teaching), BSc (Maths Physics)

Additional comments: Knowledge in laser and plasma and accelerator physics is helpful but not mandatory. Anyone interested in taking up this project should contact the supervisors beforehand.

Safety Training Requirements: Contact the project supervisor for further advice

Excitation of Heavy Atomic Species for ITER

Project Supervisors: (1) Prof. Nigel Badnell, (2) Prof. Bob Bingham (tbc)

Project Description:

The development of the ITER device for magnetic fusion requires the use of much heavier elements (Kr, Xe, W etc) than have traditionally been used, such as at the JET device.

Consequently, spectroscopic diagnostic modelling at ITER, which is already being simulated, requires atomic data where relativistic effects are likely much larger than have been seen before. The goal of the project is to assess the degree of importance of relativistic effects of relevance to ITER diagnostics. This will entail computational calculations of atomic data with varying degrees of treatments of relativistic effects viz. non-relativistic vs relativistic wavefunctions, the importance of the Breit interaction and the validity of its Pauli approximation at `low'-charge.

Key Reference (if applicable): http://www.iter.org/

Ratio of Experiment/Theory/Computation: **Exp: 0 %** **Theo: 30 %** **Comp: 70 %**

Suitable for: MPhys

Additional Comments: Familiarity with Unix (e.g. Linux) working environment and good computing skills in general.

Safety Training Requirements:

Stochastic Particle Heating of Charged Particles by Plasma Waves

Project Supervisors: (1) Dr Bengt Eliasson, (2) Dr Kevin Ronald

Project Description:

Plasmas are ubiquitous in space and laboratory. The Earth is surrounded by a plasma layer, the so-called ionosphere, which shields us from radiation and energetic particles from the sun, and in the laboratory, plasmas are artificially created and studied with application to magnetic confinement fusion and basic research. A plasma is an ionised gas in which there are free electrons and ions so that the gas is electrically conducting. The Earth's ionosphere is magnetized by the geomagnetic field, and in the laboratory, an external magnetic field is used to confine the plasma and prevent it from escaping to the walls. The acceleration of charged particles by electromagnetic waves can lead to chaotic motion of the particles and a rapid heating of the magnetised plasma due to the complicated motion of the particles. This is important for heating of particles in the laboratory, in magnetic confinement fusion devices, in the solar corona, in the Earth's ionosphere, etc., where collisions between particles are relatively rare. Stochastic heating is therefore different from Ohmic heating which is due to collisions between particles.

The project involves at building a numerical model for stochastic heating of charged particles (electrons and/or ions) in magnetized plasmas by using test-particle simulations, and to use the numerical model to study some different cases where stochastic heating takes place. A theoretical derivation and understanding of the mathematical models is also part of the project.

Key Reference: J. M. McChesney, R. A. Stern, and P. M. Bellan (1987) Observation of fast stochastic ion heating by drift waves, Phys. Rev. Lett. 59, 1436-1439.

Ratio of effort: Exp/Theo/Comp	**Exp:**	**0%**
	Theo:	**50%**
	Comp:	**50%**

Suitability: MPhys, BSc, BSc Maths and Physics

Additional comments: Experience in simulations using Matlab (or any other programming language) and good theoretical skills are beneficial.

Safety Training Requirements:

Numerical Modelling and Design of a High Power Magnetron

Project Supervisors: (1) Dr Alan Young, (2) Prof. Adrian Cross

Project Description:

Magnetrons are one of the most efficient and widely used high power microwave sources in existence today. Reliable magnetron operation is one of the main reasons for their use in numerous applications such as marine radar, radio frequency (RF) acceleration in medical LINACS for radiotherapy treatment of cancer, microwave processing and heating of materials.

The theory and design of a high power magnetron used in a medical LINAC will be studied. Numerical modelling of the magnetron will be carried out using CST Particle Studio. As the formation of a rotating electron space charge limited beam occurs in the same physical space as the RF interaction region the full capability of an advanced computer graphics processing unit will be used to carry out the simulations. The goal of the project will be to develop a numerical model that can be used to predict the output power and efficiency of the magnetron as compared to its existing experimental data.

Key References:

[1] A.F. Harvey, "Microwave Engineering", Academic Press, London and New York, 1963.

Ratio of effort: Exp/Theo/Comp

Exp:	**0%**
Theo:	**40%**
Comp:	**60%**

Suitability: BSc, BSc Maths and Physics

Additional comments:

Safety Training Requirements: High voltages will **not** be used and X-ray emission will **not** be generated during this project.

Design of a Brewster Window for a W-band Gyro-TWA

Project Supervisors: (1) Dr Liang Zhang, (2) Prof. Adrian Cross

Project Description:

A W-band gyrotron-travelling wave amplifier (gyro-TWA) based on a helically corrugated waveguide and a cusp electron gun is currently being studied. It is predicted to achieve an output power of 5 kW over a wide frequency band of 90 - 100 GHz. For an amplifier the microwave window, which separates the high vacuum side from the atmospheric pressure outside must couple in or out the microwave power with minimum absorption or reflection, and is one of the critical components for the successful operation of the gyro-TWA.

In this project, a Brewster-type microwave window will be studied using analytical theory. Numerical simulations Brewster-type microwave window will be carried out using CST Microwave Studio. A corrugated waveguide that maintains the Gaussian-like HE mode required for the Brewster window will also be designed and simulated. The design goals of the Brewster window are 10% bandwidth at a centre frequency of 95 GHz, small insertion loss and a reflection of less than -20 dB for the operating band. If the design meets the requirement, the Brewster window will be manufactured and measured using a Vector Network Analyser (VNA).

Key References:

[1] Wenlong He, Craig R. Donaldson, Liang Zhang, Kevin Ronald, Paul McElhinney and Adrian W. Cross, "High Power Wideband Gyrotron Backward Wave Oscillator Operating towards the Terahertz Region", Physical Review Letters, 110(16):165101, 04, 2013.

[2] Paul McElhinney, Craig R. Donaldson, Liang Zhang and Wenlong He, "A High Directivity Broadband Corrugated Horn for W-band Gyro-devices", IEEE Transactions on Antennas and Propagation, vol. 61, no. 3, pp. 1453-1456, 2013.

Ratio of effort: Exp/Theo/Comp	**Exp:**	**20%**
	Theo:	**30%**
	Comp:	**50%**

Suitability: MPhys, BSc, BSc Maths and Physics

Additional comments:

Safety Training Requirements: High voltages will **not** be used and X-ray emission will **not** be generated during this project although a risk assessment will need to be completed in semester 1.

Monte Carlo Simulation and Cooling Performance of the MICE Step V Laboratory Experiment.

Project Supervisors: (1) Dr David Speirs, (2) Dr Kevin Ronald

Project Description:

A Neutrino Factory based on a muon storage ring represents the ultimate tool for the study of neutrino oscillations, including the potential discovery of leptonic CP violation. It is also the first step towards the construction of a $\mu^+\mu^-$ collider. Ionisation cooling of muons can make a significant contribution to both the performance (up to a factor of 10 in neutrino intensity) and cost (as much as 20%) of a Neutrino Factory. This potential benefit has motivated the undertaking and construction of the Muon Ionisation Cooling Experiment (MICE), a significant undertaking that has various key stages in its physical implementation. There are various potential lattice configurations currently under consideration for MICE Step V – the final operating configuration for the experiment. Simulating and evaluating these potential configurations is currently a critical activity in order to implement a successful MICE Step V experiment. The aim of this project is therefore to conduct a variety of simulations using the MICE Analysis User Software (MAUS), a Monte Carlo Simulation Tool which predicts the trajectories of the muons through a complex system of magnetic fields, solid beamline objects and accelerating cavities, to determine and evaluate the most suitable Step V lattice configurations and operating conditions, and to define the performance requirements of key detectors to ensure a successful MICE experiment and first practical demonstration of ionisation cooling.

Key Reference: Adams D. et al, 2013, 'Characterisation of the muon beams for the Muon Ionisation Cooling Experiment' Euro. Phys. J. C, **73,** art. 2582

Ratio of effort: Exp/Theo/Comp	**Exp:**	**0%**
	Theo:	**30%**
	Comp:	**70%**

Suitability: MPhys, BSc, BSc Maths and Physics, BSc Physics with Teaching

Additional comments:

Safety Training Requirements:

High-Power Microwave Sources

Project Supervisors: (1) Dr Phil MacInnes, (2) Dr Kevin Ronald

Project Description:

High-power microwave sources, developed for a range of applications, are of significant interest, both in industry and the academia, with new sources showing increases in achievable output frequency and power capacity. In particular this project will investigate sources based on free electron physics whereby the kinetic energy in an electron beam provides the free energy to excite a powerful electromagnetic wave.

The aim of this project is to perform a design study, investigating the current state of the art of a particular class of high power microwave source. This would involve understanding the theoretical principles underpinning the operation of the source(s) and include a review of published results. Numerical simulation, both of the passive components and the active device, will be used to evaluate the potential output power, operating frequency, bandwidth and the dependence of these performance characteristics on the adjustment of various control parameters in a given design.

Over the course of the project the student will have the opportunity to gain experience working with a range of numerical-simulation codes and their applicability to different stages in source design. The student will also have the opportunity to develop skills working with the numerical solver package MatLab – some pre-existing experience with MatLab would be beneficial but is not required. Similarly there is access to Maple / Excel etc.

It is unlikely that the project will include experimental work. However, should promising results arise from the simulations early on, there is some scope for manufacture and passive testing of parts. In this case the experimental component would be unlikely to exceed 10% of the total work.

Ratio of effort: Exp/Theo/Comp	**Exp:**	**0%**
	Theo:	**30-40%**
	Comp:	**60-70%**

Suitability: MPhys, BSc, BSc Maths and Physics, BSc Physics with Teaching

Additional comments:

Safety Training Requirements:

Design and Measurement of a Mode Converter for a Microwave Amplifier

Project Supervisors: (1) Dr Wenlong He, (2) Dr Craig Donaldson

Project Description:

A microwave amplifier in the form of a gyrotron traveling wave amplifier is being studied at the University of Strathclyde. The amplifier uses the interaction between a rotating electron beam and a low power microwave signal to amplify the microwaves to high power over a wide bandwidth. In order to have the correct interaction a low power microwave signal needs to go through a mode converter to change from a $TE_{1,1}$ mode to a $TE_{3,1}$ mode.

In this project, a mode converter will be studied using analytical theory. Numerical simulations will be carried out using CST Microwave Studio. This converter is a four-fold helical corrugated waveguide. Initially this will be studied and measured using a vector network analyser (VNA), at X-band frequencies ~9 GHz.

In year 2 of the project the converter will be scaled down in size to operate at a much higher frequency in the W-band, at ~ 94 GHz. In both applications the converter will have to operate over the amplifiers bandwidth range of 10GHz and have a high conversion efficiency whilst maintaining a low reflection coefficient.

Key Reference: He W., Donaldson C.R, Zhang L., Ronald K., McElhinney P., and Cross A.W., "High power wideband gyrotron backward wave oscillator towards the terahertz region", Phys. Rev. Letts, 110, art 165101, (2013).

Ratio of effort: Exp/Theo/Comp	**Exp:**	**25%**
	Theo:	**25%**
	Comp:	**50%**

Suitability: MPhys

Additional comments:

Safety Training Requirements: High voltages and X-ray emission will **not** be required for this project although a risk assessment will need to be completed in semester 1.

Institute of Photonics

Neurophotonic Systems for Interfacing with the Retina

Project Supervisor (1) Dr Keith Mathieson, (2) Dr Niall McAlinden

Project Description

Optical coherence tomography (OCT) [1] is an interferometric technique that detects backscattered photons that are then used to create a 3D image of neural tissue, such as the retina. It has become commonplace in ophthalmology clinics where it is used to diagnose diseases of the retina. However, many diseases affect the functional (electrical signalling) behaviour of the retina and leave the structure unaffected. There is some evidence that optical techniques can be used to measure this loss of function [2]. During this project the student will be able to work on an OCT system that has been combined with electrophysiological recording equipment that monitors the electrical behaviour of the retinal output cells. The analysis of these OCT images and subsequent correlation with the electrical recordings will be able to show whether OCT techniques have the sensitivity required to measure the small refractive index changes that occur during neural signalling in the retina. The project will require analysis of large datasets and experience with programming would be an advantage.

Key Reference (if applicable):

[1] "Cellular and Functional Optical Coherence Tomography of the Human Retina", W. Drexler, DOI:10.1167/iovs.07-0895 Investigative Ophthalmology & Visual Science, **48**, 12 (2007)

[2] "In vivo imaging of intrinsic optical signals in chicken retina with functional optical coherence tomography" Moayed et al., *Optics Letters* **36**, 23 (2011**)**

Ratio of effort: Exp/Theo/Comp

Exp: 40%
Theo: 10%
Comp: 50%

Suitability: MPhys, BSc

Additional comments:

Safety Training Requirements: Laser Safety Training

Photonic Materials and Devices for Visible Light Communication (VLC)

Project Supervisors: (1) Dr Benoit Guilhabert, (2) Dr Nicolas Laurand

Project Description:

As part of the research programme "Ultra-parallel Visible Light Communications" led by the Institute of Photonics, light-emitting diodes (LEDs) are modulated in intensity at high frequencies to create data links using visible light.[1] There are basically two possible embodiments for VLC: white, single-colour and multi-colour light can be utilised (i) for free-space communications and (ii) for waveguide systems (e.g. optical fibres). The focus of our team is on the development of photonic materials and novel device formats for these applications.

The project proposes to combine blue InGaN LEDs with 'fast' colour converters (namely organic semiconductors, colloidal quantum dots and quantum-well membranes) to explore hybrid sources for VLC links. A particular focus for the student will be the study of colour conversion efficiency and the coupling of hybrid sources to plastic optical fibres.

Key Reference:

[1] J.J.D. McKendry *et al*, High-speed visible light communications using individual pixels in a micro light-emitting diode array, IEEE Photon, Tech. Lett., 22 (2010)

Ratio of effort: Exp/Theo/Comp	**Exp:**	**50 %**
	Theo:	**20 %**
	Comp:	**30 %**

Suitability: MPhys, BSc, BSc Maths and Physics, BSc Physics with Teaching

Additional comments:

Safety Training Requirements: YES "Working with high power laser sources and light-emitting diodes" + Specific risk assessment

Modelling Non-linear Processes in Micro-waveguides

Project Supervisor (1) Dr Michael Strain, (2) Dr Nicolas Laurand

Project Description

Waveguides with sub-micron cross-sectional dimensions have proven extremely successful in non-linear optical applications. By using materials with high refractive index, such as silicon, light can be confined into ultra-small volumes, producing extremely high local field intensities. If these materials also exhibit an optical non-linearity, i.e. their susceptibility\refractive index is a function of the strength of the optical field, then a wide array of devices can be designed. For example, ultra-fast photonic switches can be created that are triggered using optical pulses (i.e. without the need for electronics) with potential applications in optical signal processing. Non-linear processes can also create new wavelengths of light in a device, for example allowing a signal input at λ_1 to be broadcast on a wide range of new wavelengths, simply by propagating through a non-linear device. Finally, these devices can take a single laser wavelength input and, through self-phase modulation, generate a supercontinuum of light.

The effects of dispersion in non-linear waveguides are critical in the design of these devices. The refractive index as a function wavelength of nanowire waveguides exhibits a strong dependence on the waveguide geometry. The dispersion induced by the waveguide in turn induces variation in the non-linear optical processes in the waveguide. In order to achieve efficient operation, a balance must be achieved between increasing the field intensity by reducing the waveguide cross sectional area and finding the optimal waveguide dispersion regime.

In this project the student will use numerical tools to model the dispersive behaviour of nanowire waveguides in a variety of materials. This analysis will then underpin further calculation of the non-linear effects in nanowire waveguides, with particular reference to self-phase modulation and four wave mixing processes. The student will write customised simulation codes to probe the behaviour of these waveguides and compare their results with experimental demonstrations.

Key Reference (if applicable):

1. Q. Lin, O. J. Painter, and G. P. Agrawal, "Nonlinear optical phenomena in silicon waveguides: modeling and applications.," Opt. Express, vol. 15, no. 25, pp. 16604–44, Dec. 2007.
2. J. Leuthold, C. Koos, & W. Freude, *"Nonlinear silicon photonics,"* Nature Photonics, 4(8), 535–544, 2010.
3. A.C. Turner, M.A. Foster, A.L. Gaeta, M. Lipson, *"Ultra-low power parametric frequency conversion in a silicon microring resonator,"* Optics express, 16, (7), p. 4881-7, 2008.

Ratio of effort: Exp/Theo/Comp	**Exp:**	**0%**
	Theo:	**50%**
	Comp:	**50%**

Suitability: MPhys, BSc

Additional comments: Some previous experience of Matlab would be beneficial but not essential.

Safety Training Requirements: NA

Allocated Projects (Fifth Year students)

Project Name	*Supervisors*	*Student Name*
Atomic Processes for Astrophysical Plasmas	Nigel Badnell, Luis Menchero	Gavriil Chatzitheodoridis
Spectroscopic Studies of Pheomelanin: Spectra, Kinetics, Modulators	Jens Sutter, David Birch	Junaid Ahmad
Exotic quantum operations with light	John Jeffers, Daniel Oi	Liviu Chirondojan
Optical Properties of Nanoparticles	Yu Chen, Olaf Rolinski	Chloe Chung
Highly efficient frequency up-conversion in Rb vapour	Aidan Arnold, Erling Riis	Craig Colquhoun
The theory of X-ray Free electron Lasers	Brian McNeil, Gordon Robb	Sean Davies
Holographic Atom Traps	Stefan Kuhr, Elmar Haller	Charelle Dunbar-Dawe
Effects of electron irradiation on photoluminescence spectra of thin film Cu(InGa)Se2	Rob Martin, Michael Yakushev	Rachel Elvin
Electroluminescence spectroscopy and electrical characterisation of light-emitting diodes	Rob Martin, Paul Edwards	Catherine Freeke
Radiotherapy using Beams from Laser-plasma Accelerators	Dino Jaroszynski, Silvia Cipiccia	Gregor Garbutt
BEC-light interactions	Gordon Robb, Gian-Luca Oppo	Kristofer Gray
Optical forces on nanoparticles	Ben Hourahine, Francesco Papooff, Gordon Robb	Robert Harris
Simulation of electromagnetic waves in magnetized plasmas	Bengt Eliasson, Kevin Ronald, David Speirs	Timothy Heelis
The Physics of DNA	Neil Hunt, Katrin Adamczyk, Glenn Burley	Stephen Howorth
Luminescence Hysteresis	Kevin O'Donnell, Paul Edwards	Matthew Lebessis
Laser-Wakefield Plasma Accelerated electron optimization for Very High Energy Electron (VHEE) cancer treatment	Dino Jaroszynski, Silvia Cipiccia	Alexander MacDonald
Radiation Reaction	Dino Jaroszynski, Adam Noble	Alexander MacLeod
High energy ion acceleration in intense laser-plasma interactions	Paul McKenna, Ross Gray	John McCreadie
Eu-doped GaN	Kevin O'Donnell, Rob Martin	Ivan Morgan
Capillary Discharge Waveguides for Laser-Plasma Interactions	Dino Jaroszynski, Mark Wiggins	Lewis Reid
The scientific applications of X-ray Free Electron Lasers	Brian McNeil, Gordon Robb	James Simpson
Optical Second Harmonic Generation in Urea	Tom Han, Nigel Langford	Neil Stevenson
Nanoparticle Metrology	David Birch, Jens Sutter	Hazel Stewart
Testing for gravitational coupling to Entropy	Nick Lockerbie, Tom Han	Peter Tinning

Appendices

Safety induction training record for Undergraduate students undertaking project work

This form **MUST** be completed by student and supervisor and returned **before** student enters a laboratory and by 28th November 2014 at the **latest.**

1) I have read and understood the '*Local rules for the Safe Use of Lasers*' (available from https://moss.strath.ac.uk/physics/Safety/Laser%20Information/Local%20Rules/130222_LocalRulesLaserSafety_Append.doc) ❑

N/A ❑

Others: ………………………………………………………………………

…………………………………………………………………………………

2) I have attended the following safety training lectures:

Physics Laser Safety ❑ **N/A** ❑

Others: ……………………………………………………………………..

…………………………………………………………………………………

3) I have received an induction in the use of the local safety systems and access controls in rooms:

…………………………………………………………………………………

4) I have received an induction in operating the following devices and/or instrumentation (e.g. laser)

………………………………………………………………………………..

………………………………………………………………………………..

5) I received an induction in the following techniques:
Laser beam alignment procedures ❑ **N/A** ❑

Others: ………………………………………………………………………

………………………………………………………………………

Signature of student: .... Date: ....

Name (print): ....

Signature of supervisor: .... Date: ....

Name (print) ....

Please return this completed form to Students Office, JA 8.31

Project allocation request form 2014/15

(To be returned by the student to Students Office JA 8.31 by 4pm 03/10/14)

Student Name: **Student Number:**

Project title:		
Supervisor’s signature: **Supervisor’s name:**		**This project has been discussed by us, and we have agreed that it is appropriate for the student to undertake the work.**
Student’s signature:		
Preference:		**For student to choose on completion of the form**

Project title:		
Supervisor’s signature: **Supervisor’s name:**		**This project has been discussed by us, and we have agreed that it is appropriate for the student to undertake the work.**
Student’s signature:		
Preference:		**For student to choose on completion of the form**

Project title:		
Supervisor’s signature: **Supervisor’s name:**		**This project has been discussed by us, and we have agreed that it is appropriate for the student to undertake the work.**
Student’s signature:		
Preference:		**For student to choose on completion of the form**

Note: where several allocation request forms are submitted for the same project, I will choose the successful student by lot.

Projects allocated will be announced by Timothy Briggs on Wednesday the 8th October 2014 – *Kevin O'Donnell*

Project Timetables

PH450

Taken in 4th year by MPhys and BSc Physics.
Optional for BSc Physics with Teaching and BSc Mathematics and Physics students

22nd September 2014 Project booklet to students

Students will receive project handbook with project request page.

22nd September –3rd October 2014 Students choose projects

Students should visit supervisors and draw up a shortlist of 3 potential projects in order of preference from 1 to 3. Each project request must be signed and dated by both the student and the supervisor and submitted to the student office, JA8.31.

4pm 3rd October 2014 Deadline for submission of Project choice form to JA8.31

8th October 2014 Official start of Projects

Project allocations announced at 12 noon through Myplace. Students who have been unsuccessful in getting their choice of project will receive an updated booklet for a second round.

27th October 2014 Literature review complete

Students submit literature survey and a risk assessment for project. The literature review will usually take the form of the Final Report's introductory chapter.

28th November 2014 Completed safety form to be returned to JA 8.31 by this date

30th January 2015 Progress report with aims of project to be returned by students to JA 8.31 by this date

25th March & 1st April 2015 Project Talks 1-5 pm in parallel Sessions

Each student will be given a 15-minute slot. The expectation is that students will talk about their project for 10 minutes and then be questioned by the audience for 5 minutes.

20th April 2015 Project reports submitted

Project reports to be submitted as Word or PDF format through MyPlace and then passed through Turnitin for plagiarism detection.

In preparing the report, please be aware that supervisors can advise on up to 10 pages of material, to help with the style of writing and content, but not to correct physics.

Week beginning 5th May 2015 Viva week

Each viva will be about 35 minutes long, with 5 minutes for the student to outline their project work and 30 minutes of questions about project content.

Project Information for Continuing 5th Year Students

PH 550

Taken in 5th year by MPhys Physics students. The expectation is that students will continue with the project started in 4th year.

Week beginning 30th September Meeting with supervisor during Week 1

Projects should be underway by 8th October

7th November 2014 Progress report to be returned by students to JA 8.31 by this date

10th December 2014 Project Talks 1-5 pm in parallel sessions

Each student will be given a 15-minute slot. The expectation is that students will talk about their project for 10 minutes and then be questioned by the audience for 5 minutes.

23rd January 2015 Project papers submitted

Project papers to be submitted as PDF format through MyPlace and then passed through Turnitin for plagiarism detection.

Week beginning 2nd February 2015 Vivas

Each viva will be about 35 minutes long, with 5 minutes for the student to outline their project work and 30 minutes of questions about project content.

Plagiarism

Plagiarism most commonly involves the passing off of another person's work as your own and is regarded as a form of academic dishonesty. Plagiarism more often than not involves the copying of another person's work, be it a figure, text, experimental data or homework for example and not acknowledging the source of the work. Plagiarism can be avoided by suitable referencing.

For more details on plagiarism please see the University Handbook and follow this link http://www.strath.ac.uk/media/ps/cs/gmap/plagiarism/plagiarism_student_booklet.pdf for guidelines on plagiarism. If you are unsure of any aspect of this, please contact the department. The department will make extensive use of software capable of detecting plagiarism. The Department will use the anti-plagiarism software Turnitin (https://turnitin.com/static/index.php) to check for plagiarism. Any student caught plagiarising another person's work may be reported to the University Disciplinary committee.

Index of Project Titles