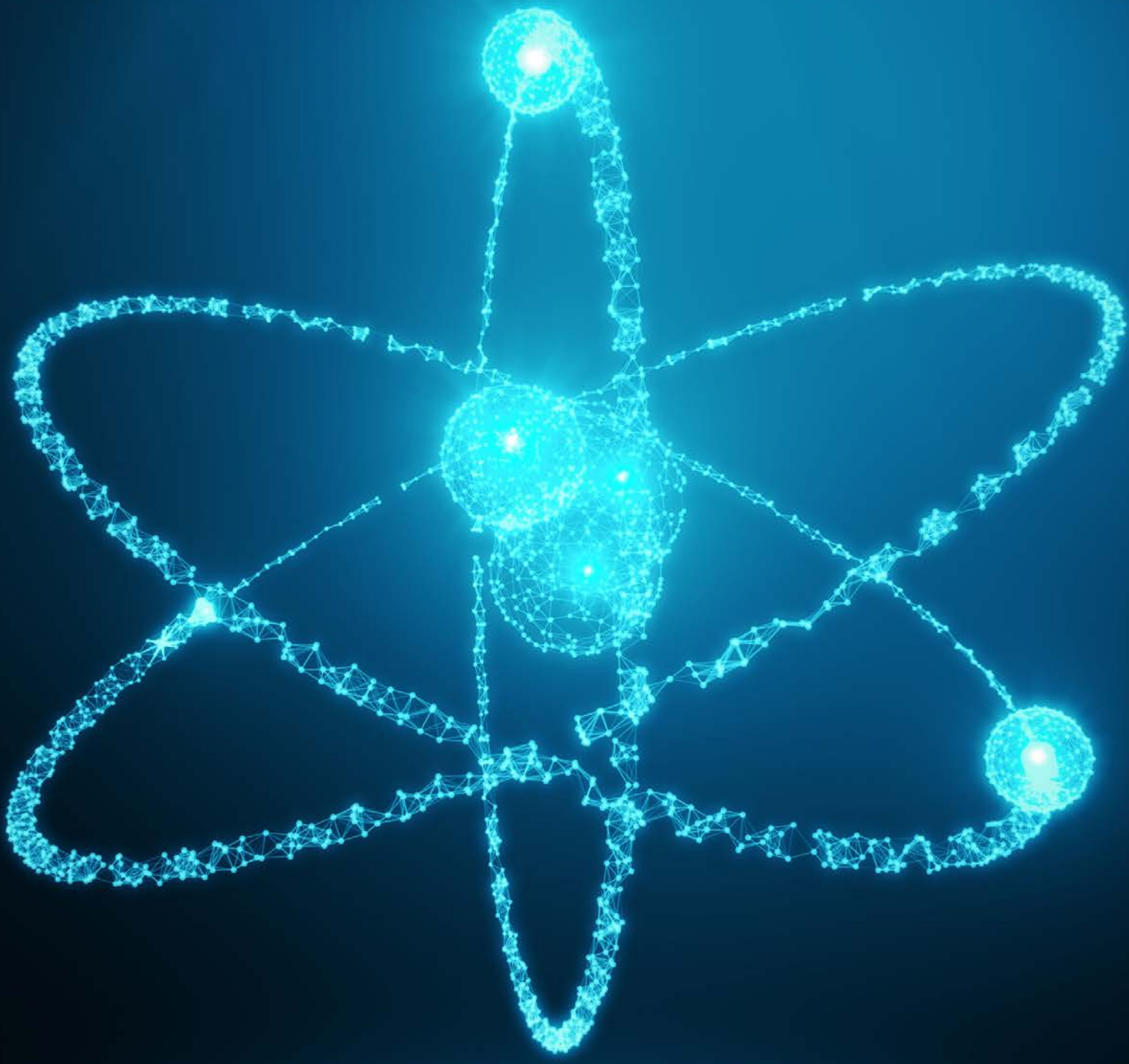
HERIOT WATT UNIVERSITY



The Institute of Photonics and Quantum Sciences

ANNUAL REPORT 2019

99
Publications

113
PhD and EngD Students

44
PDRAs

£11,822,796
Research Income

35
Faculty Members

Director's Statement

Welcome to the annual report from the Institute of Photonic and Quantum Sciences (IPAQS).

IPAQS is one of five research institutes comprising Heriot-Watt's School of Engineering and Physical Sciences. Formed in 2012, we are one of the UK's largest concentrations of researchers in photonics, with a breadth of expertise extending from fundamental concepts in condensed matter and quantum physics, to applied topics in industrial laser processing and astronomical instrumentation.

Our staff play a leading role in the UK photonics community, and include Principal and Co-Investigators of major EPSRC investments such as Centres for Innovative Manufacturing, Quantum Technology Hubs and Centres for Doctoral Training. We are also a centre of entrepreneurship and innovation in photonics, with several spin-out companies founded by IPAQS staff.

In 2019 we have seen research highlights in theoretical physics, quantum technology, laser-based manufacturing and photochemistry. As an Institute we continue to work closely with industry, with more than 50 companies collaborating in our research activities. Community culture is important in IPAQS, whether through student-led activities like the OSA Chapter and postgraduate lab tours, or the regular research seminars and the unmissable Friday coffee-and-donuts time.

Staff in the Institute interact closely with undergraduates through lectures and final-year project supervision, but also informally in social events such as those run by the Heriot-Watt Physics Society. Activities such as these make IPAQS a vibrant and dynamic home for researchers of all career stages.

I welcome your interest in IPAQS and hope that you find this report interesting and informative.

Professor Patrik Öhberg
Head, Institute of Photonics and Quantum Sciences

RESEARCH HIGHLIGHTS

Highlight

Light Harvesting with Guide-Slide Superabsorbing Condensed-Matter Nanostructures

Dr Erik M Gauger | E.Gauger@hw.ac.uk

Publication:
W. M. Brown and E. M Gauger, The Journal of Physical Chemistry Letters, 2019, 10, 15, 4323-4329
https://doi.org/10.1021/acs.jpclett.9b01349.

In this publication, Mr William Brown and Dr Gauger establish design principles for light-harvesting antennae whose energy capture scales superlinearly with system size. Controlling the absorber dipole orientations produces sets of "guide-slide" states that promote steady-state superabsorbing characteristics in noisy condensed-matter nanostructures. Inspired by natural photosynthetic complexes, they discuss the example of ring-like dipole arrangements and show that, in their setup, vibrational relaxation enhances rather than impedes performance. Remarkably, the superabsorption effect proves to be robust to $\mathcal{O}(5\%)$ disorder simultaneously for all relevant system parameters, showing promise for experimental exploration across a broad range of platforms.

This publication was selected as a Supplementary Journal Cover for the August 2019 Issue of the Journal of Physical Chemistry Letters.

Fig. 1 Supplementary Journal Cover, featuring a schematic depiction of a superabsorbing antenna for light-harvesting.

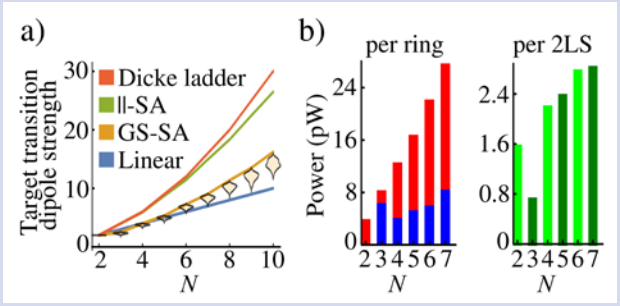


Fig. 2: (a) Scaling of oscillator strength with system size, showing a super-linear increase for the superabsorbing ring antennae. (b) Output (red) and input (blue) power for different system sizes. The green bars show the super-linear growth of net power per site.

Highlight

Understanding resonant charge transport through weakly coupled single-molecule junctions

Dr Erik M Gauger | E.Gauger@hw.ac.uk

Publication:
J. O. Thomas et al., Nature Communications 10, 4628 (2019).
https://www.nature.com/articles/s41467-019-12625-4

Together with experimental collaborators from the University of Oxford, Dr Gauger and his former PhD student Dr Jakub Sowa have provided a much-sought after qualitative and quantitative understanding of the resonant transport regime for molecular junctions: an adaptation of Dr Sowa and Dr Gauger's theoretical model (J. Chem. Phys. 149, 154112 (2018)) provides an excellent description of experimental data from over a dozen single molecule graphene-based zinc-porphyrin junctions, including across a wide range of temperatures, gate and bias voltages, and for different lead coupling strengths. In particular this publication shows that at low temperature a quantum mechanical description of the transport process is indispensable, and that the venerable Marcus theory only applies in the high temperature limit.

Molecular devices are promising candidates for energy efficient information processing as well as for generating thermoelectricity. Most previous work on single molecule junctions had focused on the off-resonant transport regime and co-tunnelling processes. However, the resonant regime allows for much faster transport and higher currents, which is important for practical applications.

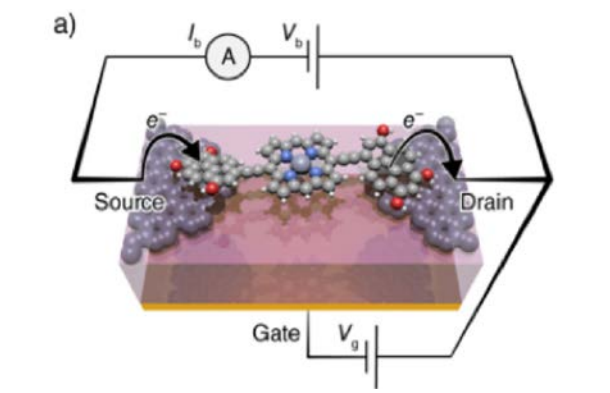


Fig. 1 Schematic depiction of a single porphyrin molecule spanning an electro-burnt nanometre-sized gap between two graphene electrodes. The molecular orbitals of the porphyrin can be tuned via the gate electrode shown under the (pink) SiO2 substrate.

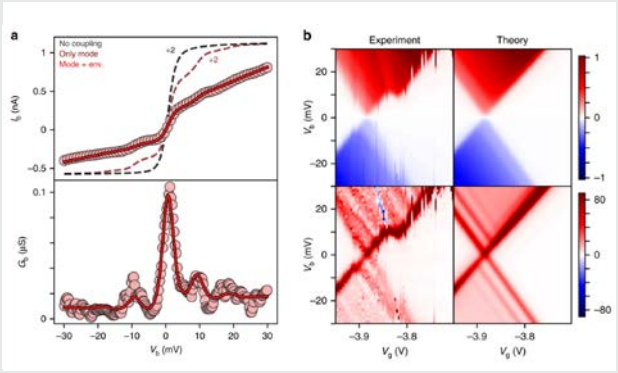


Fig. 2: (a) Bias-Voltage relationship (top) and differential conductance (bottom). The solid red curve is the theoretical prediction and the circles are measured data. (b) Comparison of measured and calculated "stability diagram", i.e. current as a function of applied gate and bias voltages. In the white regions there is no current as there is no molecular level within the bias window of the electrodes.


SCHOTT

FACULTY AND STAFF

STAFF

Professor Patrik Öhberg
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Research interests:
- Gauge field theories
- Bose-Einstein Condensate dynamics

Dr Cristian Bonato
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Research interests:
- Spin-based quantum technology
- Nanoscience

Dr Maria Anna Cataluna
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Research interests:
- Ultrafast photonics
- Pulsed semiconductor lasers
- High-speed sensing

Professor Daniel M J Esser
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Research interests:
- Mid-infrared laser sources

Professor Erika A Andersson
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Research interests:
- Quantum information science, including quantum signatures
- Quantum optics
- Quantum measurements

Professor Gerald S Buller
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Research interests:
- Sparse photon depth imaging
- Quantum communications
- Single-photon detection technologies

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Research interests:
- Holographic optics
- Metasurface optics

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Research interests:
- Foundations of quantum physics
- Quantum optics

Dr Fabio Biancalana
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Research interests:
- Nonlinear fibre optics
- Condensed matter analogues in optics

Dr Richard Carter
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Research interests:
- High power laser manufacturing processes
- Fibre optics

Dr Ross Donaldson
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Research interests:
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- Quantum cryptography

Dr Marcello Ferrera
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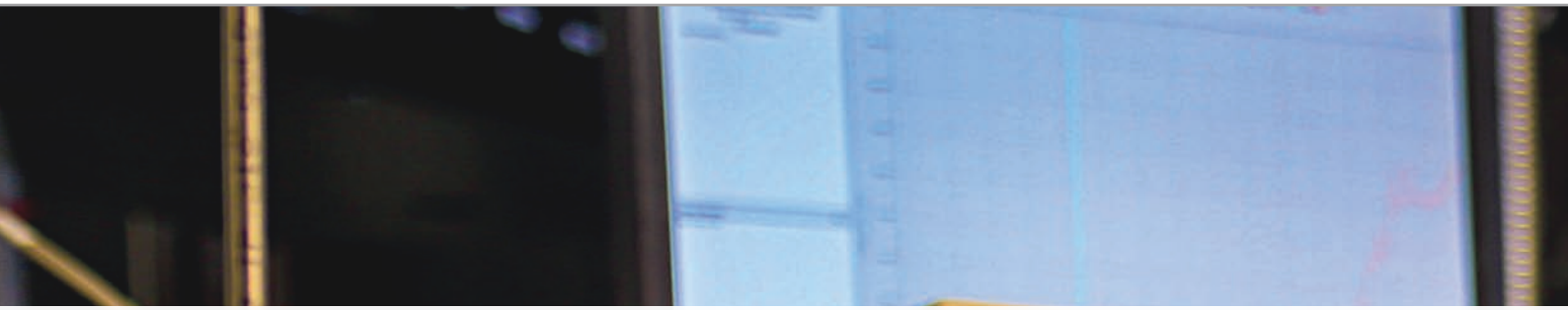
Research interests:
- Plasmonics
- Metamaterial physics



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Research interests:
- Semiconductors
- Exciton physics

Professor D P Hand
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Research interests:
- Applications of high power lasers in manufacturing and medicine
- Fibre optics for high peak power laser light
- Optical sensing

Dr Jonathan Leach
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Research interests:
- Quantum optics
- Entangled orbital angular momentum states
- Novel imaging technologies

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Research interests:
- Quantum photonics
- Quantum information
- Quantum technologies

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Research interests:
- Information theory
- Quantum physics
- Super and sub-radiance dynamics

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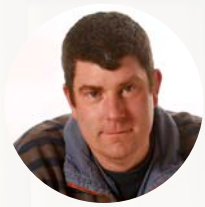
Research interests:
- Many body quantum systems
- Quantum opto-mechanics



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Research interests:
- Optical sensors

Dr Margherita Mazzera
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Research interests:
- Coherent spectroscopy of solid state systems
- Quantum photonics
- Quantum memories

Professor Brian Gerardot
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Research interests:
- Solid-state quantum photonics
- Nanoscience
- Quantum optics

Professor Ajoy Kar
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Research interests:
- Graphene Photonics
- Chalcogende Photonics
- Biophotonics and Healthcare
- Ultrafast Waveguide Lasers

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Research interests:
- High-speed quantum random number generation
- Tunable pulsed lasers for multi-photon microscopy
- Mid-infrared single-photon generation
- Frequency combs for astronomical spectrograph calibration

Professor A J Moore
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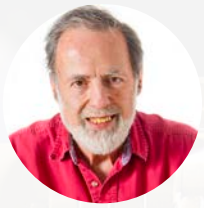
Research interests:
- Additive manufacture of metals
- THz metrology



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Research interests:
- Quantum optics of impurities in Si

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Research interests:
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- Laser manufacturing processes

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Research interests:
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- Bio-sensors

Dr Wei Wang
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Research interests:
- Optical Information Processing
- Statistical Optics
- Optical Metrology
- Biomedical Optics

Professor Derryck T Reid
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Research interests:
- Optical frequency combs
- Femtosecond OPOs
- Sub-surface semiconductor microscopy

Professor Mohammad Taghizadeh
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Research interests:
- Holography

Dr Dave Townsend
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Research interests:
- Femtochemistry
- Time-resolved photoelectron spectroscopy

Dr Xu Wang
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Research interests:
- Optical communication
- All optical signal processing
- Real-time ultra-fast imaging

Dr Mohammed Saleh
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Research interests:
- Fibre based nonlinear optics

Dr Michael G Tanner
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Research interests:
- Biomedical photonics
- Application of single photon technology

Professor John Travers
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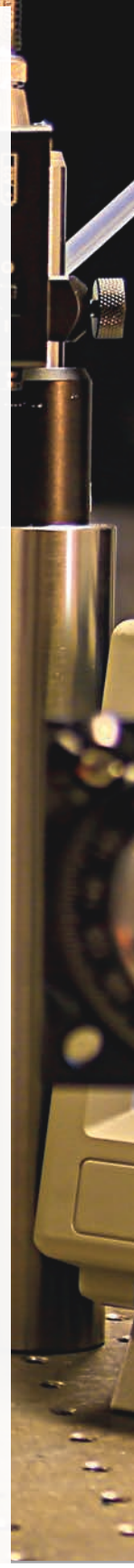
Research interests:
- Nonlinear fibre optics
- VUV and EUV pulse generation
- High intensity light-matter interaction



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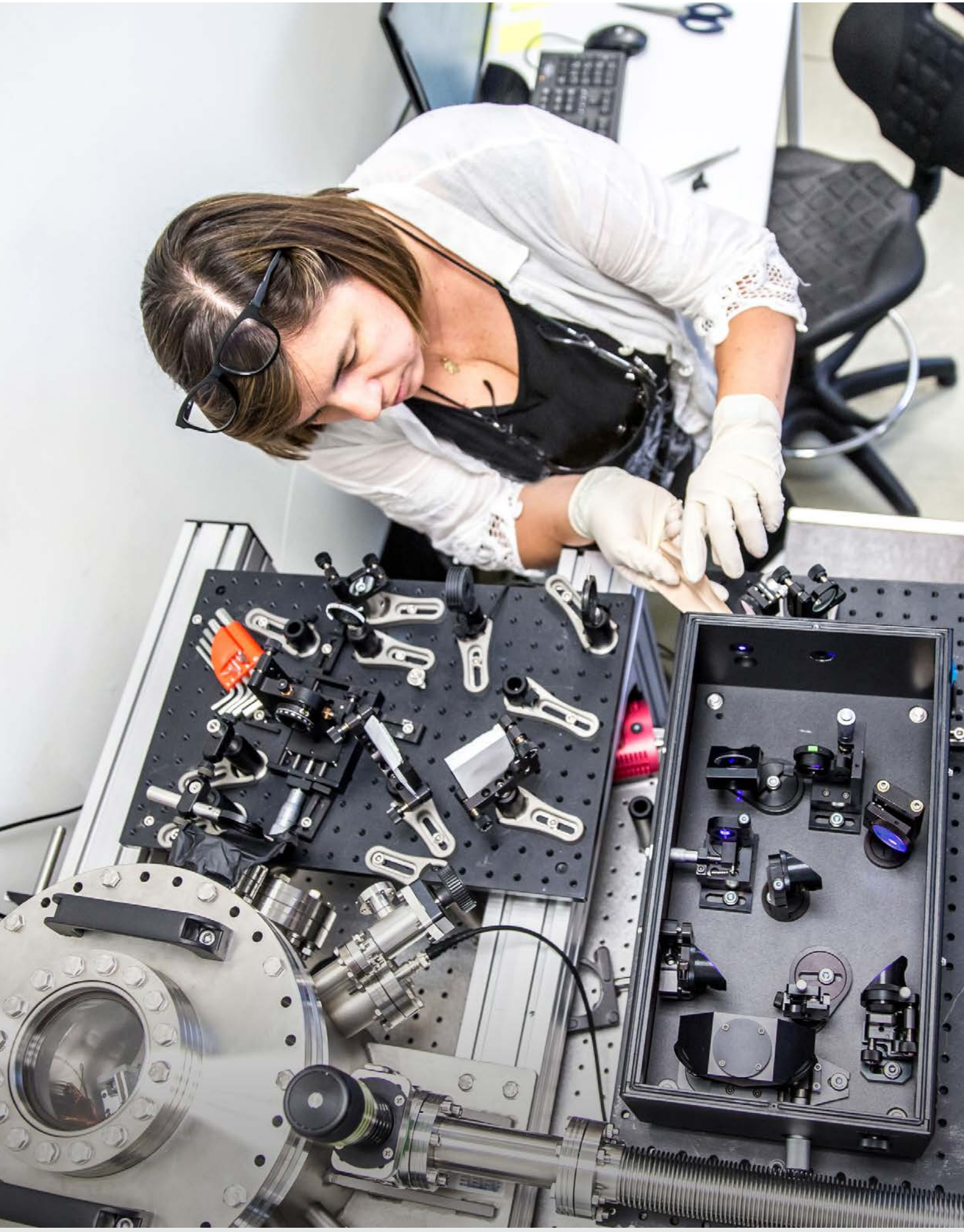
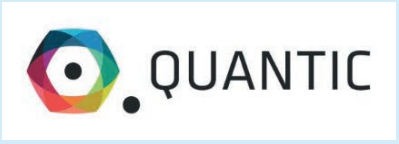


RESEARCH PROJECTS AND TECHNOLOGY DEVELOPMENT

Quantum Hubs:
EPSRC Quantum Technology Hubs

IPaQS is an established centre of excellence in Quantum Technology (QT), playing a major role in the UK's National Quantum Technology Programme via the EPSRC QuantIC and QuComms Quantum Technology Hubs, the EPSRC Fellowship Programme, and several major Innovate UK projects with UK industry. In addition, IPaQS is heavily involved in other UK, EU, and International quantum technology initiatives. IPaQS has a strong mixture of established quantum technology leaders and ambitiously recruited early career leaders from the best international institutions. The following is a list of IPaQS academics at the forefront of quantum science and technology.



Gerald Buller (novel single-photon detectors; single-photon imaging; quantum-enhanced imaging; sparse photon imaging in extreme environments; quantum communication protocols; quantum amplifiers; Management Board QuantIC Hub; Member Management Board QuComms Hub, EPSRC Established Career Fellowship in QT; industry links with Leonardo, DSTL, Helia Photonics, and numerous other SME's)

Brian Gerardot (solid-state spin-photon interfaces; indistinguishable single-photon and entangled photon solid-state devices; quantum dots; 2D materials; integrated quantum photonics; Co-I QuComms Hub, ERC Consolidator Grant; RS Wolfson Merit Award; RA Eng. Chair in Emerging Technology)

Erika Andersson (quantum communications; quantum digital signatures; quantum information theory; Co-I QuComms Hub)

Jonathan Leach (single-photon imaging through obscurants; photonic QIP with OAM; quantum imaging; multi-photon entanglement; joint projects with DSTL; Co-I QuantIC Hub)

Alessandro Fedrizzi (entangled photon sources, cluster state quantum computing; quantum software; satellite QKD; multi-dimensional QKD; partnership projects with NQIT and QuComms Hubs; EPSRC Early Career Fellowship in QT)

Mehul Malik (high-dimensional QKD; multi-photon entanglement; quantum information transport through optical fibres; quantum secure imaging; EPSRC QT Fellowship)

Cristian Bonato (nitrogen-vacancy centres in diamond; solid-state spin-photon interfaces; silicon carbide quantum devices; adaptive phase estimation and single spin magnetometry; EPSRC Early Career Fellowship)

Erik Gauger (bio-inspired QT including energy harvesting; theory of quantum nanostructures; quantum biology including avian compass; molecular sensors and devices; (solid-state) quantum information; processing & metrology; RSE Research Fellowship in bio-inspired QT)

Ross Donaldson (Quantum communications with aerial platforms, including satellites; quantum amplifiers; novel photonic technology for quantum communications; RAEng Fellowship)

Michael Hartmann (quantum simulations; matrix product states; theory of superconducting quantum devices; opto- and nanomechanics; machine learning)

Patrik Öhberg (theory of ultracold atoms; quantum simulators; quantum optomechanics)

Robert Thomson (clinical applications of time-correlated single-photon imaging; integrated optical analogues of quantum phenomena; laser fabricated integrated quantum photonics; partner of the QuComms Hub)

Xu Wang (optical communication, ultrafast imaging, secure high speed optical communications with QKD, partner of the QuComms Hub)

Maria Ana Cataluna (ultrafast semiconductor quantum-confined lasers and photonic devices; ultrafast spectroscopy of novel low-dimensional semiconductor materials; ultra-high-speed optical sensing enabled by ultrafast photonics; ERC Grant holder)

Mohammed Saleh (nonlinear optics; integrated quantum photonics; RSE Research Fellowship in nonlinear photonics)

Fabio Biancalana (quantum soliton propagation and evaporation; graphene; 2D materials; nonlinear quantum optical processes)

Xianzhong Chen (metamaterials and metasurfaces; polarization control; OAM manipulation; nanophotonics, joint projects with Holoxica)

Marcello Ferrera (nanophotonics; nonlinear materials; integrated optics; plasmonics; ultra-fast all-optical devices with applications including on-chip THz science, signal processing, optical computing, integrated quantum optics)

John Travers (light-matter interactions in gases; ERC Grant)

Ian Galbraith (semiconductor quantum systems; excitons; quantum dots; 2D materials)

Margherita Mazzera (Light-matter interaction and quantum memories)

UK Quantum Technology Programme

UK NATIONAL QUANTUM TECHNOLOGIES PROGRAMME

IPaQS is a major participant in the UK Quantum Technology Programme, a nationwide £500M+ initiative in what promises to be the next revolution in technology, enabling breakthrough applications in a variety of areas such as computing, sensing, secure communications and imaging.

IPaQS is a major partner in two of the four UK Quantum Technology hubs for a total value of £10M. We also host four prestigious Quantum Technology Fellowships: an Established Career Fellowship for Professor Gerald Buller; and Early Career Fellowships for Dr Alessandro Fedrizzi, Dr Mehul Malik and Cristian Bonato. Heriot-Watt also lead the recently commenced £5M EPSRC SPEXS Programme Grant. (PI Gerald Buller).

Additional investment from the University has allowed the creation of a new laboratory work space shared between the Quantum Technology research groups involved in both Hubs, providing a unique opportunity for fostering excellence and productivity.

The UK Quantum Technology Hub for Quantum Communications

The UK Quantum Technology Hub for Quantum Communications is now entering its second five-year phase, and is a partnership of ten UK Universities (Bristol, Cambridge, Glasgow, Heriot-Watt, Kent, Oxford, Queen's Belfast, Sheffield. Strathclyde and York) numerous private sector companies (BT, Toshiba Research Europe Laboratories Ltd, amongst others), and public sector bodies (e.g. National Physical Laboratory, RAL Space and the EPSRC National Dark Fibre Facility), that have come together in a unique collaboration to exploit fundamental laws of quantum physics for the development of secure communications technologies and services.

Led by the University of York, the five-year, £25M QComms Hub aims to deliver quantum encryption systems that will in turn enable secure transactions and transmissions of data across a range of users in real-world applications: from government agencies and industrial set-ups to commercial establishments and the wider public. Heriot- Watt is specifically involved in researching new quantum communications protocols, single photon source and detector component technologies and optical ground stations for ground-to satellite quantum communications.

The UK Quantum Technology Hub for Quantum-Enhanced Imaging (QuantIC)

The UK Quantum Technology Hub for Quantum Imaging is now entering its second phase and is a partnership of nine UK Universities (Glasgow, Heriot-Watt, Strathclyde, Edinburgh, Oxford, Bristol, Imperial College, Southampton and Exeter) and a number of major companies (e.g. Thales, Leonardo, STMicroelectronics, MSquared lasers, Teledyne e2v, BAE Systems, Airbus, Optos). QuantIC aims to link world-leading quantum technologists with global industry leaders to transform imaging in alignment with industry priorities. Together we will pioneer imaging and sensing systems with breakthrough functionality by developing a family of quantum-enhanced multidimensional cameras operating across a range of wavelengths, timescales and length-scales.

Led by Glasgow University, the £50M QuantIC hub will deliver quantum-inspired imaging solutions such as single pixel cameras, ultra-high speed imaging, gravitational field imaging and covert range finders, together with an array of novel light sources and detector technologies. Heriot-Watt is specifically involved in the following areas: ultra-high speed cameras with applications such as detecting images obscured by fog, smoke or other obscurants; next generation underwater imaging systems; reconstructing colour and depth images at the single-photon level; and development of the next generation of near-infrared single photon detectors based on germanium-on-silicon.

NEW GRANT AWARDS

New Grant Awards in 2019

Name	Project Title	Sponsor	Dates	Value
Bonato	Real-time adaptive quantum sensing	Weizmann UK	5/22/19	£39,999
Bonato	Quantum Emitters for telecommunication in the O-Band	European Commission	6/20/19	£310,527
Bonato	Harnessing quantum defects for magnetic measurements	Leverhulme Trust	12/5/19	£209,757
Buller	Single Photons - Expanding the Spectrum (Programme Grant)	EPSRC	3/13/19	£1,919,933
Buller	High resolution 3D imaging through obscurants using single photons	DSTL	4/18/19	£138,380
Buller	EPSRC Quantum Technology Hub in Quantum Communications (Phase Two)	EPSRC	7/18/19	£2,775,788
Buller	Vehicle wade preview in flooded conditions	EPSRC	10/21/19	£48,222
Buller	Low Power Imaging LIDAR	Qinetiq Ltd	11/22/19	£48,931
Chen	Real-time circular polarization camera	Renishaw PLC	12/18/19	£30,098
Donaldson	Quantum Communications & HAPS: A Feasibility Study	EPSRC	1/24/19	£22,177
Gauger	Quantum Bio-inspired Energy harvesting	EPSRC	8/27/19	£352,431
Gauger	Understanding and engineering dissipation in nanoscale quantum devices	EPSRC	11/20/19	£321,384
Gerardot	Chair in Emerging Technologies: Top-Up Award	Royal Academy of Engineering	2/12/19	£54,250
Hand	3D printing of micro-scale graded shape memory components for in-vivo actuated medical devices	EPSRC	2/25/19	£249,961
Hand	NMIS-IDP studentship Aidin Barabi (Renishaw part)	Renishaw PLC	5/20/19	£39,928
McCracken	STFC IPS - Harnessing photonic technologies for deep-tissue imaging	STFC	17/20/2019	£358,909
McCracken	Wavelength–versatile pulsed laser sources for multiphoton microscopy	Scottish Universities Physics Alliance	5/20/19	£1,750

Much of the research in IPAQS is collaborative with industry, leading to opportunities for impact beyond the academic community.

Name	Project Title	Sponsor	Dates	Value
McCracken	STFC IPS Capital Call - Follow on for B18R13142	STFC	5/29/19	£69,885
McLaughlin	QuantIC Phase 2	EPSRC	7/18/19	£2,564,031
Moore	THz measurements for ceramic coatings	Renishaw PLC	12/12/19	£49,965
Pender	EPSRC Core Equipment Funding Award	EPSRC	11/22/19	£250,000
Reid	ELT PPRP 2018	STFC	3/7/19	£381,874
Reid	Fibre delivery of broadband mid-infrared light for hydrocarbon spectroscopy	EPSRC	5/24/19	£31,141
Reid	Quantitative multi-species hydrocarbon metrology in gas pipelines	STFC	6/18/19	£358,566
Reid	High Resolution Multi-Species Gas Analysis for Defence Applications	Chromacity Ltd	9/24/19	£16,817
Reid	STFC Equipment Grant: Quantitative multi-species hydrocarbon metrology in gas pipelines	STFC	10/30/19	£69,420
Shephard	Endoscopically deployable optics for picosecond laser surgery	EPSRC	6/18/19	£58,567
Thomson	Laser Manufacturing Distal-End-Microsystems for Fibre-Optic Medical Instruments	EPSRC	11/15/19	£62,069
Travers	Universal Light Sources	Anonymous	5/17/19	£858,297
Travers	Bright and compact deep ultraviolet light sources for healthcare and industry	European Commission	12/19/19	£129,739

PUBLICATIONS, PATENTS AND AWARDS

Journal Articles

Optimal simultaneous measurements of incompatible observables of a single photon
Dada, A. C., Mccutcheon, W., **Andersson, E.**, Crickmore, J., Puthoor, I., **Gerardot, B. D.**, Mcmillan, A., Rarity, J. & Oulton, R., 20 Mar 2019, In: Optica. 6, 3, p. 257-263 7 p.

Universal quantum Hawking evaporation of integrable two-dimensional solitons
Robson, C. W., Di Mauro Villari, L. & **Biancalana, F.**,
29 May 2019, In: New Journal of Physics. 21, 053042.

Topological nature of the Hawking temperature of black holes
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Professor Erika Andersson associate Editor of Physical Review A

Dr Cristian Bonato - editorial board of Scientific Reports.

Professor GS Buller - guest editor 'Photon Counting Technologies' Special Section, Optical Engineering Journal (publication date May 2018).

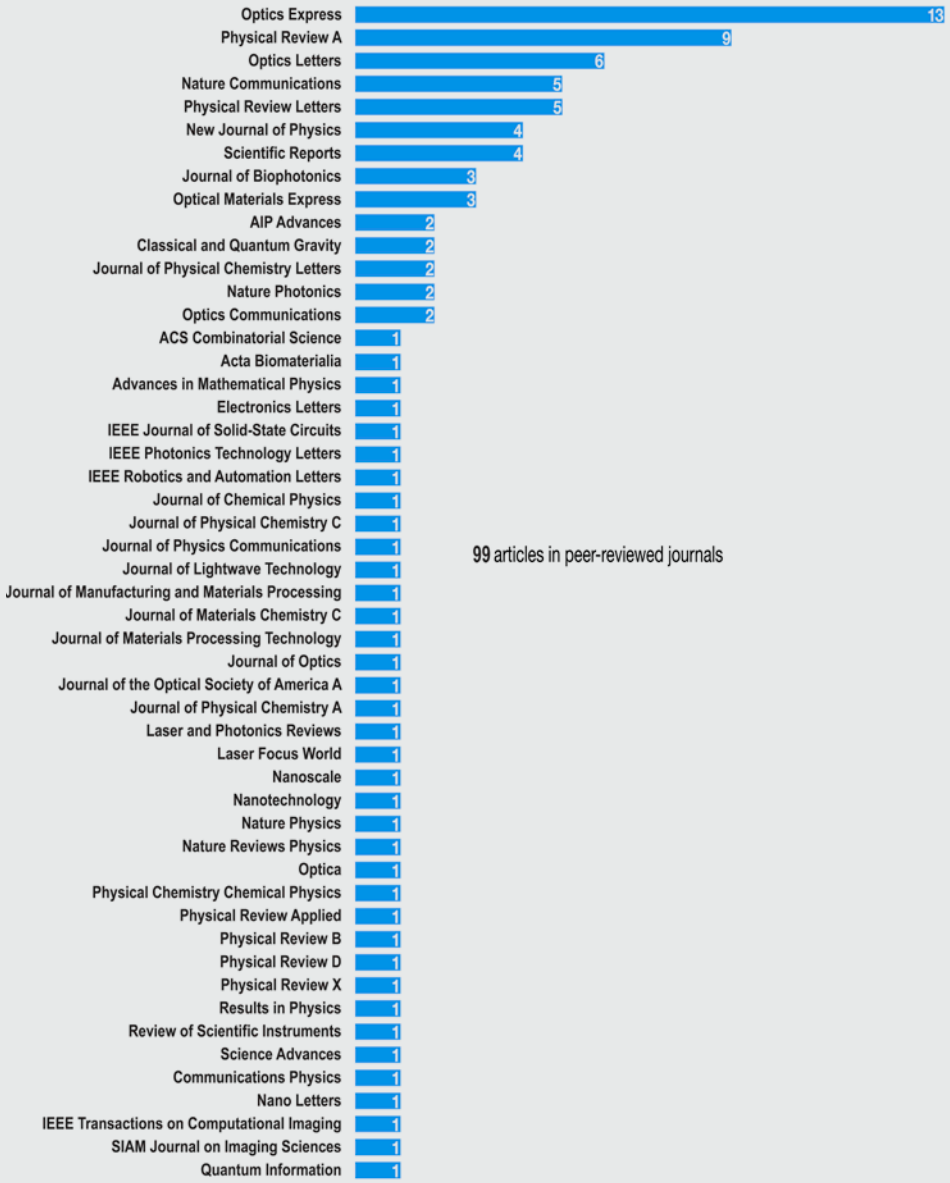
Dr Maria Ana Cataluna - editorial board of Scientific Reports. Editorial Board of Optical and Quantum Electronics

Dr Xianzhong Chen - guest editor on special issue on metasurfaces, Journal of Physics D: Applied Physics.

Professor Andrew Moore - editorial board of Optics and Lasers in Engineering.

Professor John Travers - editorial board of the Journal of Physics: Photonics.

Publications List



New Awards, Prizes and Fellowships

Dr Cristian Bonato has been awarded a 5 year EPSRC Early-Career Research Fellowship. The fellowship will enable the development of a quantum memory based on individual electronic and nuclear spins in silicon carbide. Silicon carbide, a material widely used by the microelectronics industry, will enable, for the first time, to integrate spintronic, electronic and photonic functionalities on a single device. The grant will fund new facilities to equip the Quantum Photonics Lab to investigate single spins in a wide temperature range (from T=3.5K to room temperature) with high-fidelity sequences of optical and microwave pulses.

Dr Maria Ana Cataluna was selected as a Member of the Technical Programme sub-Committee for Semiconductor Lasers, CLEO/Europe 2019.

Dr Maria Ana Cataluna was accepted as a Member of the Royal Society of Edinburgh Young Academy of Scotland.

Dr Maria Ana Cataluna was selected to become a member of AcademiaNet.

Dr Robert J Collins won the 'Heriot-Watt University Principal's Public Engagement Prize 2018'.

Dr Ross Donaldson was awarded the Royal Academy of Engineering Early Career Research Fellowship, 2018 -2023, 'Practical Optical Ground Station Receivers for Satellite-Based Quantum Communication'.

Dr Erik Gauger was accepted as a Member of the RSE Young Academy of Scotland.

Dr Michael Hartmann was awarded a prestigious Visiting Researcher position at Google through the Google Visiting Faculty Program.

Dr Michael Hartmann was awarded the FET open grant 'Quromorphic' as coordinator. The Neuromorphic Quantum Computing (Quromorphic) Project aims to build a computer processor that transfers data in the same way neurons work in the human brain.

Patents

'Single-photon avalanche diode detector, method for use therefore and method of its manufacture' P. Vines, K. Kuzmenko, J. Kirdoda, D. D. S. Dumas, M. M. Mirza, R. W. Millar, D. J. Paul and **G. S. Buller**, Application No: 1814688.6.

'Improvements in or relating to laser based machining' P. Blair, C. Courtney, T. Parsonage, A. Lopes, K. L. Wlodarczyk and **D. P. Hand**, European patent no: 18214474.1 - 1016, filed 20 December 2018.

'An instrument and principle to image through tissue to determine the location of an optic fibre endoscope' **M.G. Tanner**, 1611819.2 UK filing 7/7/2016 PCT/GB2017/052005 7/7/2017 WO2018007829A1 11/01/2018.

'Multiple point source illumination for inserted medical devices such as NG tubes', **M. G. Tanner**, 1800340.0 UK filing 9/1/2018 PCT filing 9/1/2019 (patent not yet formally published).

'Optical system and method', **R. R. Thomson**, WO2018GB51214 20180504.

'Imaging method and apparatus', **R. R. Thomson** WO2017GB52005 20170707.

'Direct laser writing and chemical etching and optical devices', **R. R. Thomson** WO2018GB50195 20180124.

'Laser-assisted device alteration using synchronized laser pulses', Vedagarbha, P., **Reid, D. T.**, Serrels, K. & Vickers, J. S., 19 Feb 2019, Patent No. US10209274B2, 23 Oct 2015, Priority date 8 Sep 2010.

PhD AND EngD STUDENTS

PhD Students

Surname	Forename	Email	Project Title
Georgia	Anastasiadi	ga10@hw.ac.uk	Machined multicore optical fibres for on-chip optical manipulation
Muhammad	Arshad	ma455@hw.ac.uk	An adaptive spin-based quantum magnetometer
Aneirin	Baker	ajb17@hw.ac.uk	Many-body operations and simulations of lattice gauge theories with superconducting qubits
Guillem	Ballesteros-Garcia	gb173@hw.ac.uk	Efficient generation and collection of indistinguishable single photons
Peter	Barrow	pb31@hw.ac.uk	Photonic cluster state computing
William	Brown	wmb1@hw.ac.uk	Vibrationally assisted quantum optical effects in collective systems
Yvan	Buggy	yb25@hw.ac.uk	Hydrodynamical properties of non-linear gauge coupled quantum fluids
Alexander	Burton	atb30@hw.ac.uk	Temperature control in the additive manufacturing (3D printing) of metals
Aidan	Campbell	ac174@hw.ac.uk	Efficient light-matter interaction with two-dimensional semiconductor crystals
David	Canning	dwc1@hw.ac.uk	Quantum digital signatures and quantum amplifiers
Yuk Shan	Cheng	yc40@hw.ac.uk	Wide-mode-spacing broadband optical parametrc oscillator frequency combs
Alexandre	Coates	ac173@hw.ac.uk	Harvesting light beyond classical limits
Oliver	Collett	ojc30@hw.ac.uk	High average power 2µm amplifiers and laser systems
Peter	Connolly	pc23@hw.ac.uk	Next generation imaging using sparse single-photon data
Karen	Craigie	klc31@hw.ac.uk	Spin-photon interfacing in silicon carbide
Jonathan	Crickmore	jc29@hw.ac.uk	Quantum digital signatures
Scott	Davidson	sd109@hw.ac.uk	Information theoretic optimisation of energy transport in molecular networks
Leone	Di Mauro Villari	ld33@hw.ac.uk	New physics of 2D materials with Dirac-like dispersion
Stephen	Dondieu	sdd1@hw.ac.uk	High quality, high speed engraving using high average power nanosecond pulsed fibre lasers
Francesco	Graffitti	fg13@hw.ac.uk	Hybrid photonic quantum technology
Zoe	Greener	zmg1@hw.ac.uk	Single photon and quantum enhanced imaging
Harrison	Greenwood	hg35@hw.ac.uk	Engineering the spectral properties of single photons using inhomogeneous waveguides
Teodora	Grigorova	tfg2@hw.ac.uk	Ultrafast nonlinear optics in gas-filled hollow-core waveguides
Samuel	Hann	snh30@hw.ac.uk	A novel approach to manufacturing lasers using ultrafast laser welding
Rosie	Hayward	rh45@hw.ac.uk	Quantum field theory/particle physics analogues in nonlinear optics

PhD Students

Surname	Forename	Email	Project Title
Natalia	Herrera	nah2@hw.ac.uk	High dimensional entanglement: pushing the boundaries of quantum technologies
Laura	Huddleston	llh4@hw.ac.uk	Short-wave infrared single-photon avalanche detectors
Yuttana	Intaravanne	yi9@hw.ac.uk	Nanostructures for developing novel photonic devices with unusual functionalities
Dean	Johnstone	dj79@hw.ac.uk	Topology of strongly correlated systems
Sharad	Joshi	sj2@hw.ac.uk	Computational analysis of photon echo and exceptional points dynamics in lossy quantum systems
Rishad	Kaipurath	mk382@hw.ac.uk	Laboratory based models for cosmological expansion using nonlinear optics
Vikram	Kamaljith	vk1@hw.ac.uk	Developmentof 3D photonic structures for advanced biomedic endoscopy
Christy	Kelly	ckk1@hw.ac.uk	Ising model: a universal framework in condensed matter physics
Maximilian	Koegl	mk220@hw.ac.uk	Strain engineering of electronic properties in van der Waals heterostructures
Zak	Koong	zk49@hw.ac.uk	Quantum teleportation with a telecom wavelength spin-photon interface
Micaela	Laini	ml114@hw.ac.uk	Two dimensional integrated quantum photonics
Simone	Lauria	sl196@hw.ac.uk	Interplay between second- and third-order nonlinear Interactions in optical microstructures
Athanasios	Lekosiotis	al104@hw.ac.uk	Ultrafast nonlinear optics in gas-filled hollow-core waveguides
Nathan	Macleod	nm178@hw.ac.uk	Digital manufacturing of industrial lasers
Gillian	Madden	gem31@hw.ac.uk	Ultrafast laser inscription of mid-infrared guided wave components for astronomical interferometry
Calum	Maitland-Warne	cm350@hw.ac.uk	Gravitational and quantum field theory analogues in condensed matter physics and nonlienar optics
Amirali	Matin	am626@hw.ac.uk	Novel real-time imaging system
Sam	McArthur	srm37@hw.ac.uk	Optimising ultrafast laser processing processes using structured light
Mark	McDonald	mwm32@hw.ac.uk	Laser post-processing of metal additively manufactured parts
Duncan	McNicholl	dkm2@hw.ac.uk	Advanced microendoscopy modalities
Eunan	McShane	epm1@hw.ac.uk	Tracking medical devices using time-corrrelated single photon counting imaging
Nirosh	Meckamalil Eldose	nm20@hw.ac.uk	MBE growth and epitaxial lift-off of II-VI semiconductors for device applications
Toby	Mitchell	tm55@hw.ac.uk	Femtosecond frequency combs for precision distance metrology

Surname	Forename	Email	Project Title
Imogen	Morland	im19@hw.ac.uk	Imaging turbulence with single-photon detector array technology
Daniel	Morris	dm113@hw.ac.uk	Ultra-short-pulse 2 µm wavelength oscillator-amplifier development
Christopher	Morrison	clm6@hw.ac.uk	Frequency conversion for quantum networking
Graeme	Nicoll	gan2@hw.ac.uk	Investigating the interaction between laser parameters for ultra-fast laser processing of glass
Raphael	Picard	rmp5@hw.ac.uk	An artificial atom in a two-dimensional semiconductor
Alexander	Pickston	ap343@hw.ac.uk	Quantum communication with photonic cluster states
Fraser	Pike	fap30@hw.ac.uk	Precision photonic spectroscopy for astronomy and metrology
Radivoje	Prizia	rp38@hw.ac.uk	Photon fluids and photon condensation
Massimiliano	Proietti	mp68@hw.ac.uk	All-optical quantum networking
David	Reichmuth	dr23@hw.ac.uk	Quantum communication and quantum measurements
Ana	Ribeiro	afr3@hw.ac.uk	High scan rate optical sampling with quantum-dot lasers
Berke	Ricketti	bvr1@hw.ac.uk	Ultrafast sunlight emulator for quantum biology
Donald	Risbridger	drr30@hw.ac.uk	Novel technologies to enhance minimally invasive laser surgery
Alex	Ross	ar300@hw.ac.uk	Additive manufacture (3D printing) of metals
David	Ross	dr55@hw.ac.uk	The effect of luminescent down shifting layers on thin film solar cells
Lisa	Saalbach	ls55@hw.ac.uk	Time-resolved photoelectron imaging of model biological chromophores
Mohammed	Sabbah	ms246@hw.ac.uk	Ultrafast nonlinear optics in hollow-core waveguides filled with Raman active gases
Hamish	Scott	has15@hw.ac.uk	Theoretical quantum imaging and tomography
Jacopo	Siliprandi	js281@hw.ac.uk	Topological photonics using ultrafast laser inscribed photonic lattices
Chris	Sparling	cs177@hw.ac.uk	The role of multiple chiral centres in photoelectron circular dichroism
Vatshal	Srivastav	vs54@hw.ac.uk	Quantum communication beyond qubits
Anchit	Srivastava	as427@hw.ac.uk	PISTACHIO: Photonic imaging strategies for technical art history and conservation
Ulrich	Steinlehner	uks2@hw.ac.uk	Subsea high data rate single-photon three-dimensional imaging system
Lara	Stroh	ls149@hw.ac.uk	New protocols in quantum communication
Alfonso	Tello Castillo	at154@hw.ac.uk	Optical ground receivers for satellite-based quantum communication

PhD Students

Surname	Forename	Email	Project Title
Kimberly	**Tkalcec**	**ket3@hw.ac.uk**	Gain extraction of a multipass high energy amplifier
Max	**Tyler**	**mat3@hw.ac.uk**	SPAD array technologies for high-dimensional quantum systems
Gerard	**Valenti Rojas**	**gv16@hw.ac.uk**	Topology of strongly correlated systems
Ewan	**Wade**	**ecw3@hw.ac.uk**	Quantum-enhanced imaging in extreme environments
Kexin	**Wang**	**kw34@hw.ac.uk**	Optical code based secure optical communication system
Daniel	**White**	**dw29@hw.ac.uk**	Spin-active defects in SiC and diamond devices
Shouyue	**Wu**	**sw87@hw.ac.uk**	Hollow anti-resonant optical fibres for high power laser applications
Ugo	**Zanforlin**	**uz2@hw.ac.uk**	Quantum communications: quantum digital signatures and quantum amplifiers

Thesis Final Submissions 2019

Surname	Forename	Programme	Thesis Title
Enrico	Carnemolla	PhD	Enhanced nonlinearities in epsilon-near-zero transparent conductive oxides for applications in nanophotonics
Yang	Chen	PhD	Antiresonant hollow fibers with polygonal cores and pulse propagation in twisted fibers
Gilles	Diederich	PhD	Strain measurements with GHz and THz radiation
Robert	Dingwall	PhD	Soliton dynamics in interacting gauge theories
Callum	Duncan	PhD	Topological and unconventional states of matter
Katjana	Ehrlich	PhD	Biomedical fibre optic TCSPC spectroscopy with CMOS SPAD line arrays
Liam	Fitzgerald	Mphil	Analogue gravity approach to the electronic properties of curved graphene
Kateryna	Kuzmenko	PhD	Semiconductor photodetectors for photon–starved applications in short-wave infrared wavelength region
Amiel	Lopes	PhD	Picosecond laser micro-machining of glass for optics manufacture
Parthena	Mavridou	PhD	MBE growth, characterisation and epitaxial lift-off processing of II-VI semiconductors
Catarina	Novo	PhD	Precision laser micromachining of hollow core negative curvature fibres
Syam	Padinjaroottu Charinjathil Mohanan	PhD	Picosecond laser procedures to enhance the efficacy of tissue resection
Nikolitsa	Papachristou	PhD	Development of optical fibre curvature sensors for subsea instrumentation
Charles	Robson	PhD	Particle physics and gravitational analogues in nonlinear optics
Calum	Ross	PhD	Ultrafast laser assisted etching of fibre optic probes for optical biopsy instruments
Dale	Scerri	PhD	Solid state nanostructures as platforms for emerging quantum technologies
Najwa	Sidqi	PhD	Low loss dielectric mirrors for optical cavity applications
Alexander	Spracklen	PhD	An investigation of transport phenomena in lattices using waveguide arrays
Fiona	Thorburn	PhD	
Rachael	Tobin	PhD	Imaging through obscurants using time-correlated single-photon counting in the short-wave infrared
Niclas	Westerberg	PhD	Quantum vacuum radiation in optical media
Chunmei	Zhang	PhD	Ultrathin metasurface devices for phase and polarization control

EngD Students

Surname	Forename	Email	Project Title
Munadi	Ahmad	ma102@hw.ac.uk	Development of the technologies and techniques required to increase the repetition rate of high energy lasers
Christopher	Blackwell	cjb5@hw.ac.uk	Holographic 3D displays
Tamer	Cosgun	tyc30@hw.ac.uk	Development of fibre-based gas sensors for inaccessible locations
Mariastefania	De Vido	md50@hw.ac.uk	Development and application of high-energy, high pulse repetition rate diode-pumped solid state lasers
Leonardo	Del Bino	ld29@hw.ac.uk	Microresonator based optical frequency combs
Tom	Dyer	td13@hw.ac.uk	Development and integration of optical interrogated diagnostics with materials ageing experiments
Natalie	Flaherty	naf3@hw.ac.uk	Image processing for situational awareness in urban environments
Riccardo	Geremia	rg18@hw.ac.uk	Industrial laser microprocessing and process optimisation
Juan Pedro	Godoy Vilar	jg51@hw.ac.uk	Laser surface engineering for enhanced functional performance
Ben	Gore	bg66@hw.ac.uk	Adaptive optics and aberrations correction for super-resolution microscopy
Yili	Guo	yg72@hw.ac.uk	Non-linear optics for high power solid state lasers
Paul	Harrison	pdh4@hw.ac.uk	Development, production and characterisation of laser-machined micro-optics
Calum	Hill	chh30@hw.ac.uk	Fibre laser technology for challenging applications
Vladimirs	Horjkovs	vh5@hw.ac.uk	Robust high dynamic range transducers for surface form and finish
James	Jackson	jj55@hw.ac.uk	Optical fibre sensing for offshore renewable energy
Angel Victor	Juanco Muller	aj112@hw.ac.uk	Graph convolutional neural networks for medical image analysis
Matthew	Knights	mhk1@hw.ac.uk	Development of a one-step-interconnect process for CIGS based thin-film photovoltaics
Alexandra	Lee	al152@hw.ac.uk	Development of a novel single photon quantum key detection (QKD) optical ground station for secure satellite based communications
Gregory	May-Wilson	gm111@hw.ac.uk	Short pulse lasers for machining composite materials
Anna	Michalska	am609@hw.ac.uk	Precision distance measurement for a harsh environment
Benjamin	Michie	bjm10@hw.ac.uk	Distributed temperature and strain sensing within metallic ALM structures
Stavros	Misopolous	sm469@hw.ac.uk	Design and build of a high specification extended FTIR spectrometer
Paul	Mitchell	pm205@hw.ac.uk	3D guided-wave photonics for next generation communications networks
Rowan	Pocock	rap7@hw.ac.uk	Advanced optical coupling solutions for datacenter transceiver platforms
Gary	Quinn	gq4@hw.ac.uk	Development of a diode-pumped solid-state laser system operating at 10 J, 100 Hz
Michael	Reilly	mer4@hw.ac.uk	High power and high energy lasers: new materials, laser device architectures and laser beam modelling
Nicholas-Alexander	Smith	ns63@hw.ac.uk	Compact wind LIDAR: towards hand held remote sensing of wind
Calvin	Wan	cw277@hw.ac.uk	Miniature phase grating interferometer contact gauge/high speed phase shifting interferometric gauge
David	Webb	dw132@hw.ac.uk	The investigation and development of heavy metal free quantum dot devices for use in the general lighting markets
Michael	Woodley	mmw1@hw.ac.uk	Interaction between counter-propagating light
Hollie	Wright	hw33@hw.ac.uk	Frequency-comb metrology for manufacturing II: developing dual-comb distance metrology concepts and applications
Suki	Yao	sy51@hw.ac.uk	Biomedical imaging and signal processing for the intra-operative detection of cancerous tissue

OSA Student Chapter

OSA-IPaQS Society

Over the last year we have gained support from the IOP in addition to our existing affiliation with the OSA. To reflect that broader support across all area of Physics, the society rebranded itself as POP – Postgraduates of Physics Heriot-Watt.

POP then set about engaging in more regular events to help build the social feeling of the department. Beyond the annual summer barbecue, we also introduced the Heriot-Watt 'POP quiz', where postgraduates across Engineering and Physical Science disciplines came along and enjoyed the chance to socialise with each other and be challenged by something outside of their comfort zones. Already two of these quizzes have been run, and attendance doubled from the first to the second - so competition is getting tough!

On the research end POP has used the OSA and IOP support to help set up Theory Coffee, a new set of informal weekly talks and discussions to encourage the sharing of ideas among the Theoretical Physicists in the department.

A visit from the head of OSA Europe Yann Amouroux has helped connect POP to the two other active OSA chapters in Scotland, and the groundwork is being put down for exciting new collaborations.

Still to come is a brand-new set of peer-to-peer learning workshops, where PhD students can take knowledge they have in areas such as 3D rendering, vector illustration or new programming languages, and share it with others. Talks with SUPA are currently in place to expand the reach of these workshops to all 8 of its universities. All of us in POP look forward to finding new ways to enrich and enliven the Physics experience at Heriot-Watt over the coming year.

POP
Postgraduates of Physics
Heriot-Watt

EDUCATION AND TRAINING

CENTRE FOR DOCTORAL TRAINING IN APPLIED PHOTONICS
industry inspired: imaging | sensing | analysis

Centre for Doctoral Training in Applied Photonics

In September 2019 we welcomed the first cohort of 12 students into the new CDT in Applied Photonics. Although the branding stays the same, the new Centre has a fresh focus on imaging, sensing and analysis. In practice this means an updated training programme, with newly minted courses in Optical Imaging Concepts (St Andrews), Concepts in Signal and Image Processing (Strathclyde) and Photonics Sensors from Devices to Systems (Heriot-Watt). We've also introduced new courses in Equality and Diversity and in Responsible Research and Innovation, along with a personal development plan that students begin defining through discussion with their supervisors before formally commencing the programme. Significantly, we've now broadened our consortium to include the University of Edinburgh, who have already contributed to the training programme by providing an accredited course in Technology Innovation to many of our Year-1 students.

In April our third-Year students spent a day at Glasgow Science Centre, hosting a 'Meet the Expert" session, which occupied a large part of Floor 1.

We also celebrated some notable successes among our cohort. Mariastefania De Vido (EngD strudent and employee at STFC RAL) won the Association of Industrial Laser Users (AILU) Young UK Laser Engineer's Prize 2019, for her research project, 'Development and application of high-energy, high pulse repetition rate diode-pumped solid state lasers'; and Jonathan Crabb (CDT student, Gooch and Housego) had his research on optical transceivers for CubeSats published in Nature Communications.

Our alumni were also making an impact. Dr. Javid Khan (Holoxica) appeared on BBC news, and along with current CDT student Christopher Blackwell he represented EPSRC / UKRI research at a transatlantic workshop held in early 2019 in Washington DC. Former student Dr. Suzanne Costello was appointed Chief Operating Officer of MCS Ltd, bringing the number of alumni CEOs or COOs to six.

Our 18th CDT Annual Conference was held on 7th June 2019, attended by 90 delegates from academia and industry. Keynote talks were provided by Dr. Kristin Flagel (Univ. Glasgow, SYNAPSE) and Mr. Tom Empson (Microsoft Research 'Optics for the Cloud').

For more information on the CDT in Applied Photonics, please visit the CDT website: www.cdtphotonics.hw.ac.uk

Fig. 1 CDT students presenting at Glasgow Science Centre.

Fig. 2 Mariastefania De Vido.

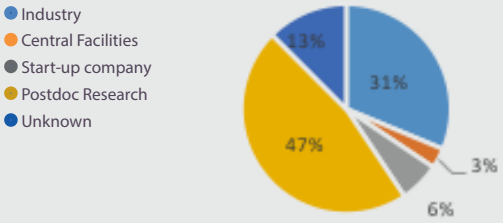
The Scottish Doctoral Training Centre in Condensed Matter Physics
An EPSRC Centre for Doctoral Training in Condensed Matter Physics

CDT Condensed Matter

The CM-CDT is a doctoral training partnership between SUPA Condensed Matter physics activities at Heriot-Watt, St Andrews and Edinburgh Universities. The CM-CDT has a threefold purpose: to provide students with a rigorous, broad graduate education across the spectrum of Condensed Matter Physics; to train them in skills that equip them for the workplace, be it industrial or academic; and to foster a vibrant, diverse research environment for their PhD projects. This endeavor is supported by EPSRC, University, Scottish Funding Council and other funding sources.

Students perform a PhD research project, take graduate level courses integrated with the SUPA Graduate School, participate in summer schools, conferences, workshops, and receive skills training relevant to their future careers. We aspire to produce well-rounded graduates equipped to lead in research, academia, and a wide range of industries and businesses.

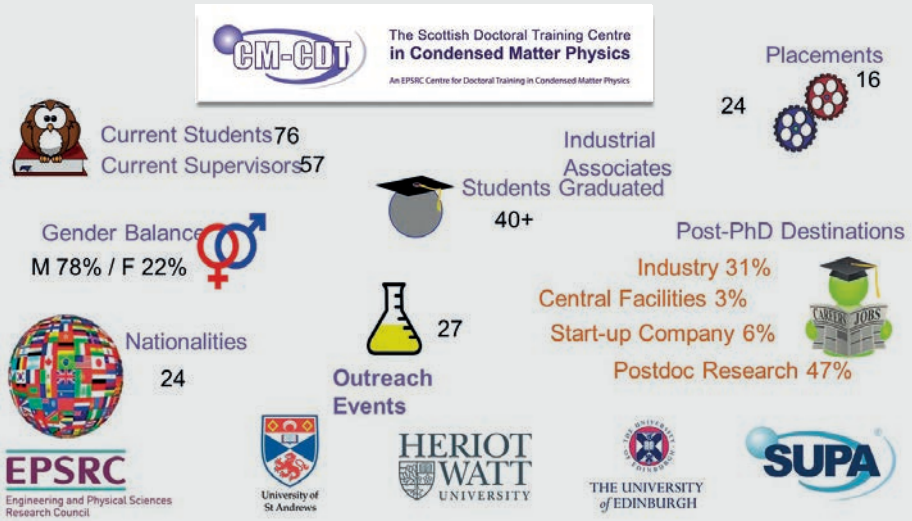
CM-CDT Student Destinations after PhD



First destinations of our graduates are shown in the pie chart above and demonstrates the wide spread of careers available to well-rounded Doctoral graduates.

The CM-CDT runs an Industrial placement programme funded by SUPA and EPSRC. Students benefit from placements with the CM-CDT Industrial Associates ranging from 2 weeks to 3 months. These placements give students the opportunities to learn about working in industry and broadens their transferable skills.

For more information on all of the above and more, see: www.cm-cdt.supa.ac.uk.



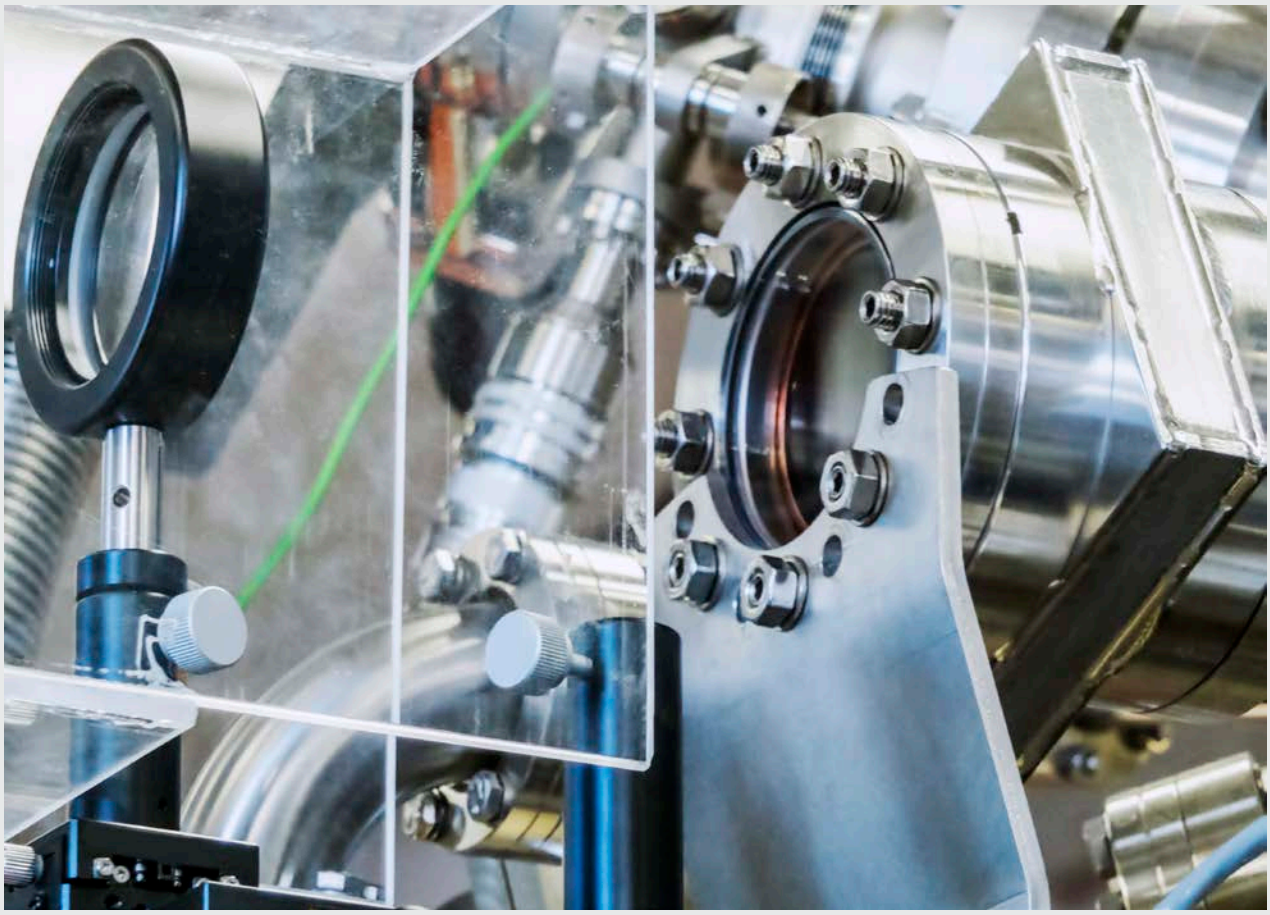
MSc in Photonics and Optoelectronic Devices (POED)

HERIOT WATT UNIVERSITY

University of St Andrews

This well-established 12-month MSc has students studying at St Andrews for semester one, Heriot-Watt in semester two, then a 3.5 month summer project that is usually undertaken in industry. This gives our students access to the broad and complementary range of photonics expertise at our two institutions. There are scholarships supported by ST Microelectronics and sponsorships from various companies for the projects and prizes. More information at www.st-andrews.ac.uk/study/pg/taught-programmes/pod-physics. This is a very successful course. So far, we have graduated more than 550 students. All the students find suitable employment just after completing the course, both in academia and industry. We aim to accept on average 15 to 20 highly qualified students in the course.

For more information contact: a.k.kar@hw.ac.uk



OUTREACH AND OTHER ACTIVITIES

Schools talks

Professor Erika Andersson
Quantum Wonderland for S4-S6, Y10-Y13

Dr Maria Ana Cataluna
Light in the fast lane: what can ultrafast lasers do? for S3-S4

Dr Alessandro Fedrizzi
Are you for real? Spooky action and other quantum mysteries for S3-S6, Y10-Y13

Professor Ian Galbraith
Astrophysics for S3-S6, Y10-Y13

Dr Erik Gauger
Quantum biology for S3-S6, Y9-Y13

Dr Brian Gerardot
Changing the light-bulb for S3-S6, Y10-Y13

Dr Robert Thomson
Using lasers to find ET for S3-S6, Y10-Y13

Summer Intern Projects

In 2019, the following Heriot-Watt University undergraduate students were awarded IPAQS summer scholarships.

Student	Project title	Supervisor
Benedict Brothers	Chalcogenide based mid-IR sources	Ajoy Kar
Hannah Turner	Evaluate a circular polariscope to measure the retardation of light	Daniel Esser
Kate Robertson	Frequency-resolved optical gating (FROG)	Dave Townsend
Ross Urquhurt	Gravitational interactions between quantum particles	Fabio Biancalana
Catalina Dobas	Epsilon-near-zero frequency resolved optical gating (ENZ-FROG)	Marcello Ferrera
Clara Flegel	Multipartite entanglement in high dimensions	Mehul Malik
Joel Priestley	Wave packets in laser induced molecular dynamics	Patrik Ohberg
Sean Anderson	Wave packets in laser induced molecular dynamics	Patrik Ohberg
Diana Hunter	Laser source development for life sciences microscopy	Richard McCracken
Matthew Robb	Optical ground station technology for satellite-based quantum communications	Ross Donaldson
Finley Giles-Book	Optical ground station technology for satellite-based quantum communications	Ross Donaldson

Seminars

Amit Finkler, Weizmann Institute, Diamond spectroscopy of molecules - spin pair steps

Krystian Wlodarczyk, Heriot-Watt University, Picosecond laser manufacturing of glass microfluidic devices for the study of flow and reactive transport in porous media

Wojciech Gora, Heriot-Watt University, Laser polishing - a way of improving surface quality of additively manufactured parts

Yonatan Dobi, Ben Gurion University of the Negev, Plasmonic photo-catalysis – 'hot electrons' or just heating?

Henry Bookey, FCAP, Applied photonics – from the lab table to the land, sea and air

Erika Andersson, Heriot-Watt University, Things to do with your quantum key distribution setup: signatures and oblivious transfer

Ilaria Gianani, Università degli Studi Roma Tre, Quantum metrology: practically as perfect as it gets

Vinod Menon, IEEE Photonics Society, Quantum photonics using 2D materials

John Hannay, University of Bristol, The windings correlation for a closed random walk (Brownian, Feynmanian, or polymer loop)

Allard Mosk, University of Utrecht, Speckle correlations and Image information in turbid media

Will McCutcheon, University of Bristol, Characterising photon pair sources beyond joint-spectra

Pauline Boucher, Laboratoire Kastler-Brossel – Ecole Normale Supérieure, Spatial mode multiplexing: from fundamental concepts to applications

Daniel Horke, Radboud University, Towards ultrafast dynamics in controlled molecules

Natalia Ares, University of Oxford, Quantum devices for thermodynamics at the nanoscale

Nick New, Optalysys, Ultra-fast coherent optical processing

Gianluca Galzerano, Politecnico di Milano, Ultrafast mid-infrared laser systems

Ann Fitzpatrick, Diamond Light Source Ltd, Developing time-resolved experiments at Diamond Light Source

Raffaele Santagati, University of Bristol, Learning the dynamics of quantum systems using Statistical Inference

Ursula Keller, ETH Zurich, From SESAM to Attoclock: A 30-year ultrafast journey

Saroch Leedumrongwatthanajun, Kastler-Brossel Laboratoire, École Normale Supérieure, Exploring a multimode fibre for programming linear quantum networks

Helder Crespo, University of Porto, New tools for extreme ultrafast science and applications

Predrag Milojkovic, Office of Naval Research, Funding opportunities for UK scientists

Steen Hanson, Technical University of Denmark, Introduction to complex-valued ABCD-matrices (Canonical Transforms) and associated statistical problems

Steen Hanson, Technical University of Denmark, Speckles – how to analyse, utilise and commercialise

Fabio Biancalana, Heriot-Watt University, The most outrageous theory in Physics

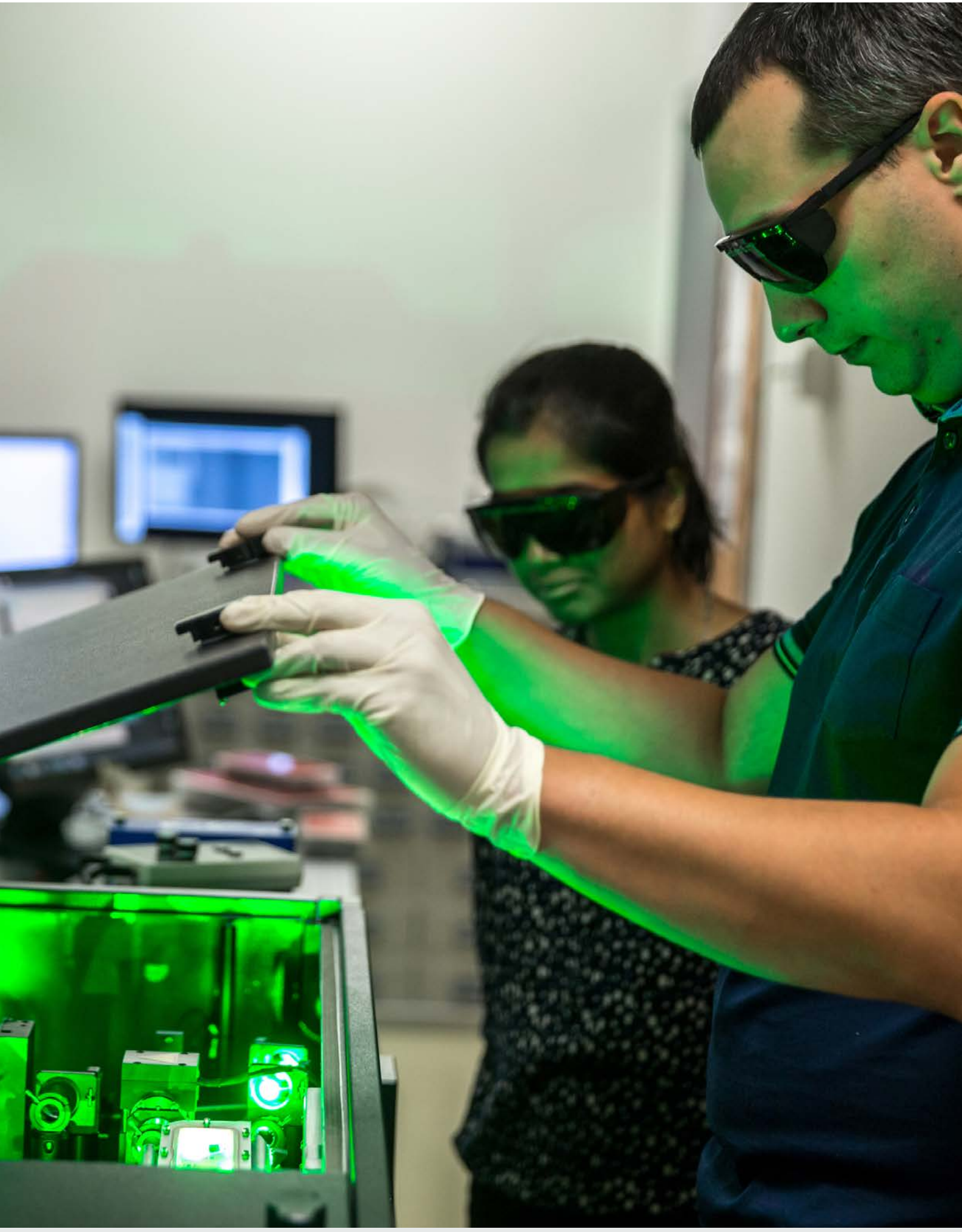
Alexander Legant, Nanoscribe, Highest resolution 3D printing in research and prototyping

Manuel Erhard, IQOQI, Science fiction or reality? The teleportation of high dimensional quantum S

Srinjoy Mitra, University of Edinburgh, Electronics for healthcare and neuroscience

Mishkat Bhattacharya, Rochester Institute of Technology, Optical tweezer phonon laser

Velimir Meded, Institute of Nanotechnology, KIT, Optoelectronic properties and functionality of low dimensional hybrid nanostructures



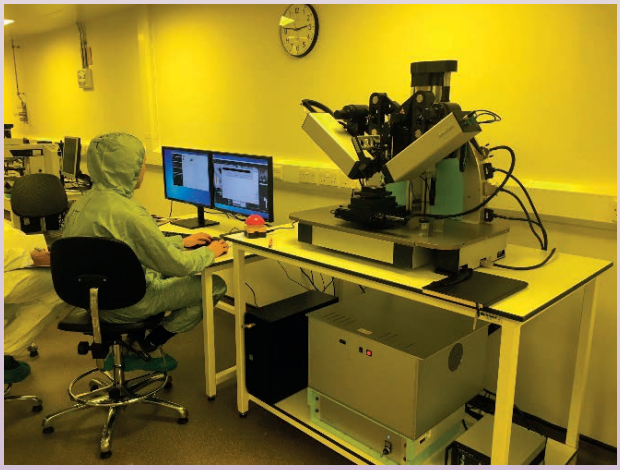
FACILITIES AND EQUIPMENT

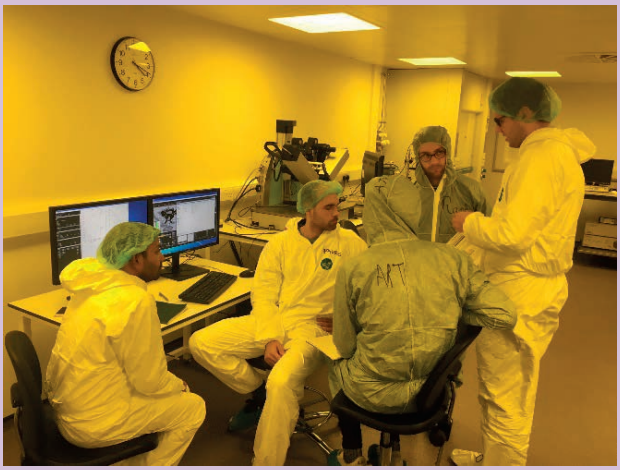
Facilities

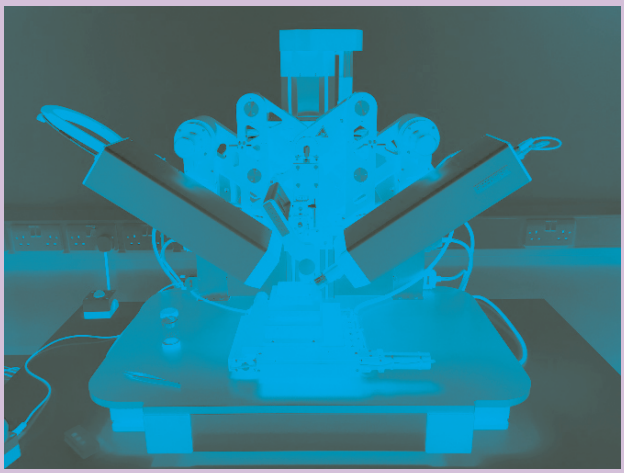
Cleanroom

HWU's newly refurbished EPS Cleanroom has recently been enhanced with the integration of the new EPSRC Two-Dimensional Photonics Fabrication Facility, a unique world-leading facility capable of characterising two-dimensional materials and rapid fabrication of bespoke photonic devices.

The 2D fabrication facility is comprised of four main instruments to complement the array of existing cleanroom equipment. The centrepiece instrument, a "maskless" direct write laser, is a lithographic tool to rapidly fabricate large scale but bespoke 2D photonic devices with novel functionalities. The maskless laser writer bridges the gap in lateral resolution and write speed between electron beam lithography and conventional photolithography to enable rapid fabrication of nanoscale photonic devices over large areas. The unique lithography system is augmented by an electron beam evaporator enabling deposition of high-quality metals and dielectrics with nanometre precision onto devices lithographically defined by the direct write laser. Finally, for the ultimate in thin-film, surface and materials metrology, a spectroscopic imaging ellipsometer (EP4 from Accurion) is used.
This unique instrument is crucial for characterization, either pre- or post-fabrication by the lithographic tool, of emerging two-dimensional semiconductor devices.
The Facility is completed by a custom-designed glovebox with integrated optical characterization tools for the bespoke fabrication and initial characterization of robust and pristine 2D semiconductor heterostructures.
With this setup, one can create new quantum devices with all degrees of freedom – even the angle of rotation between the different crystal layers, encapsulate them, and even deterministically incorporate them onto photonic chips for applications in both classical and quantum photonics.

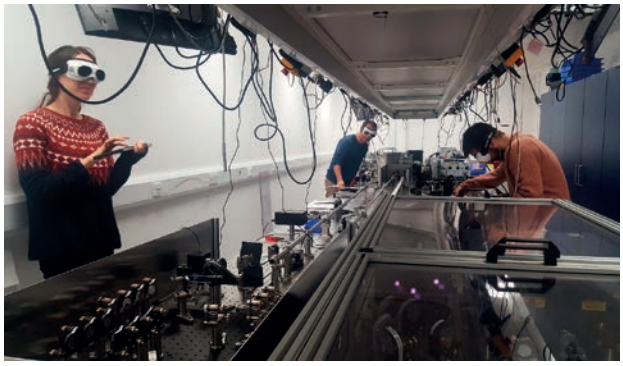






Laboratories

HISOL beam-line in the new LUPO laboratory



Professor John Travers (centre) and two of his PhD students Teodora Grigorova and Athanasios Lekosiotis work on the HISOL beam-line in the new LUPO labs of the David Brewster Building.

The new Laboratory of Ultrafast Physics and Optics (LUPO), run by Dr. John Travers, was constructed in 2016 and commissioned in 2017. The refurbishment and new research activity is funded by €1.7m from a European Research Council Starting Grant (HISOL) and start-up funding from the School of Engineering and Physical Sciences. The work in the LUPO-labs is focused on the production of new light sources through ultrafast nonlinear optics, especially in the extended propagation regime (i.e. fibres, hollow-waveguides and filamentation). We then apply these sources to study fundamental linear and nonlinear light-matter interaction using advanced ultrafast spectroscopy techniques, both in-house and through collaborations. Our first vacuum and deep ultraviolet beam-line (running from the left-hand corner of the picture to the vacuum chamber next to Dr. Travers in the centre) has just seen "first-light", producing more than 20 µJ in near single-cycle pulses, tunable from 110 nm to 300 nm.

Laser Laboratory

A new laser lab has been commissioned for IPAQS. The lab is located in the ground floor of the Scott Russell building and was ready at the end of 2017. The lab will support the research of Dr. Maria Ana Cataluna and her group, funded by an ERC Starting Grant (UPTIME: Real-TIME probing of Ultrafast Phenomena). Among other lines of research, the lab will support the development of novel high-speed optical sensing methods and corresponding applications, new semiconductor ultrafast/tunable lasers and systems and ultrafast spectroscopy to investigate the dynamics of semiconductor materials.

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