Aston University
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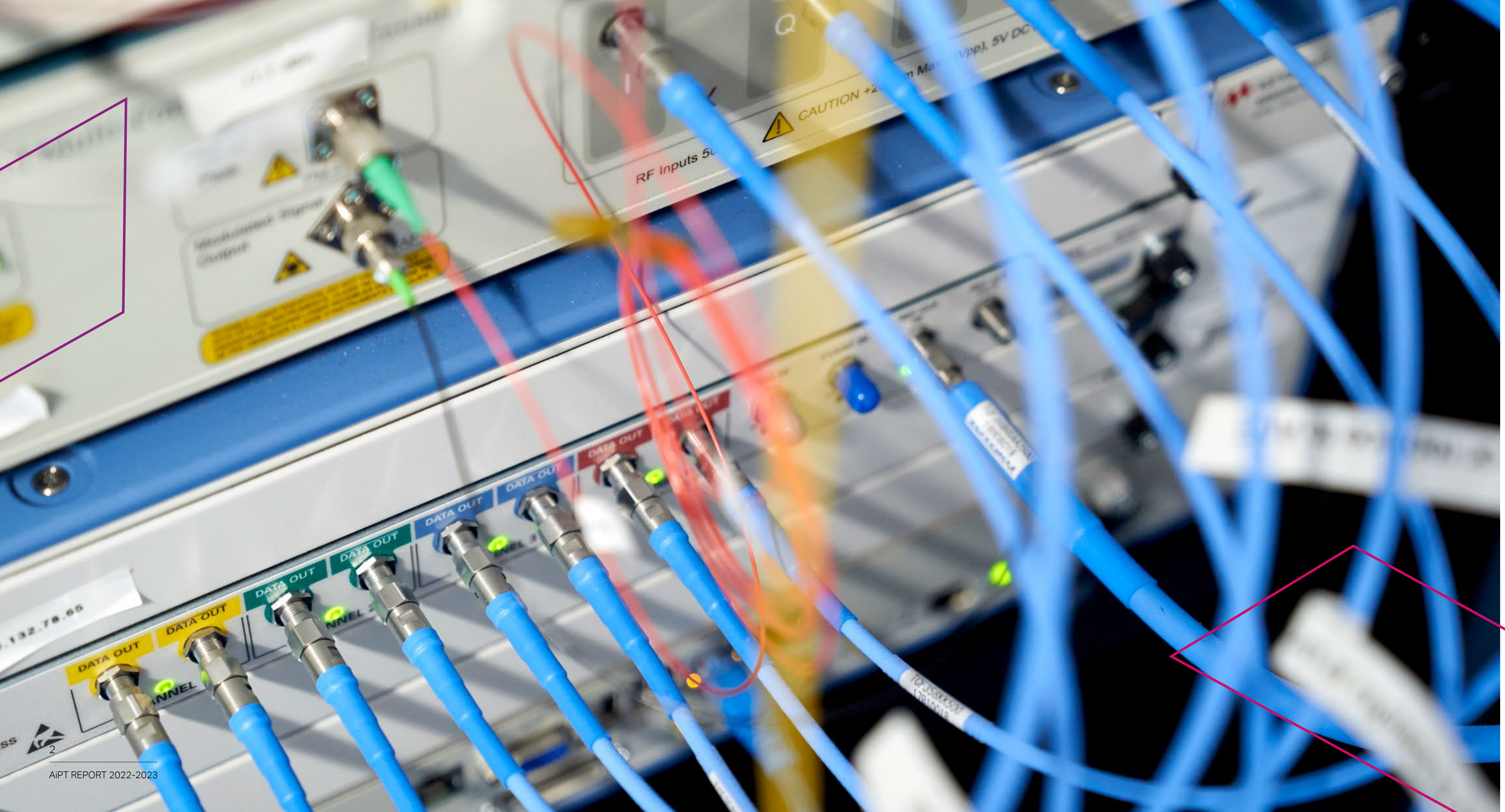
AiPT
Aston Institute of
Photonic Technologies

Annual Report 2022 – 2023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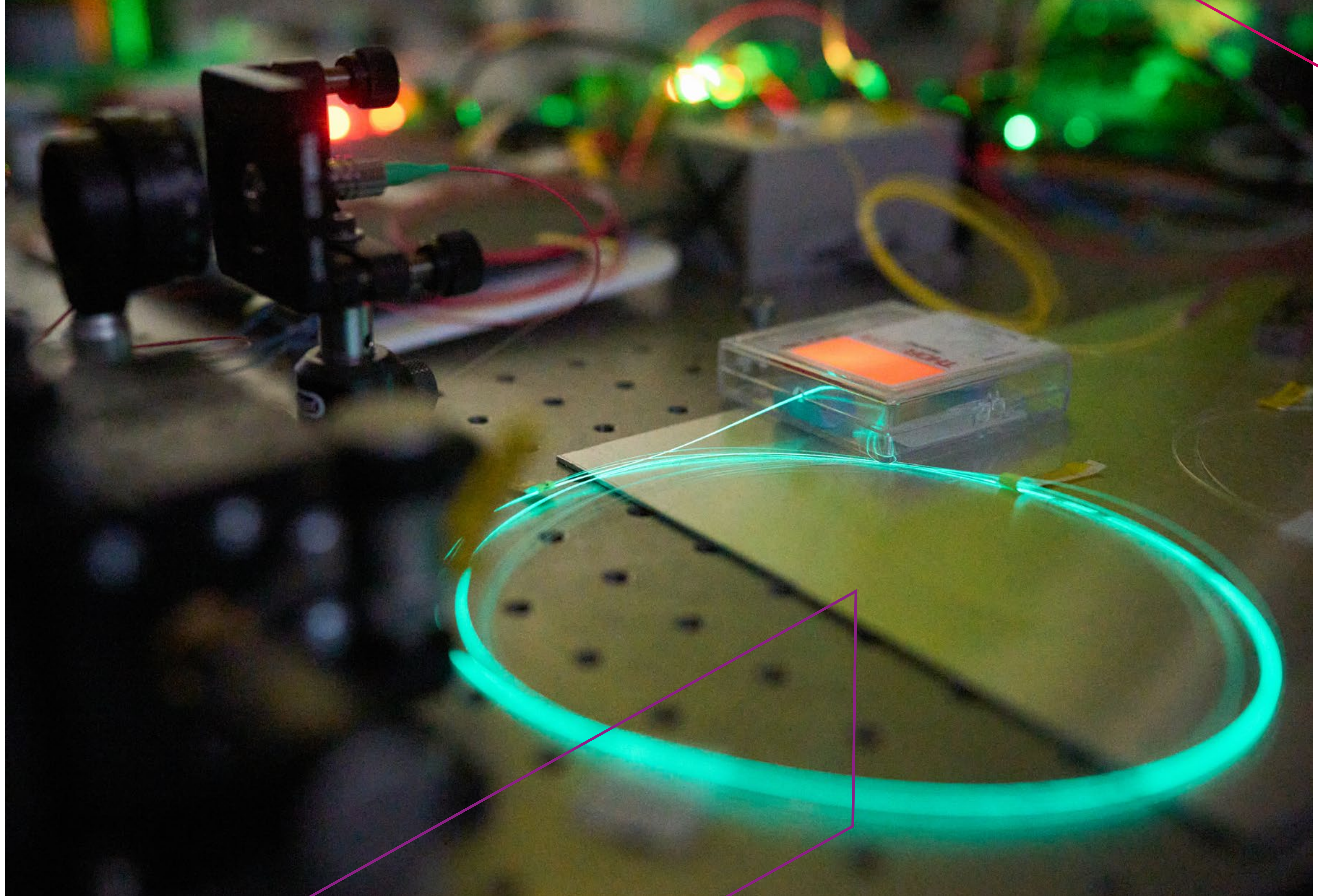
INTRODUCTION



We are pleased to present the Aston Institute of Photonic Technologies (AiPT) Annual Report 2022-2023. Here, we encapsulate our endeavours, achievements, and insights over the past few years, reflecting on our unwavering commitment to the principles of impact, excellence, collaboration, and sustainability, as outlined in Aston University's Research Strategy. We also try to have fun while doing these serious and important things.

Our mission is to generate and advance knowledge and innovation in photonics through research integrated with education, has been the guiding force behind our activities. We strived to translate scientific breakthroughs into technology, aiming to make a significant industrial, economic, and societal impact.

Our vision is to be a centre of excellence in photonics with global visibility and a reputation as a trailblazer in research and innovation. We worked to expand our capabilities, build strong industrial links, foster knowledge transfer and be an attractor to bright researchers around the world. Our reputation, both nationally and internationally, continues to grow, reflecting our achievements in research, technology and impact.

Our aims are ambitious, yet we have made significant strides towards achieving them. We attracted world-leading academics, talented young researchers, and students, and developed world-class laboratory facilities with a firm and infrangible support and trust of Aston University.

In 2022-2023 we navigated a bustling landscape of events and milestones and this report provides a detailed account of the AiPT research activities, our dedication to tailored education and training, and our international and industrial collaborations. It also offers an overview of the numerous events we have hosted and participated in, demonstrating active engagement with the broader scientific community. It also features our outreach and public engagement activities, integral to our mission of making a societal impact.

Guided by our four interconnected strategic goals: research, post-graduate education, translational activities, and public outreach, we look back on the last few years filled with challenges and achievements with a sense of accomplishment and optimism for the future. We invite you to delve into the pages that follow, to gain a deeper understanding of our work, and our ongoing journey in the realm of photonic science and technology.

AiPT Members in 2022-2023

Academic Staff

Professor Sergei Turitsyn
Professor Andrew Ellis
Professor Wladek Forysiak
Professor David Webb
Professor Edik Rafailov
Professor Kate Sugden
Professor Misha Sumetsky
Professor Nick Doran
Professor Richard Hogg
Professor Keith Blow, Emeritus Professor
Professor Lin Zhang, Emeritus Professor
Associate Professor Sergey Sergeyev
Associate Professor Stylianos Sygletos
Dr Alex Rozhin
Dr Elena Turitsyna
Dr Ian Phillips
Dr John Williams
Dr Kaiming Zhou
Dr Paul Harper
Dr Petro Lutsyk
Dr Richard Nock
Dr Shu Xuewen

Research Staff

Dr Abdallah A.I.Ali
Dr Aleksandr Donodin
Dr Aleksandr Koviarov
Dr Amit Yadav
Dr Aneesh Sobhanan
Dr Asif Md Iqbal
Dr Auro Perego
Dr Chandra Gaur
Dr Daniel Hill
Dr David Benton
Dr Dmitry Stoliarov
Dr Egor Manuylovich
Dr Eugene Obodo
Dr Florent Bessin
Dr Gabriella Gardosi
Dr Hani Kbashi
Dr Lucas Souza (part LHS)
Dr Manuel Crespo
Dr Marco Della-Gala
Dr Mariia Sorokina
Dr Mingming Tan
Dr Mohammed Umar Patel
Dr Morteza Kamalian Kopae
Dr Muhammad Malik
Dr Muhidin Mohamed
Dr Nand Kishor Meena
Dr Natalia Bazieva
Dr Pavel Skvortcov
Dr Pratim Hazarika
Dr Raghavan Chinnambedu-Murugesan
Dr Ricardo Da-Silva
Dr Sergei Sokolovski
Dr Shabnam Noor
Dr Sonia Boscolo
Dr Steven Daniels
Dr Tatjana Gric
Dr ThanTu Nguyen
Dr Victor Dremin
Dr Vitor Ribeiro
Dr Vladimir Gordienko
Dr Vladimir Osipov
Dr Vladislav Dvoyrin
Dr Yang Lu
Dr Yaroslav Prylepskiy
Dr Yiming Li
Dr Zhijia Hu
Dr Zhiqiang Wang
Dr Zhouyi Hu

Research Students

Aisha Bibi
Alberto Rodriguez Cuevas
Arooj Khalid
Atif Syed Igrar
Diana Galiakhmetova
Diego Argüello Ron
Dini Pratiwi
Egor Sedov
Geraldo Gomes
Igor Kudelin
Karina Nurlybayeva
Long Hoang Nguyen
Mahmood Abu Romoh
Marie Zandi
Mariia Bastamova
Mike Anderson
Minji Shi
Mohammad Hosseini
Namita Sahoo
Nasir Garba Bello
Negar Shaabani Shishavan
Nelson J Castro Salgado
Pedro J Freire
Peiyun Cheng
Qing Wang
Paulami Ray
Sajid Zaki
Sasipim Srivallapanondh
Stepan Bogdanov
Victor Vassiliev
Vladislav Neskorniuk

Professional Staff

Adriana Svetozarova
Christiane Doering-Saad
Claire Lindow
Karola Woods
Kirill Tokmakov
Martin Grant
Martina Pasini
Miriam Messiha
Nadira Begum
Natalia Manuilovich
Swaroopa Mucheli-Sudhakar
Tatiana Kilina
Tetyana Gordienko
Valentina Barker

HIGHLIGHTS

AiPT newly appointed professor

Professor Richard Hogg joined AiPT in May 2023 to focus on research and commercialisation. He brings with him outstanding experience in semiconductor optical devices, which complements the Institute's nano and grating device technologies and will support the curiosity- and applications-driven research programmes in fibre lasers, optical communications, agricultural phonics and sensing. Professor Hogg previously held a professorship at the James Watt School of Engineering, University of Glasgow, and will continue to expand his research into novel light-emitting devices spanning the UV to THz regions of the spectrum. He will work with AiPT collaborators to develop these devices for a wide range of application areas.

Grants and Awards recent news

The AiPT team (which includes Professor Sergei Turitsyn as principle investigator and project coordinator, **Dr Morteza Kamalian-Kopae** and **Professor Wladek Forysiak** as co-investigators, and AiPT managers **Christiane Doering-Saad** and **Tatiana Kilina** as key contributors to the proposal) was awarded a highly competitive €2.7 million Horizon Europe project – the Marie Sklodowska-Curie Doctoral Network NESTOR (next generation high-speed optical networks for metro access). **Paul Knobbs** and **Suzie Hayman** from Research and Knowledge Exchange (RKE) helped with the NESTOR proposal preparation. The NESTOR consortium includes leading European academic centres and major telecom industry players including Infinera, BT, Orange, SM-Optics, VPI and Ericsson. NESTOR will provide ten doctoral students with a uniquely broad education in digital and photonic technologies, ranging from recent advances in artificial intelligence (AI) and machine learning to real-world telecom engineering, which will enable them to design and implement high-capacity access and metro networks that are the core infrastructure for the digital future of Europe.

Professor Wladek Forysiak received a three-year grant from the Engineering and Physical Sciences Research Council (EPSRC) titled: "All-Raman Optical Amplification for Next Generation Ultra-Wideband Optical Networks (ARGON)". The research programme, worth £978,000, will be carried out with co-investigators Dr Paul Harper and Dr Ian Phillips, two research fellows and industrial partners II-VI Photonics, BT and Corning.

Associate Professor Sergey Sergeyev was awarded a Leverhulme Trust Grant worth £176,000 for his project "Harnessing Vector Soliton Supramolecular Structures". The research is based on a bio-inspired approach to revealing mechanisms of how the interactions between individual system components driven by localised external perturbations produce large-scale collective patterns. The research will potentially lead to new designs of complex engineering networks including wireless communication and sensing networks, as well as power grids.

Professor Andrew Ellis leads the AiPT team in the Transforming Systems through Partnership (TSP) grant funded by the Royal Academy of Engineering. The project titled "Fibre Before the Fibre: Bridging the Digital Divide in Informal Settlements" is coordinated by the University of the Witwatersrand (South Africa) in partnership with Aston and the University of Glasgow. The total award is £171,978.

The Royal Academy of Engineering has awarded **Associate Professor Sergey Sergeyev** £100,000 as an Industrial Fellowship (Energy Thematic Round) for the project 'Improving the Energy Efficiency of Wind Turbines". In a collaboration with the sensor technology industrial partner Insensys, Sergey will develop a novel, cost-effective method for monitoring the blade shape of wind turbines. The new technology is a result of his research on the polarisation properties of light, fibre optic sensors and laser physics, supported by the Aston University photonics facilities.

Dr Alex Rozhin, a lead of the Nanoscience Research Group, together with Dr Boris Kysela from Aston Medical School, were successful in applying for a Researcher at Risk Fellowship worth £84,000 for Dr Yuliya Kremenska, a biomedical researcher from Ukraine. The goal of the project is to develop a foundation for the nanomedical treatment of neurodegenerative diseases and cancer.

AiPT Professors have been awarded £180,000 by the British Council to establish a scholarship programme for women in STEM. The award will allow AiPT to host three one-year female postdoctoral fellows from Southeast Asia. The programme aims to have an impact on the fellows' careers and their countries by developing photonic technologies for healthcare, low-cost medicine, food and agriculture. The fellows hope to apply the knowledge and new technologies obtained during the programme in their region.

Professor Edik Rafailov, together with Professor Rhein Parri (Pharmacy) and Dr Eric Hill (Biosciences), have been awarded a £200,000 EPSRC New Horizons grant which aims to support high-risk, speculative engineering or information and communication technologies research with a potentially transformative impact. The project "Scaff-Net" aims to develop technology combining human stem cell-derived neuronal networks, 3D printing and electrical recording to enable increased throughput screening of drug candidates.

Associate Professor Stelios Sygletos (principal investigator), **Professor Wladek Forysiak** (co-investigator) and **Professor Andrew Ellis** (co-investigator) have been awarded a £250,000 UKRI research grant under the EPSRC's New Horizons, high-risk speculative engineering and ICT research scheme. The project will focus on the development of new transceiver units for optical and 5G/6G wireless communication systems, exploiting pioneering concepts of photonic-analogue signal processing and machine learning enabled digital signal processors (DSPs).

Dr Richard Nock has been awarded £200,000 as part of the £511,000 Innovate UK Commercialising quantum technologies grant for the project "Photon Absorption Spectroscopy Camera for Leaks (PASCAL)". This is a collaborative effort between QLM Technology Ltd, Aston University and Redwave Labs and will develop a novel high-speed and highly sensitive photon counting greenhouse gas detection camera which will help monitor and localise greenhouse gas emissions. Novel photon counting instrumentation will also be developed.

Dr Mingming Tan and **Professor Wladek Forysiak**, together with Dr Ben Puttnam from the National Institute of Information and Communications Technology (NICT) in Japan have been awarded a Royal Society International Exchange grant of £12,000 for the project "Ultra-High Capacity, Ultra-Wideband, Space-Division Multiplexed Optical Fibre Communication Systems". NICT Japan is a world-leading research institute with long-standing scientific excellence in optical communications. This project aims to explore ultra-wideband space-division multiplexing technology, enabling an order of magnitude growth in optical communication capacity.

Dr Auro M Perego has been awarded a £12,000 Royal Society International Exchanges grant for his two-year project "Instability-Driven Versatile Mode-Locked All-Fibre Lasers Emitting in the Short-Wave Infrared Wavelength Range". Dr Perego will collaborate with Dr Maria Chernysheva from the Leibniz Institute of Photonic Technologies in Jena, Germany, on developing novel methods for generating laser light pulses in the challenging two microns wavelength spectral region, to unlock novel possibilities for medical and sensing applications.

Dr Pratim Hazarika and **Dr Aleksandr Donodin** were awarded £9,470 from the Aston Research Impact Fund to organise a workshop to bring together academic and industrial stakeholders in the telecommunications industry. The event was held at Aston University on 18 and 19 May 2023, with the aim of addressing the key challenges in optical communication, particularly focusing on the complexity of band-limited transmission systems. The workshop featured a number of distinguished national and international researchers from the industry including Dr Ming-Jun Li of Corning USA, a research partner of AiPT who was recently awarded the 2023 John Tyndall prize, a major award in the optical communication field.

Dr David Benton and **Valentina Barker** have been awarded funding for a project titled "Multichannel, Multispectral LIDAR with a Micromirror Array-Based Streak Camera". This six-month project is the first stage of a multistage development process. This new concept in light detection and ranging (LiDAR) is the first award through a platform called SERAPIS, supported by the Defence Science and Technology Laboratory (DSTL).

AiPT at Conferences and Workshops


AIPT team at TOP Conference 2022

TOP Conference 2022/2023

AIPT researchers contributed to the "Telecommunications, Optics and Photonics Conference" (TOP Conference) in both 2022 and 2023, presenting their recent research results. The conference provided excellent networking opportunities for optical and photonic component and systems manufacturers and developers, along with fibre infrastructure and data centre providers. It focused on the development and application of optics and photonics in telecommunications and data centres, with presentations on photonic components and free-space optics. In both years, Professor Wladek Forysiak co-organized and co-chaired some sessions, joining leading UK and EU academic and industry figures in presenting at the conference.


From left to right: Emadreza Soltanian (imec), Pratim Hazarika, Prof Wladek Forysiak, Dr Andrew Lord (BT)

IEEE Summer Topical Meetings 2022

11-13 July 2022, Cabo San Lucas, Mexico

Professor Wladek Forysiak, Dr Mingming Tan and Dr Pratim Hazarika, represented AiPT at the IEEE Photonics Society Summer Meeting Series giving three presentations and chairing eight sessions on the UWB – Ultra-wideband Optical Fibre Communication Systems topic area, and also presenting a virtual labs tour showcasing AIPT's outstanding facilities in optical communications.


From left to right: Prof Wladek Forysiak, Pratim Hazarika, Dr Abdallah A I Ali, Pedro J. Freire

OFC 2022

6-10 March 2022, San Diego, California, USA

OFC, Optical Fiber Communication Conference, took place in San Diego, US, 6-10 March 2022. It was one of the first post-COVID conferences run on-site. For more than 40 years, OFC has been the premier destination for converging breakthrough research and innovation in telecommunications, optical networking, fibre optics, datacom and computing.


From left to right: Alberto Rodríguez Cuevas , Manuel Crespo, Dr Gabriella Gardosi, Dr Auro Michele Perego, Qing Wang, Prof Misha Sumetsky

Photon 2022

30 August-2 September 2022, Nottingham, UK

Photon 2022 was the eleventh conference in a biennial series that started in 2002, covering optics and photonics. During the event, participants had the opportunity to hear from leading technology experts in the field, attend lectures from leading technology experts, and visit the exhibition profiling the latest in optics and photonics technology. AiPT was represented by the SNAP group led by Professor Misha Sumetsky, as well as by Dr Auro Perego, and some researchers from the EC project MEFISTA.


Participants of the Summer School Machine Learning Photonics 2022


From left to right: Long Hoang Nguyen, Pedro J. Freire, Nelson Castro Salgado, Egor Sedov, Prof Sergei Turitsyn and Sasipim Srivallapanondh

Summer School Machine Leaning Photonics 2022

Lake Como School of Advanced Studies, Como, Italy August 29 – September 2, 2022.

For many years, AiPT is a co-organiser of the Summer School 'Machine Learning in Photonics', which brings together experts in emerging photonic technologies, machine learning techniques, and fundamental physics who will share with young researchers their knowledge and interdisciplinary approaches for understanding and designing complex photonic systems and their practical applications. In 2022, the school the organisation was supported and linked to several EU-funded projects coordinated by AiPT – FONTE (GA766115), REAL-NET (GA 813144), MOCCA (814147), MEFISTA (GA 861152), POST-DIGITAL (GA 860360), MENTOR (GA 956713), WON (GA 814276), MULTIPLY (GA 713694).

ECOC 2022

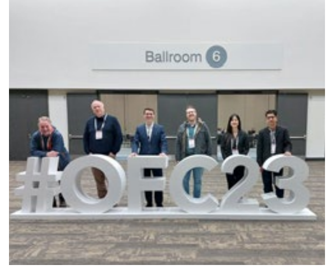
18 – 22 September 2022, Bazel, Switzerland

From left to right: Mariia Bastamova, Dr Yaroslav Prilepskiy, Aleksandr Donodin, Prof Wladek Forysiak, Dr Vladimir Gordienko, Diego Arguello Ron, Sasipim Srivallapanondh, Karina Nurlybayeva, Pedro J. Freire, Prof Sergei Turitsyn

SPIE Photonics West 2023

22-27 January 2023, San Francisco, USA

From left to right: Diana Galiakhmetova, Prof Edik Rafailov, Dr Gabriella Gardosi, Prof Misha Sumetsky, Dr Daniel Hill, Prof Wladek Forysiak, Dr Manuel Crespo, Aisha Bibi



OFC 2023

OFC 2023, 5-9 March 2023 San Diego, California, USA

From left to right: Prof Wladek Forysiak, Prof Sergei Turitsyn, Dr Vladimir Gordienko, Aleksandr Donodin, Sasipim Srivallapanondh, Pratim Hazarika

CLEO 2023

The Conference on Lasers and Electro-Optics 7-12 May 2023, San Jose, California

From left to right: Igor Kudelin, Diego Arguello Ron, Long Hoang Nguyen, Dr Sonia Boscolo, Prof Wladek Forysiak, Sasipim Srivallapanondh, Prof Sergei Turitsyn

Honours and awards

Diana Galiakhmetova at SPIE Photonics West 2023

PhD student **Diana Galiakhmetova** from the Laser and Biomedical Photonics group won the first prize at the JBO / Neurophotonics competition presenting NEUROPA project results at the SPIE Photonics West Conference in San Francisco on 31 January 2023.

Mark Elliott (Europa Science Ltd) and Dr Gabriella Gardosi at SPIE Photonics West 2023

Dr Gabriella Gardosi was named in the Photonics top 100 by Electro Optics and is among those at the cutting edge of photonics evolution. Gabriella's work has been breaking precision boundaries in optical microresonator fabrication. The AiPT team developed a new method for fabricating ultralow-loss optical microresonators and the technique may yield more surprises in unlocking 'slow light' devices. It's an ambition that has been challenging researchers for years and Gabriella has been incorporating micro-fluidics into the SNAP platform to better utilise thermal methods to tune microresonators under development.

Prof Edik Rafailov

Professor Edik Rafailov has been elected a Fellow Member of Optica (formerly OSA) by the society's Board of Directors. Optica is committed to advancing knowledge in optics and photonics globally through research, application, archiving and dissemination. Fellowship in Optica is a prestigious honour reserved for distinguished members who have made significant contributions to the field. It is limited to no more than ten per cent of the membership. Professor Rafailov has been recognised for his outstanding contributions to the development of novel gain media for semiconductor lasers, particularly in the 750nm to 1300nm wavelength range.

Pedro J Freire and René-Jean Essiambre (the IEEE Photonics Society President)

In 2022, the AiPT Early Stage Researcher **Pedro J Freire** received the prestigious IEEE Photonics Society Graduate Student Scholarship Award for outstanding achievements in applications of machine learning methods in optical communications. The ceremony took place during the 35th IEEE Photonics Conference, which was held in Vancouver, BC, Canada from 13-17 November, 2022.

Anne, the Princess Royal and Prof Sergei Turitsyn at the ceremony of the Royal Academy of Engineering. Draper's Hall, London, 8 November 2022.

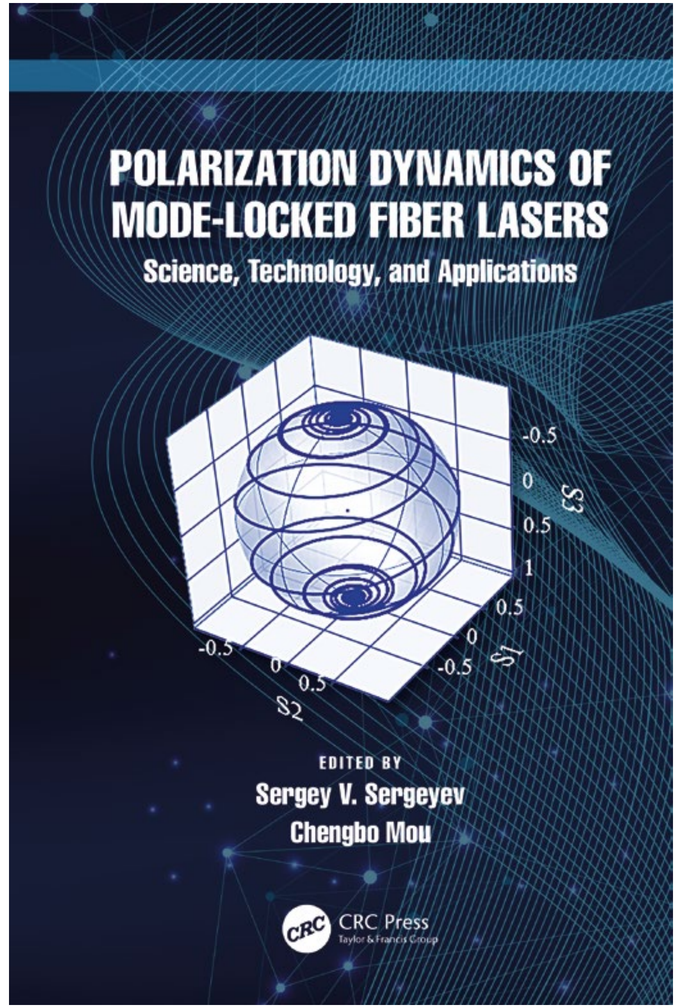
Professor Sergei Turitsyn has been elected a Fellow of the Royal Academy of Engineering. Fellows are nominated by their peers based on their engineering accomplishments. The Academy Fellows are chosen from the leading business people, entrepreneurs, innovators and academics in engineering and technology. Professor Turitsyn is a world-renowned expert and the originator of several key concepts in the fields of nonlinear photonics, optical fibre communications and fibre lasers. His work lies at the interface between fundamental nonlinear science and engineering applications of photonics.

AiPT PhD students **Paulami Ray** and **Aisha Bibi** are the overall winners of the Ashok and Rupa Kochhar Engineering Prize for Outstanding Achievement for 2022 and 2023. The prize was established in 2020 by Professor Ashok Kochhar and his wife Rupa, who wanted to give back to the Aston student community and encourage students to aim for the very best. Professor Kochhar was Executive Dean of the School of Engineering and Applied Science from 1999 to 2008 and was named Professor Emeritus in 2011.

Featured Publications

A paper titled 'Diagnosis of Skin Vascular Complications Revealed by Time-Frequency Analysis and Laser Doppler Spectrum Decomposition,' authored by **Professor Igor Meglinski** (Mechanical, Biomedical and Design Engineering) and **Dr Victor Dremin** of AiPT, has been selected as a featured article in the IEEE Transactions on Biomedical Engineering. Professor Meglinski is the lead author, and Dr Dremin is a key researcher on the paper.

Associate Professor Sergey Sergeyev with the Institute's collaborator **Dr Chengbo Mou** from Shanghai University published the book titled "Polarization Dynamics of Mode-Locked Fiber Lasers". This book provides a comprehensive review of the latest research on the science, technology, and applications of mode-locked fiber lasers generating pulse trains with the evolving state of polarization at time scales ranging from a few pulse widths to 10,000 laser cavity round-trip times. It supports readers with a timely source of information on the current novel scientific concepts, and cost-effective schematics, in addition to an overview of the feasible applications. The book aims to demonstrate for the nonlinear science community a newly emerging field of nonlinear science, and so stimulates the development of new theoretical approaches and opens new horizons for the photonics community by pushing boundaries of the existing laser systems towards new applications. The new classes of optical sources and photonic devices explored in this book will be relevant with applications to other fields, including medicine, bio-photonics, metrology, and environmental safety.



Dr Gabriella Gardosi and **Professor Misha Sumetsky**, in collaboration with researchers from OFS Laboratories (USA) Dr Brian Mangan and Dr Gabe Puc, demonstrated the fabrication of optical microresonators with unprecedented picometre precision. This achievement resulted from the development of the slow cooking fabrication method recently discovered by Dr Gardosi. The new method is expected to have a variety of applications, ranging from optical communication devices to food industry sensors. This result has attracted the attention of public media and was announced on the website of the Electro Optics Magazine and in the editorial paper of this journal's October 2022 issue.

Dr Sonia Boscolo published a research paper entitled 'Farey tree and devil's staircase of frequency-locked breathers in ultrafast lasers' in the top multidisciplinary sciences journal Nature Communications. This work demonstrates for the first time that a fibre laser working in the breathing soliton generation regime is a nonlinear system showing frequency locking at Farey fractions, where the locked breather states occur in the order they appear in the Farey tree and within a pump-power range equalling the width of the corresponding step in the devil's staircase. The breather laser may, therefore, serve as a simple test bed to explore ubiquitous synchronisation dynamics of nonlinear systems. The locked breathing frequencies feature a high signal-to-noise ratio and can give rise to dense radio-frequency combs, which are attractive for applications. The research was conducted in collaboration with scientists from East China Normal University (Shanghai, China) and Université de Bourgogne – Franche Comté (Dijon, France).

Dr Auro Perego and **Dr Florent Bessin** together with Professor Arnaud Mussot of the Université de Lille (France), have published in 'Physical Review Research' (American Physical Society) 'Complexity of Modulation Instability', the first study of the computational complexity of modulation instability of light waves propagating through an optical fibre. The proposed method can be applied to a variety of other domains from photonics to fluid dynamics and biology, in order to characterise complex systems where there is an interplay between nonlinearity and noise.

Dr Petro Lutsyk and **Dr Alex Rozhin** published a research article in Dyes and Pigments (Q1 in Chemical Engineering, Applied Chemistry), entitled "Excited State Relaxation in Cationic Pentamethine Cyanines Studied by Time-Resolved Spectroscopy". This work reports on establishing a novel model of relaxation for carbon chain-based molecules of dye characterized by symmetric and non-symmetric structures. The research was conducted in collaboration with scientists from the Institute of Physics, Institute of Bioorganic Chemistry and Petrochemistry, and Institute of Organic Chemistry (all National Academy of Sciences of Ukraine).

RESEARCH AREAS

Optical Communications

The capacity of our communication network continues to be a major concern, especially in the first half of 2020, where the response to COVID-19 has tested the capabilities of the network in response to a rapid switch towards home working. The pressure is felt across a wide range of areas of specialism, ranging from hardware issues such as the total volume of information passing through a single optical fibre, the cost of access networks to connect with end users, or the maximum potential bit rate of a wireless link, through software, such as the stability of the Internet Protocol, to political issues such as the future of net-neutrality with governments requesting that video content providers restrict the bandwidths of their streams in response to the crisis.

AiPT's optical communications research group is working on several key aspects of optical fibre communications to enable society's increasing demand for information. Our current research involves the application of machine learning to develop a new family of optical transceiver technologies, tailored to the needs of future network architectures. Furthermore, we maintain strong research in broadband amplification demonstrating robust subsystem solutions with record level performance. Our activity expands also in the area of free-space optics to simultaneously dramatically increase connection bandwidths to the home and reduce the installation cost and to develop systems employing purely optical signal processing to perform critical network functions.

Whilst the team at Aston continue to push back the known limits to provide even greater capacities (see publications) the UK government continues to prioritise the deployment of fibre-backed technologies capable of Gbit/s connection speeds such as "pure fibre" and "fibre to the pole", and the deployment of 5G networks, where each antenna is connected to the network by fibre, continues to grow.

Grants and awards

- EPSRC Transforming Networks Building an Optical Network Infrastructure (TRANSNET)
- EPSRC-SFI Energy Efficient M Communications using Combs (EEMC)
- EPSRC All-Raman Optical Amplification for Next Generation Ultra-Wideband Optical Networks (ARGON)
- EPSRC Superchannel Transponders for the Big Data Era (CREATE)
- EFFECT Photonics / REng Research Chair in Highly Integrated Coherent Optical Fibre Communications

Academic staff:

Professor Andrew Ellis

Professor Nick Doran

Professor Sergei Turitsyn

Professor Wladek Forysiak

Associate Professor Stylianos Sygletos

Dr Ian Philips

Dr Paul Harper

Research fellows:

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Dr Aneesh Sobhanan

Dr Aleksander Donodin

Dr Florent Bessin

Dr Mariia Sorokina

Dr MingMing Tan

Dr Mohammed Umar Patel

Dr Morteza Kamalian-Kopae

Dr Pavel Skvortcov

Dr Pratim Hazarika

Dr Pedro Freire De Carvalho Sourza

Dr ThanTu Nguyen

Dr Shabnam Noor

Dr Sonia Boscolo

Dr Viktor Ribeiro

Dr Vladimir Gordienko

Dr Yaroslav Prylepskiy

Dr Yiming Li

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Anderson Mike (industry)

Diego Arguello Ron

Dini Pratiwi

Egor Sedov

Karina Nulrybayeva

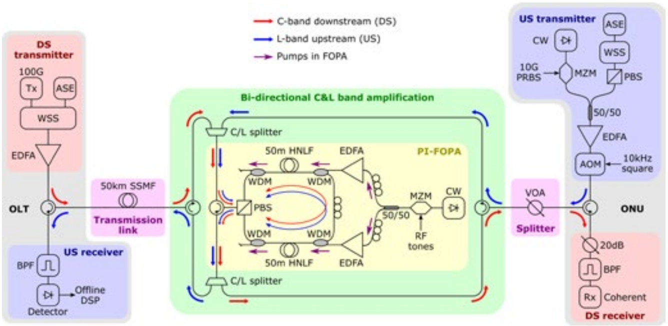
Mariia Bastamova

Long Hoang Nguyen

Nelson Castro Salgado

Sasipim Srivallapondh

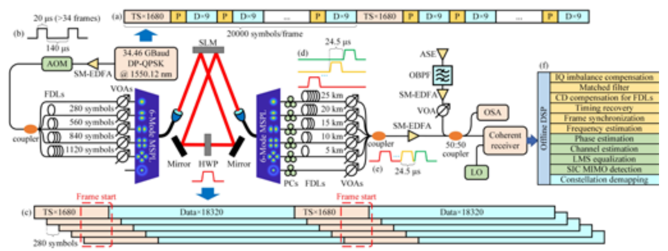
Vladislav Neskorniuk



Fully automated phase insensitive FOPA

Fibre optical parametric amplifiers (FOPAs) have a great potential to increase the capacity of future optical communications with their unique abilities which include their wavelength unconstrained operation, virtually unlimited gain bandwidth, high gain and ultra-fast response. However, devising practical polarisation-insensitive FOPAs (PI-FOPAs) as required for implementation in optical communications remains a challenge. We have significantly advanced state-of-the-art of PI-FOPAs by proposing, exploring and demonstrating their different configurations. One of the key highlights of our research is employment of the first-ever robust fully automated PI-FOPA for amplification of polarisation and wavelength multiplexed signals across C and L bands in a transient-sensitive extended-reach TWDM PON scenario. The power budget improvement delivered by a PI-FOPA in this demonstration allows us to increase the number of customers served by an access link more than tenfold.

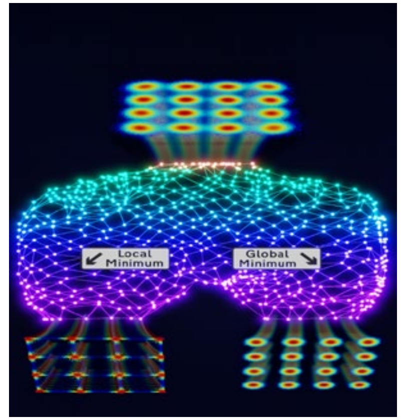
V. Gordienko, C. B. Gaur, F. Bessin, I. D. Phillips, and N. J. Doran. Robust Polarization-Insensitive C & L Band Fopa with >17db Gain for both Wdm And Bursty Traffic. *Optical Fiber Communication Conference (OFC)* 2021, paper M5B.3.



Record signal transmission over a MIMO free space optical link

We experimentally demonstrate the enhanced atmospheric turbulence resiliency in a mode-division multiplexing free-space optical communication link through the application of a successive interference cancellation digital signal processing algorithm. The turbulence resiliency is further enhanced through redundant receive channels in the mode-division multiplexing link. The proof-of-concept demonstration is performed using commercially available mode-selective photonic lanterns, a commercial transponder, and a spatial light modulator-based turbulence emulator. In this link, five spatial modes, each carrying 34.46 GBaud dual-polarisation signals, are successfully transmitted. As a result, we achieved a record-high mode- and polarisation-division multiplexing channel number of 10, a record-high line rate of 689.23 Gbit/s, and a record-high net spectral efficiency of 13.9 bit/s/Hz in emulated turbulent links in a mode-division multiplexing free-space optical system.

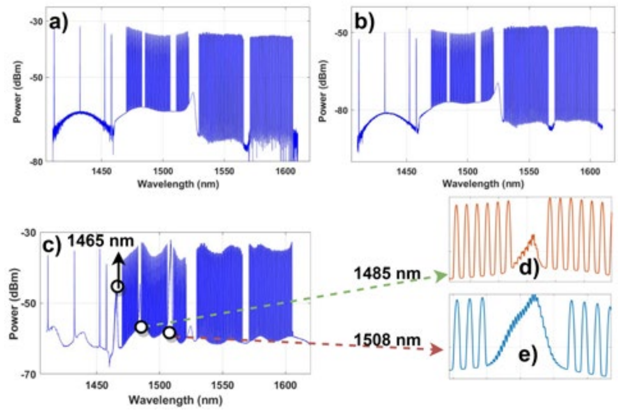
Y. Li, Z. Chen, Z. Hu, D. M. Benton, A. A. I. Ali, M. Patel, M. P. Lavery, A. D. Ellis. Enhanced Atmospheric Turbulence Resiliency with Successive Interference Cancellation DSP in Mode Division Multiplexing Free-Space Optical Links. *IEEE Journal of Lightwave Technology* vol. 40, no. 24, Dec 2022



Neural networks-based equalisers for coherent optical transmission: Caveats and pitfalls

Network operators and system suppliers face the challenge of handling large amounts of data traffic, prompting them to find ways to meet demand and optimise investments. To boost the performance of optical fibre systems, it's necessary to address the negative impact of linear and nonlinear transmission impairments. Very recently, a new channel equalisation paradigm has started to emerge, owing its attraction to the recent breakthroughs achieved in the field of artificial intelligence and machine learning. Our group has provided an overview of typical misunderstandings and misinterpretations occurring when applying neural network-based methods to channel equalisation in coherent optical communications and present the respective recommendations and direct solutions to the aforementioned difficulties, underlining the challenges, underwater stones that can seriously hinder the success of a neural network in performing the equalisation task.

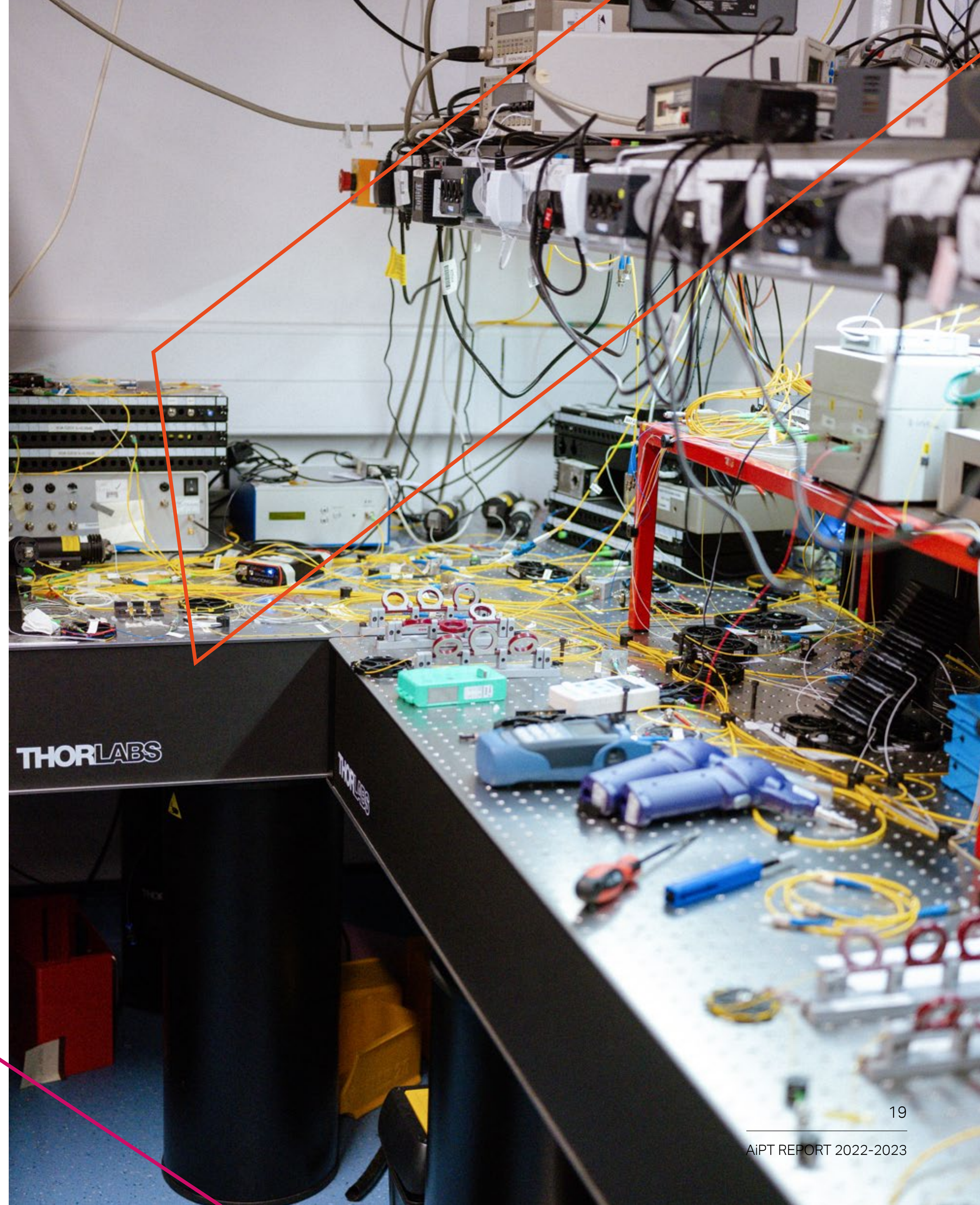
P. J. Freire, A. Napoli, B. Spinnler, N. Costa, S. K. Turitsyn and J. E. Prilepsky. Neural Networks-Based Equalizers for Coherent Optical Transmission: Caveats and Pitfalls. *IEEE Journal of Selected Topics in Quantum Electronics*, vol. 28, no. 4, pp. 1-23, July-Aug. 2022



E-, S-, C- and L-band coherent transmission with a multistage discrete Raman amplifier

For the first time, we have reported an ultra-wideband coherent (UWB) WDM transmission over a 70 km standard single mode fibre (SSMF) solely using a multistage discrete Raman amplifier (DRA) over the E-, S-, C- and L-bands of the optical window. The amplifier was based on a split-combine approach of spectral bands enabling signal amplification from 1410-1605 nm over an optical bandwidth of 195 nm (25.8 THz). It was characterised with 143 channelised amplified spontaneous emission (ASE) dummy channels in the S-, C- and L-bands and four laser sources in the E-band (1410–1605 nm). The amplification results show an average gain of 14 dB and a maximum noise figure (NF) of 7.5 dB over the entire bandwidth. Coherent transmission with the proposed amplifier was performed using a 30 Gbaud PM-16-QAM channel coupled with the ASE channels over a 70 km SMF.

P. Hazarika, M. Tan, A. Donodin, S. Noor, I. Phillips, P. Harper, J. S. Stone, M. J. Li, W. Forysiak, E-, S-, C- and L- Band Coherent Transmission with a Multistage Discrete Raman Amplifier. *Optics Express*, vol. 30, no. 24, Nov 2022



Optical Sensing

The use of optical techniques to make measurements brings a number of advantages. Optical fibre sensors can be configured to sense a wide range of parameters, from the physical (such as pressure, temperature or strain) through to the highly specific detection of chemical or biochemical species.

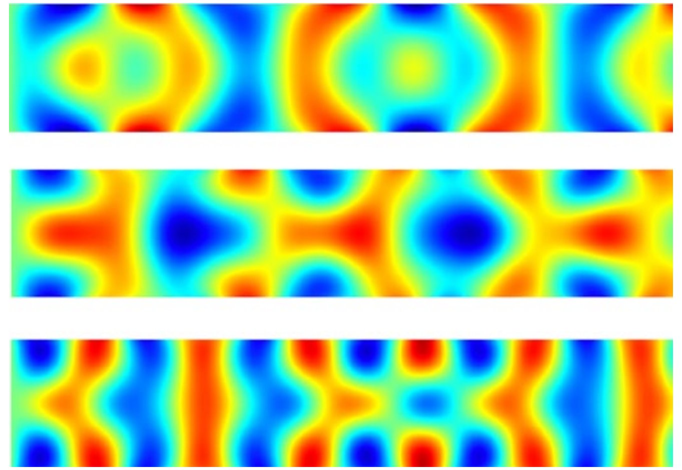
Fibre sensors are light in weight, can operate passively over long distances, are immune to electromagnetic interference, can be configured with many hundreds of individual sensing points and are small enough to be embedded in materials to create smart structures. The spectroscopic investigation of light can reveal information about the source of the light or about the medium that the light has passed through.

The applications of optical sensing technology are wide ranging and include civil engineering, aerospace, medicine, pollution monitoring, defence, energy generation and agriculture. Some examples of current work illustrate this breadth of applicability:

- We lead an international team developing technologies to analyse micro and nanoplastics in the environment, a topic of increasing concern. Bibi, A. et al. A Review on State-of-the-Art Detection Techniques for Micro- and Nano-Plastics with Prospective Use in Point-of-Site Detection. *Comprehensive Analytical Chemistry* (Elsevier, 2023). doi:10.1016/bs.coac.2022.11.003.
- Detection of laser radiation is important to the airline industry, where a low-cost laser pointer could easily blind a pilot. We have been researching better means to do this. Zandi, M., Sugden, K. and Benton, D.M. Low-Cost Laser Detection System with w 360-Deg Horizontal Field of View. *Optical Engineering* 60, 027106 (2021).
- Surface plasmon resonance can be used to realise highly sensitive and specific biosensors, which may be targeted at SARS-Cov-2 - Dai, Z. et al. Surface plasmon resonance biosensor with laser heterodyne feedback for highly sensitive and rapid detection of COVID-19 spike antigen. *Biosensors and Bioelectronics* 206, 114163 (2022).
- We are developing sensors to monitor different aspects of soil - Fadaie, S., Mehravar, M., Webb, D. J. & Zhang, W. Nearshore Contamination Monitoring in Sandy Soils Using Polymer Optical Fibre Bragg Grating Sensing Systems. *Sensors* 22, 5213 (2022).

Grants and awards

- MonPlas: The Training of Early-Stage Researchers for the Development of Technologies to Monitor Concentrations of Micro and Nano Plastics in Water for their Presence, Uptake and Threat to Animal and Human Life (European Commission).
- Determining the Feasibility of Photonic Noses to Improve In-Field Pest Monitoring (NERC/BBSRC).
- Photonic Fibre Gas Sensor Fabrication by Two-Photon Polymerisation Techniques (Leverhulme Trust).
- Agritech Growth and Resources for Innovation (AGRI) (European Regional Development Fund).
- Advanced Prototyping Facility (APF) (European Regional Development Fund).



Representations of the complex patterns produced by ultrasonic fields in an optical fibre. Detailed simulations have shown that efficient acousto-optic interaction is possible at frequencies well above the upper limit of current acousto-optic devices.

Academic staff:

Professor David Webb

Professor Kate Sugden

Dr Christian Broadway

Dr Haris Alexakis

Dr Kaiming Zhou

Dr Moura Mehravar

Dr Sergey Sergeyev

Emeritus Professor Lin Zhang

Research fellows:

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Dr Daniel Hill

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Dr Ricardo da Silva

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Research students:

Aisha Bibi

Sina Sestelani

Yang Lu

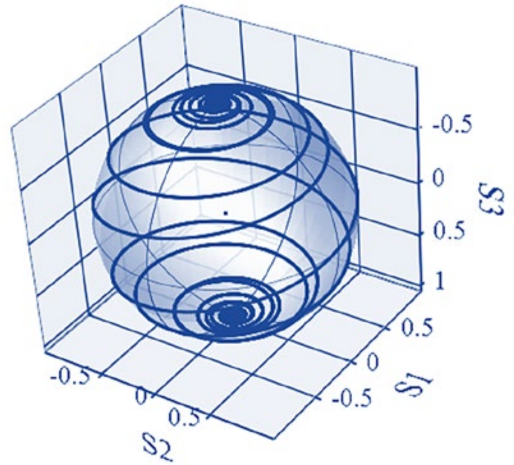
Visitors and collaborators:

Dr Thomas Allsop (Visiting Fellow)

Liliana Sousa (Visiting Research Student)

Infrastructure sensing

In a longstanding collaboration with Cambridge University and Highways England, Dr Haris Alexakis and Nikolaos Tziavos are using a mixture of fibre Bragg grating and conventional (piezoelectric) sensors to monitor the deterioration of bridges. They are doing this with the assistance of advanced signal processing using machine learning. The figure shows an installation on the M6 near Stafford.

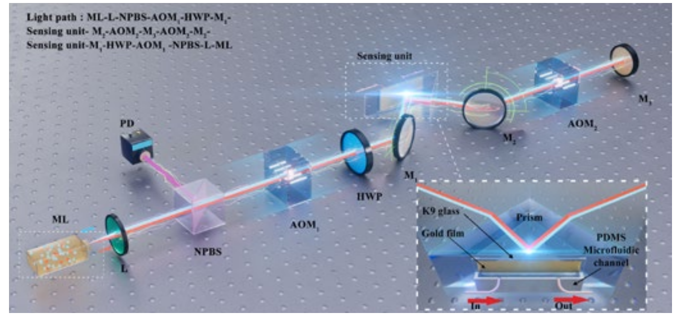


Polarisation dynamics

The figure shows the polarisation dynamics of an erbium-doped fibre laser in the form of double scroll polarisation attractor on the Poincaré sphere. Fundamental work on polarisation dynamics is now being applied by Dr Sergey Sergeyev in novel approaches to interrogation fibre Bragg grating sensors.

Polarization Dynamics of Mode-Locked Fiber Lasers. *Science, Technology, and Applications*, CRC_Press 2023

Edited By Sergey V. Sergeyev, Chengbo Mou.



Optical biosensor for COVID-19

The COVID-19 outbreak has emphasised the importance of pandemic prevention and control, which requires a rapid and sensitive antigen assay. Dr Kaiming Zhou and colleagues have developed a new biosensor based on surface plasmon resonance and laser heterodyne feedback interferometry for detecting the SARS-CoV-2 spike antigen.

Dai, Z. *et al.* Surface plasmon resonance biosensor with laser heterodyne feedback for highly sensitive and rapid detection of COVID-19 spike antigen. *Biosensors and Bioelectronics* 206, 114163 (2022).

Nonlinear Photonics and Fibre Lasers

The Nonlinear Photonics and Fibre Lasers (NPFL) group pursues cutting-edge fundamental and applied research in a diverse range of topics, including temporal nonlinear dynamics, ultrafast processes, ultrafast fibre laser sources, solitons, optical frequency combs, dissipative structures, nonlinear effects optical communications, machine learning in photonic systems and neuromorphic computing. A major focus of our research is the study of various phenomena encountered by the manipulation of fundamental properties of light, such as the intensity profile, phase and state of polarisation, as well as the new applications already made possible by the nonlinear fibre-optic technology.

One of the new directions in the NPFL research activities is the application of machine learning algorithms in optical systems to add new functionalities and to enhance their performance. The increasing complexity of modern laser systems, mostly originated from the nonlinear dynamics of radiation, makes control of their operation more and more challenging, calling for the development of new approaches in laser engineering. Machine learning methods, providing proven tools for identification, control and data analytics of various complex systems, have been recently applied to mode-locked fibre lasers with the special focus on three key areas: self-starting, system optimisation and characterisation.

However, the development of the machine learning algorithms for a particular laser system, while an interesting research problem, is a demanding task requiring arduous efforts and tuning a large number of hyper-parameters in the laboratory arrangements. It is not obvious that this learning can be smoothly transferred to systems that differ from the specific laser used for the algorithm development by design or by varying environmental parameters. Therefore, methods such as deep reinforcement learning (DRL), based on trials and errors and sequential decisions, could be important for the control of complex laser systems. On the other hand, modern mode-locked laser systems – which generate data at high speed – present an interesting photonic testbed for various machine learning concepts based on large datasets.

Another strategic new direction in NPFL is neuromorphic photonics. AiPT research in the field of neuromorphic photonics is supported by the European Training Network POST-DIGITAL, coordinated by AiPT (postdigital.astonphotonics.uk), with 13 partners including IBM, Thales and SMEs LightOn, VLC Photonics and IniLabs.

Nonlinear photonics and fibre laser science and technology are naturally connected. Understanding the fundamental physics behind laser generation in nonlinear fibre resonators is critically important for the development of novel high-performance laser sources offering turn-key solutions for various practical applications.

Grants and awards

- Leverhulme Trust research project grant "Harnessing Vector Soliton Supramolecular Structures", (Ref: RPG-2023-073, 2023/26, £176,421)
- RAENG Industrial Fellowships - Energy Thematic Round 2023/24 "Improving the Energy Efficiency of Wind Turbines" (IF2223B-133, 2023/24, £98,000)
- EPSRC project "Advanced Optical Frequency Comb Technologies and Applications" (EP/W002868/1, 2022/27, £1,722,851)

Academic staff:

Professor Sergei K. Turitsyn

Associate Professor Sergey Sergeyev

Dr Auro Michele Perego

Dr Sonia Boscolo

Research fellows:

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Dr Egor Manuylovich

Dr Hani Kbashi

Dr Morteza Kamalian-Kopae

Dr Vladislav Dvoyrin

Dr Yaroslav Prylepski

Research students:

Alberto Rodríguez Cuevas

Diego Arguello Ron

Egor Sedov

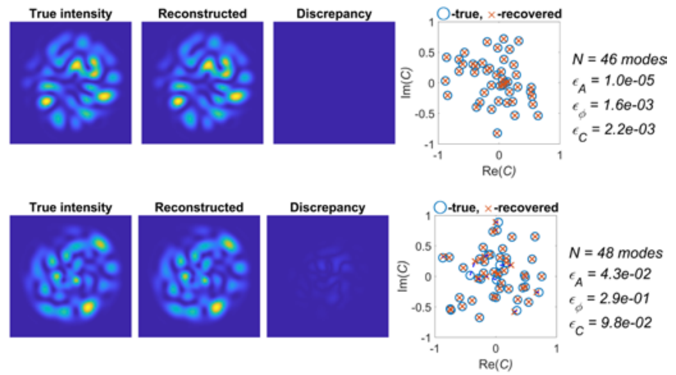
Minji Shi

Negar Shaabani Shishavan

Qing Wang

Stepan Bogdanov

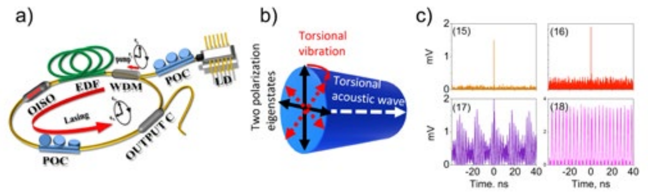
Zhiqiang Wang



Intensity-only-measurement mode decomposition in few-mode fibres

Recovering a complex wavefront using intensity measurements is an ill-posed problem because different phase patterns can produce identical intensity distributions. But it is an attractive approach with various applications ranging from imaging to telecommunications. In the case of multi-mode fibres, the known structure of eigenmodes allows for complex field recovery using only intensity measurements. Eigenmode weight recovery, or mode decomposition (MD), is equivalent to wavefront reconstruction. Here we show an intensity-only MD technique that outperforms the fastest previously published method regarding the number of modes while offering the same decomposition speed. The developed technique can perform MD in up to 48-mode fibre. We also improved noise resilience: the required SNR decreases by 10 dB for a three-mode fibre and by 7.5 dB for a five-mode fibre. We provide a complexity analysis of the proposed method and experimentally demonstrate its applicability for a five-mode fibre. We expect the developed technique to find many applications, from ultra-fast fibre imaging to beam characterisation.

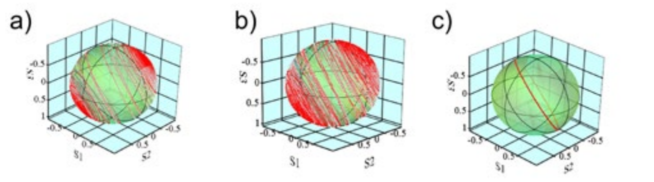
Manuylovich, E., Donodin, A. and Turitsyn, S., 2021. Intensity-Only-Measurement Mode Decomposition in Few-Mode Fibers. *Optics Express*, 29(22), pp.36769-36783. https://doi.org/10.1364/OE.437907



Vector harmonic mode-locking by acoustic resonance

For mode-locked fibre lasers, the selective excitation of the harmonics of the fundamental frequency - harmonic mode-locking (HML) - is a practical pathway to increase the repetition rate hundreds of times through the use of resonance with the acoustic phonons, four-wave mixing, pattern-forming modulation instability or/and through the insertion of a linear component featuring a periodic spectral transfer function. Our work first demonstrated both experimentally and theoretically a novel mechanism of harmonic mode-locking based on the electrostriction effect driven by the torsional acoustic modes generated in the transverse section of the laser. The research was conducted in collaboration with former AiPT researchers Dr Stanislav Kolpakov and Dr Yuri Loika.

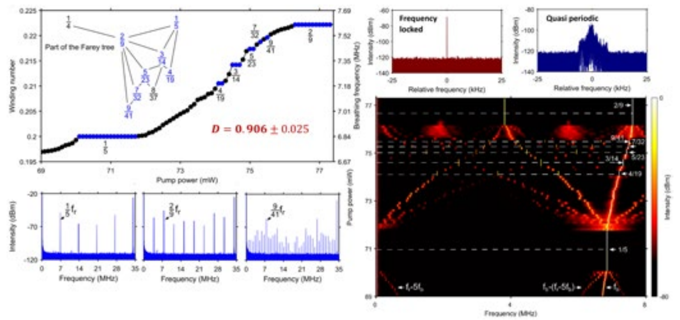
S. Sergeyev, S. Kolpakov, and Yu. Loika, 2021. Vector Harmonic Mode-Locking by Acoustic Resonance. *Photonics Research*, 9, 1432-1438. https://doi.org/10.1364/PRJ.424759



Polarisation attractors driven by vector soliton rain

Soliton rain is a bunch of small soliton pulses slowly drifting nearby the main pulse having the period of a round trip. For Er-doped fibre laser mode-locked by carbon nanotubes, for the first time, we demonstrated both experimentally and theoretically a new type of polarisation attractors controllable by the vector soliton rain in terms of transforming slowly evolving trajectories on the Poincaré sphere from the double-scroll spiral to the circle. The obtained results on controlling complex multisoliton dynamics can be of interest in laser physics and engineering with potential applications in spectroscopy, metrology and biomedical diagnostics.

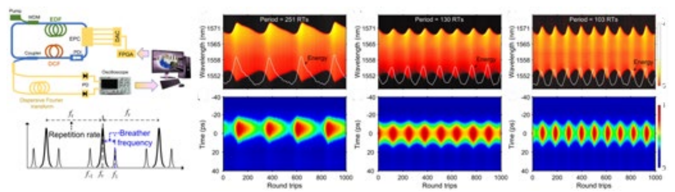
Sergeyev, S.V., Eliwa, M. and Kbashi, H., 2022. Polarisation Attractors Driven by Vector Soliton Rain. *Optics Express*, 30(20), pp.35663-35670. https://doi.org/10.1364/OE.462491



Frequency locking, Farey tree and devil's staircase of breathers in ultrafast lasers

Nonlinear systems with two competing frequencies show frequency locking, in which the system locks into a resonant periodic response featuring a rational frequency ratio (winding number). The excitation of breathing solitons in an ultrafast laser naturally triggers a second characteristic frequency in the system, which therefore shows competition between the cavity repetition frequency and the breathing frequency. In this work, we demonstrate frequency locking at Farey fractions of a breather laser. The winding numbers exhibit the hierarchy of the Farey tree and the structure of a devil's staircase. The fractal dimension of the stairs calculated from both experiments and numerical simulations of a discrete laser model approaches the value (0.87) expected from a complete devil's staircase. The breather laser may therefore serve as a simple test bed to explore universal synchronisation dynamics of nonlinear systems. The locked breathing frequencies feature a high signal-to-noise ratio and can give rise to dense radio-frequency combs, which are attractive for many applications such as in high-resolution spectroscopy.

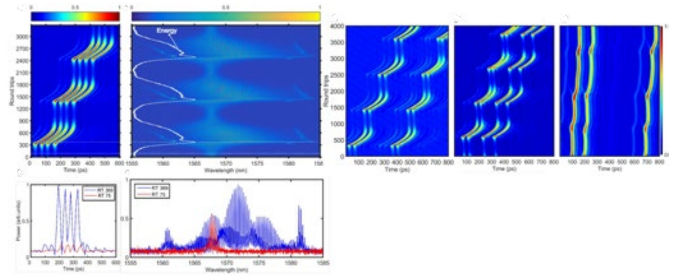
Wu, X., Zhang, Y., Peng, J., Boscolo, S., Finot, C. & Zeng, H. Farey Tree and Devil's Staircase of Frequency-Locked Breathers in Ultrafast Lasers. *Nature Communications* 13, 5784 (2022).



Intelligent control of breather dynamics generation

Harnessing pulse generation from an ultrafast laser is a challenging task as reaching a specific mode-locked regime generally involves adjusting multiple control parameters. Breathing solitons exhibiting periodic oscillatory behaviour have recently emerged as ubiquitous mode-locked regime of ultrafast lasers. In this work, we demonstrate, for the first time, the possibility of using genetic algorithms to perform search and optimisation of the breather regime in a fibre laser cavity. We design merit functions relying on the characteristic features of the radiofrequency spectrum of the laser output, which are capable to locate various self-starting breather states in the laser, including single breathers with controllable breathing ratio and period, and breather molecular complexes with a controllable number of elementary constituents. Contrary to the generation regimes of stationary pulses that have been mainly addressed by previous works using GAs, breathing solitons exhibit a fast evolutionary behaviour. Therefore, our work opens novel opportunities for the exploration of highly dynamic, nonstationary operating regimes of ultrafast lasers, such as soliton explosions, nonrepetitive rare events and intermittent nonlinear regimes.

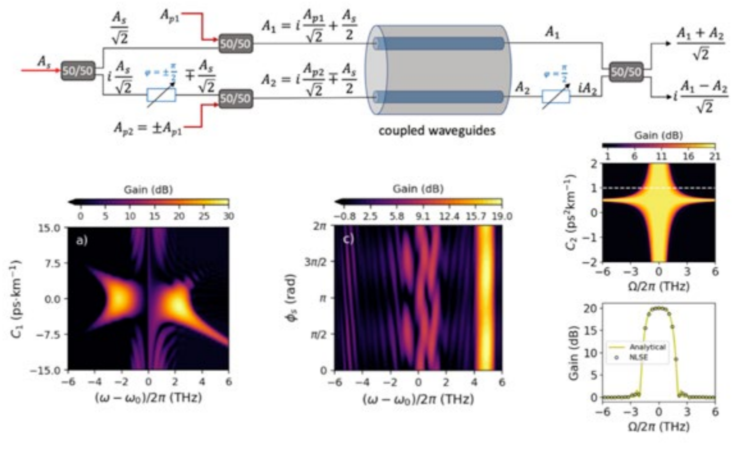
Wu, X., Peng, J., Boscolo, S., Zhang, Y., Finot, C. & Zeng, H. Intelligent Breathing Soliton Generation in Ultrafast Fiber Lasers. *Laser Photonics Reviews* 16, 2100191 (2022).



Dissipative optical breather molecular complexes

One of the remarkable properties of dissipative solitons, which are mostly absent in integrable systems, is the ability to form robust multi-pulse bound states, also termed "soliton molecules", and showing similar dynamics to matter molecules. Breathing dissipative solitons have recently emerged as ubiquitous mode-locked regime of ultrafast lasers. In this work, we reveal the similarity in collective behaviour between breathing and stationary dissipative solitons by demonstrating experimentally and numerically different types of breather complexes in a passively mode-locked fibre laser. These include tetratomic molecules, and molecular complexes formed from the binding of two diatomic molecules or a diatomic and a monoatomic molecule. We also report on the observation non-equilibrium dynamics of breathers, including collisions and annihilation. Since breathing dissipative solitons are fundamental modes of many nonlinear physical systems, it is reasonable to assume that the breather dynamics observed in this work will incentivise the investigation of breather molecular complexes in various other systems.

Peng, J., Zhao, Z., Boscolo, S., Finot, C., Sugavanam, S., Churkin, D. V. & Zeng, H. Breather Molecular Complexes in a Passively Mode-Locked Fiber Laser. *Laser Photonics Reviews* 15, 2000132 (2021).



Dual-waveguide parametric amplification

Parametric amplifiers are a promising nonlinear photonic technology for providing broadband low noise amplification in optical communications and in other applications too. We have investigated parametric amplification in coupled nonlinear waveguides, showing the possibility of a novel class of optical amplifiers that can be implemented either in dual core fibres or in integrated photonic platforms, exhibiting low noise figure and broadband flat gain spectrum. Dual-waveguide parametric amplifiers are robust with respect to pump and phase fluctuations between the two waveguides and can enable signal and idler separation among the two supermodes of the system based on a peculiar intermodal four-wave mixing process. Spatial management of the coupling strength can further enable the possibility of overcoming loss induced phase-matching degradation which is typical of integrated waveguides, hence improving performances in terms of gain peak and bandwidth compared to standard single waveguide devices.

V. Ribeiro and A. M. Perego. Parametric Amplification in Lossy Nonlinear Waveguides with Spatially Dependent Coupling. *Opt. Express* 30, 17614-17624 (2022).

M. Shi, V. Ribeiro, and A. M. Perego. Parametric Amplification in Coupled Nonlinear Waveguides: The Role of Coupling Dispersion. *Frontiers in Photonics* 4, 1051294 (2023).

M. Shi, V. Ribeiro, and A. M. Perego. On the Resilience of Dual-Waveguide Parametric Amplifiers to Pump Power and Phase Fluctuations. *Appl. Phys. Lett.* 122, 101102 (2023).

M. Shi, V. Ribeiro, and A. M. Perego. Parametric Amplification Based on Intermodal Four-Wave Mixing Between Different Supermodes In Coupled-Core Fibers. *Opt. Express* 31, 9760-9768 (2023).

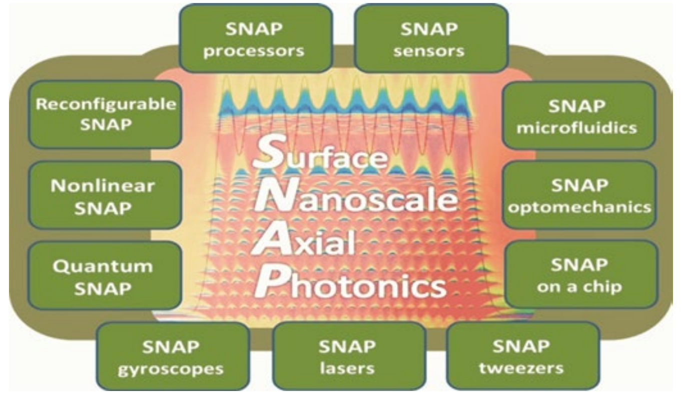
Other Key Publications:

1. Genty, G., Salmela, L., Dudley, J.M. et al. Machine Learning and Applications in Ultrafast Photonics. Nat. Photonics 15, 91–101 (2021). https://doi.org/10.1038/s41566-020-00716-4
2. Manuylovich, E.S., Dvoyrin, V.V. & Turitsyn, S.K. Fast Mode Decomposition in Few-Mode Fibers. Nat Commun 11, 5507 (2020). https://doi.org/10.1038/s41467-020-19323-6
3. Meng, F., Lapre, C., Billet, C., Sylvestre, T., Merolla, J.M., Finot, C., Turitsyn, S.K., Genty, G. and Dudley, J.M., 2021. Intracavity Incoherent Supercontinuum Dynamics and Rogue Waves in a Broadband Dissipative Soliton Laser. Nature Communications, 12(1), p.5567. https://doi.org/10.1038/s41467-021-25861-4
4. Kuprikov, E., Kokhanovskiy, A., Serebrennikov, K. and Turitsyn, S., 2022. Deep Reinforcement Learning for Self-Tuning Laser Source of Dissipative Solitons. Scientific Reports, 12(1), p.7185. https://doi.org/10.1038/s41598-022-11274-w
5. Beličev, P.P., Gligorić, G., Maluckov, A., Hadžievski, L. and Turitsyn, S., 2021. Topological Charge Switch in Active Multi-Core Fibers. Annalen der Physik, 533(9), p.2100108. https://doi.org/10.1002/andp.202100108
6. Fanchao Meng, Coraline Lapre, Cyril Billet, Thibaut Sylvestre, Jean-Marc Merolla, Christophe Finot, Sergei K. Turitsyn, Goëry Genty & John M. Dudley. Intracavity Incoherent Supercontinuum Dynamics and Rogue Waves in a Broadband Dissipative Soliton Laser. Nat. Commun. 12, 5567 (2021)
7. Egor V Sedov, Pedro J Freire, Vladimir V Seredin, Vladyslav A Kolbasin, Morteza Kamalian-Kopae, Igor S Chekhovskoy, Sergei K Turitsyn, Jaroslaw E Prilepsky. Neural Networks for Computing and Denoising the Continuous Nonlinear Fourier Spectrum in Focusing Nonlinear Schrödinger Equation. Scientific Reports, 11(1) 1, (2021)
8. S. K. Turitsyn, I. S. Chekhovskoy, and M. P. Fedoruk, Nonlinear Fourier Transform for Analysis of Optical Spectral Combs. Phys. Rev. E 103, L020202, (2021)

Nanoscale Photonics

In 2021-22, the Nanoscale Photonics group continued to work on the experimental and theoretical development of SNAP technology which enables the fabrication of resonant structures and devices at the optical fibre surface with unprecedented subangstrom precision. Experimentally, we developed new methods for the fabrication of SNAP microresonators, worked on the improvement of their fabrication precision and also demonstrated new types of microresonators. Theoretically, we worked on the explanation of the experimentally observed effects, developed approaches to improve the performance of SNAP devices and proposed devices with new functionalities. The major results of our work in 2021-23 were published in *Optics Letters* (4 papers), *Physical Review Letters, ACS Photonics, Communications Physics, and Laser Physics Letters*.

Dr Nikita Toropov and PhD student Sajid Zaki demonstrated miniature delay lines fabricated lithographically at the optical fibre surface. In Sajid's theoretical work, he developed an approach to improve the impedance matching between the input-output waveguides and SNAP microresonators. Together with Dr Hani Kbashi, Sajid investigated the effect of microfibre bending on its coupling to SNAP microresonators. PhD student (now Dr) Gabriella Gardosi defended her PhD thesis where she developed the slow cooking approach for the fabrication of SNAP microresonators which allowed her to demonstrate their picometer-order fabrication precision. Gabriella's results attracted the attention of public media and, in October 2022, were overviewed in the editorial article of *Electro Optics Magazine*. This magazine named Gabriella among the 100 most innovative people in photonics in 2022. Very recently, Gabriella performed the first proof-of concept experimental demonstration of the non-local microfluidic sensing with slow-cooked microresonators. Dr Manuel Crespo-Ballesteros made significant progress in understanding the transportation and manipulation of light in SNAP microresonators due to the Kerr effect and due to their parametric modulation. In particular, he demonstrated the importance of the spatial distribution of parametric modulation along a microresonator on the optical frequency comb (OFC) generation, which was further studied by Prof Sumetsky. Currently, Manuel is working on the experimental demonstration of OFC generated by SNAP microresonators. Dr Yong Yang experimentally demonstrated a bat microresonator theoretically introduced by Prof Sumetsky in 2020, who also proposed a new type of microwave filter composed of coupled SNAP microresonators and discovered the fundamental limit of the microresonator field uniformity. PhD student Victor Vassiliev experimentally demonstrated the sub-angstrom precise fabrication of SNAP microresonators with a flame. Recently, Victor experimentally discovered novel high-quality factor tuneable optical microresonators which are induced in the region of side coupling of two optical fibres.



Grants and awards

- EPSRC: SNAP
- Leverhulme Trust: LighTruck
- H2020 MSCA ITN EID: MOCCA
- EPSRC: Optical Frequency Comb Collaboration

Academic staff:

Professor M Sumetsky

Research fellows:

Dr Gabriella Gardosi

Dr Kirill Tokmakov

Dr Manuel Crespo-Ballesteros

Dr Yong Yang

Research students:

Mr Sajid Zaki

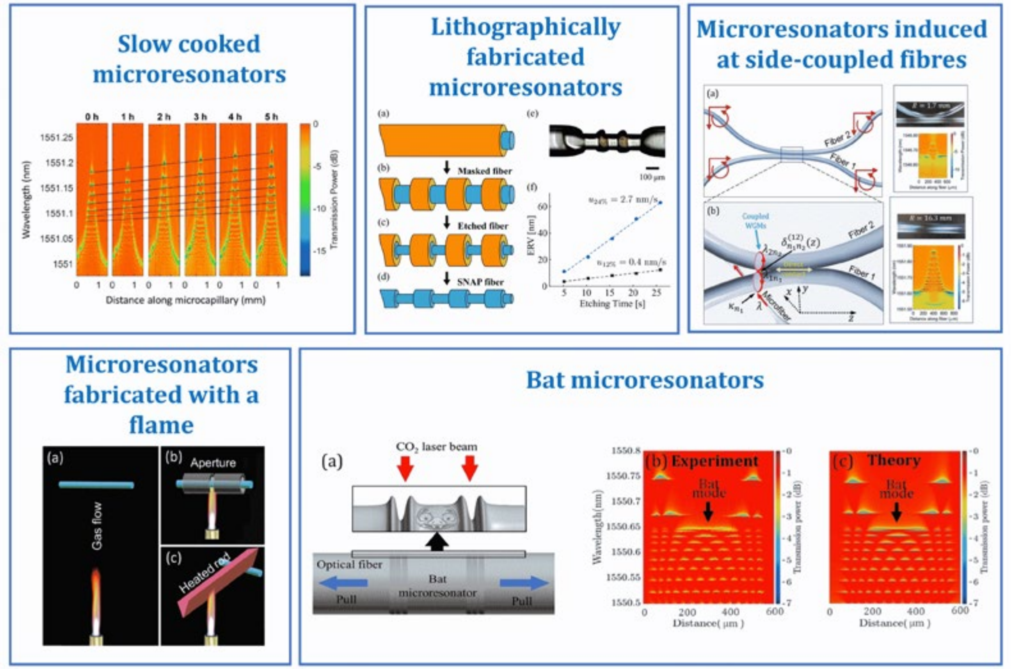
Mr Victor Vassiliev

Collaborators:

Dr A Matsko (Jet Propulsion Lab)

Dr B J Mangan and
Dr G S Puc (OFS)

Experimental achievements



Picometre-Precise Fabrication of Microresonators by the Slow-Cooking Method and Nonlocal Microfluidic Sensing

We advanced the slow cooking fabrication method of optical microresonators [1] and demonstrated their fabrication with picometer precision in resonance wavelength position [2]. In our recent proof-of-concept experiment [3], we determine the position of the water edge moving along the section of microcapillary fibre containing a 2 mm long SNAP microresonator by monitoring the microresonator spectrum.

Miniature Delay Lines Fabricated Lithographically at the Optical Fibre Surface

We developed a simple lithographic method for the fabrication of microresonator devices at the optical fibre surface [4]. As an application, we fabricated a rectangular 5 mm long SNAP microresonator at the surface of a 38 μm diameter fibre and demonstrated its performance as a miniature dispersionless delay line.

Experimental Demonstration of Bat Microresonators

Optical microresonators with elongated uniform field distribution of their eigenmodes are important for application in quantum electrodynamics and for the ultraprecise sensing of microparticles. We experimentally demonstrated an optical microresonator fabricated at the 125-micron diameter optical fibre having an eigenmode which amplitude is uniform along the more than 100 microns of the fibre length with 7% accuracy [5].

Subangstrom-Precise Fabrication of SNAP Microresonators with a Flame

We demonstrated the fabrication of SNAP bottle microresonators with angstrom precision using a flame [6]. We observed strongly unscalable behaviour of the whispering gallery mode cutoff wavelengths with different radial quantum numbers along the fibre length.

Discovery of Microresonators Induced in the Region of Side Coupling of Optical Fibres

We experimentally demonstrated that side-coupling of coplanar bent optical fibres can induce a high Q-factor whispering gallery mode optical microresonator [7]. By varying the characteristic curvature fibre radius from the centimetre order to millimetre order, we demonstrated fully mechanically reconfigurable high Q-factor optical microresonators with dimensions varying from the millimetre order to 100-micron order and free spectral range varying from a picometer to hundreds of picometers. The new microresonators may find applications in cavity QED, microresonator optomechanics, frequency comb generation with tuneable repetition rate, tuneable lasing and tuneable processing and delay of optical pulses.

[1] Gardosi, G., Mangan, B. J., Puc, G. S., and Sumetsky, M., Photonic Microresonators Created by Slow Optical Cooking. *ACS Photonics* 8, 436-442 (2021).

[2] Gardosi, G., Mangan, B. J., and Sumetsky, M., Picometer-Precise Post-Processing of Optical Microresonators via Slow-Cooking. *CLEO: Science and Innovations*, JW3A. 49 (2022).

[3] Gardosi, G. and Sumetsky, M. Nonlocal microcapillary fibre sensing platform, *CLEO Europe*, CK-3.2 (2023).

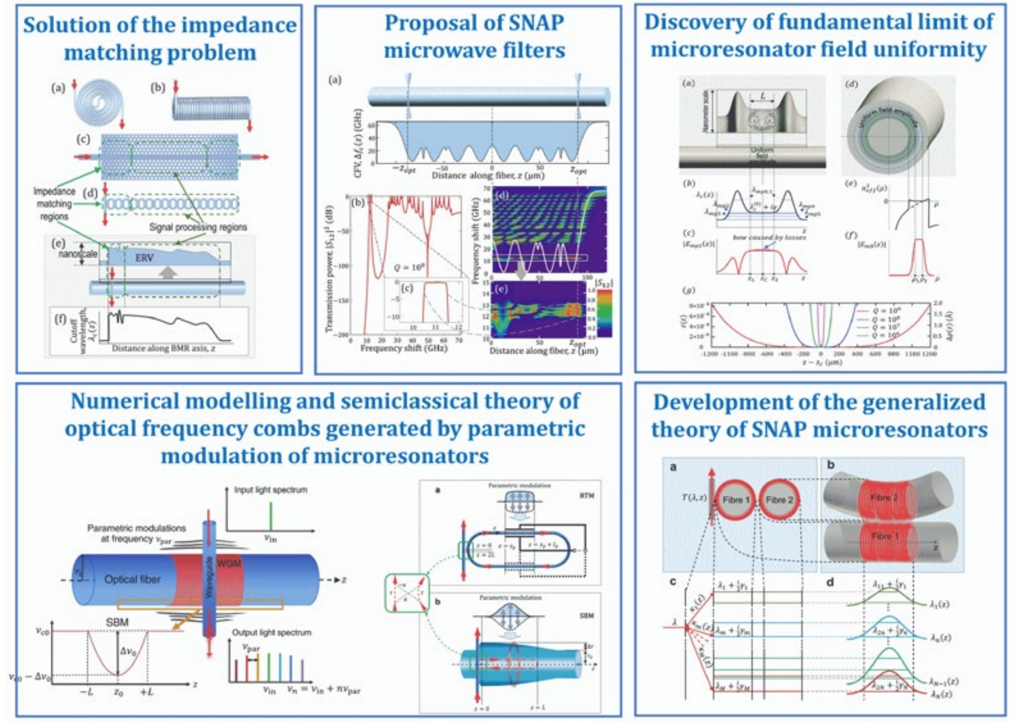
[4] Toropov, N., Zaki, S., Vartanyan, T., and Sumetsky, M. Microresonator Devices Lithographically Introduced at the Optical Fiber Surface. *Opt. Lett.* 46, 1784-1787 (2021).

[5] Yang, Y., Crespo-Ballesteros, M. and Sumetsky, M. Experimental Demonstration of a Bat Microresonator. *CLEO Europe* (2021).

[6] Sumetsky, M. and Vassiliev, V. Angstrom-Precise Fabrication of Surface Nanoscale Axial Photonics (SNAP) Microresonators with w Flame. *Las. Phys. Lett.* 19, 056202 (2022).

[7] Vassiliev, V. and Sumetsky, M. Reconfigurable Microresonators Induced in Side-Coupled Optical Fibers. *arXiv preprint* arXiv:2301.01262 (2023).

Theoretical achievements



Solution of the Problem of Impedance Matching Between the Input-Output Waveguide and Snap Microresonator

To avoid insertion losses and processing errors, a pulse should completely transfer from the waveguide into microresonator and, after being processed, completely return back into the waveguide. For this purpose, the waveguide and microresonator should be impedance matched along the pulse bandwidth. We showed how to enhance the impedance matched bandwidth by optimization of the effective radius variation of a SNAP microresonator in a small vicinity of the input–output waveguide [8].

Discovery of the Fundamental Limit of the Microresonator Field Uniformity

We showed that there exists the fundamental limit of microresonator eigenmode field uniformity [9]. This limit can be achieved in a bat microresonator. We showed that the relative fields nonuniformity is inverse proportional to the microresonator's quality factor squared. For example, for a silica microresonator with quality factor 10^8 the relative eigenmode field nonuniformity along the 100 micron length cannot be less than 10^{-7}.

Proposal of SNAP Microwave Filters

We investigated the resonance transmission of series of coupled SNAP microresonators [10]. We showed that, if appropriately designed, these series can be realised as microwave photonic tuneable filters with an outstanding flatness within the predetermined bandwidth and rejection rate.

Numerical Modelling and Semiclassical Theory of Optical Frequency Combs Generated by Parametric Modulation of Microresonators

Based on the approach developed in our proposal of SNAP microwave filters, we numerically investigated the optical frequency comb spectrum of parametrically modulated SNAP bottle microresonators [11]. By modulating microresonators resonantly and adiabatically, we showed that the flatness and bandwidth of the frequency comb spectra can be enhanced by optimising the spatial distribution of the parametric modulation. In Ref. [13] we developed the semiclassical theory of parametrically modulated microresonators, which explained the numerical observations of Ref. [12].

Generalized Theory of SNAP Microresonators

Our efforts to explain the appearance of high quality factor microresonators in the region of side coupling optical fibres led us to the development of the generalized theory of SNAP microresonators [7].

[8] Crespo-Ballesteros, M., Matsko, A. B., and Sumetsky, M. Optimized Frequency Comb Spectrum of Parametrically Modulated Bottle Microresonators. *Commun. Phys.* 6, 52 (2023).

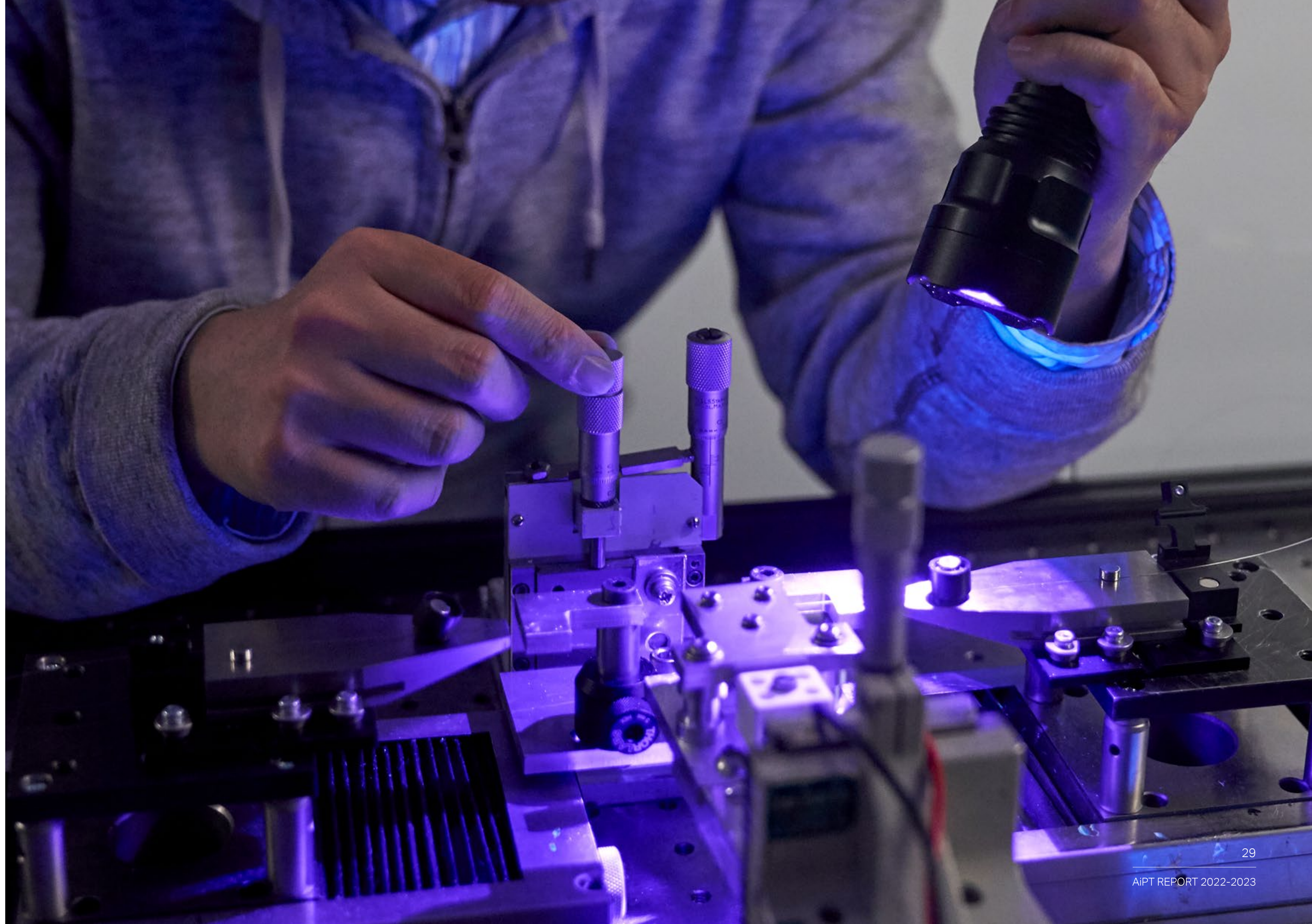
[9] Sumetsky, M. and Zaki, S. Enhancing the Impedance Matched Bandwidth of Bottle Microresonator Signal Processing Devices. *Opt. Lett.* 46, 3227-3230 (2021).

[10] Sumetsky, M. Semiclassical Theory of Frequency Combs Generated by Parametric Modulation of Optical Microresonators. *arXiv preprint* arXiv:2303.06959 (2023).

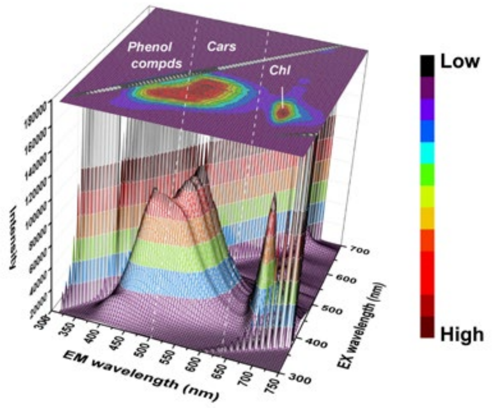
[11] Sumetsky, M. SNAP Microwave Optical Filters. Opt. Lett. 46, 4144-4147 (2021).

[12] Crespo-Ballesteros M. and Sumetsky, M. Controlled Transportation of Light by Light at the Microscale. Phys. *Rev. Lett.* 126, 153901 (2021).

[13] Sumetsky M. Fundamental Limit of Microresonator Field Uniformity and Slow Light Enabled Ultraprecise Displacement Metrology. *Opt. Lett.* 46, 1656-1659 (2021).



Nanoscience Research Group



The Nanoscience Research Group is engaged in investigating diverse advanced materials including carbon nanotubes, graphene, 2D hybrid perovskites, synthetic fluorescence and laser dyes, natural and food pigments, polymer composites, and micro and nano plastics. Our research primarily focuses on the modification of the material surfaces or the development of novel composites to impart them with new functional properties. Subsequently, we integrate these functionally enhanced materials into a variety of device platforms to create novel optical and nano-electronic systems, such as ultra-short pulse fibre lasers, random lasers, biological and gas sensors, bio-transistors and photodetectors.

The ongoing projects at NRG, supported by Horizon 2020 and ERDF (led by Dr Alex Rozhin), are directed towards creating novel techniques for spectroscopic identification of:

- Micro/nano plastics in water and food
- The freshness and safety of food samples.

Projects sponsored by the Royal Society (led by Dr Petro Lutsyk) are focused on the evaluation of applications of ink-jet printing and new materials for the recording of electrical activities of brain tissue.

Our group possesses cutting-edge equipment for wet chemistry processing of nanomaterials, which includes ultrasonic processors, shear force mixers, benchtop and ultra-centrifuges, filtration systems and microfluidic systems. Moreover, we have facilities dedicated to manufacturing polymer nanocomposites and thin films using knife-edge casting and ink-jet printing techniques. To analyse and study these materials, we employ a range of sophisticated characterisation methods such as absorption/transmission spectroscopy, photoluminescence excitation-emission spectroscopy, X-ray photoelectron spectroscopy, scanning electron microscopy and tomographic holographic 3D microscopy.

Grants and awards

- "The Training of Early-Stage Researchers (ESR) for the Development of Technologies to Monitor Concentrations of Micro/Nano Plastics in Water for their Presence, Uptake, Threat to Animal and Human Life". M Curie Innovative Training Network (H2020-MSCA-ITN-2019 Project: 860775, MONPLAS) (ESR2 project)
- "New Foundations for Nanomedical Treatment of Neurodegenerative Diseases and Cancer", The British Academy Researchers at Risk Fellowship to Dr Y Kremenska (RaR\100585)
- Royal Society Research Grant project "Novel Pathways on Solution-Processing Carbon Nanotube Transistors for Low-Power Electronics" in 2020-21 (PI, Dr P Lutsyk)
- Royal Society APEX project "Nanomaterial Electrode Webs for Revolutionary Brain Recording Systems" in 2022-2024 (PI, Dr P Lutsyk)
- APEX Public Engagement Grant project "How do our Brain Cells Talk to Each Other?" in 2022-2024 (PI, Dr P Lutsyk)

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Dr Petro Lutsyk

Research fellows:

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Mr Syed Atif Iqrar

Mrs Debjani Goswami

Research visitors:

M. Sklodowska-Curie IF Project with Tartu University (Estonia)

Science Park & Institute of High Technologies, Taras Shevchenko National University of Kyiv, Ukraine – Professor Glen Kelp and Professor Tanel Tatte

111 collaborative project, Key Laboratory of Specialty Fiber Optics and Optical Access Networks, Shanghai University, China – Professor Chengbo Mou

Collaborations:

Drs Yu Piryatinski and A Verbitsky, Institute of Physics National Academy of Sciences of Ukraine (NASU)

Professor O Kachkovsky and Dr Ya Prostota, Institute of Bioorganic Chemistry and Petrochemistry, NASU, Ukraine

Professor V Skryshevsky and Professor S Alekseyev, Taras Shevchenko National University of Kyiv, Ukraine

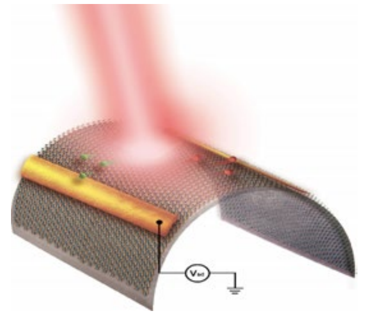
Dr C Mou, Shanghai University, China

Dr M Al Araimi, Higher College of Technology, Sultanate of Oman.

Dr R K Ulaganathan and Dr S Canulescu, Technical University of Denmark

Dr R Sankar, Institute of Physics, Academia Sinica, Taiwan

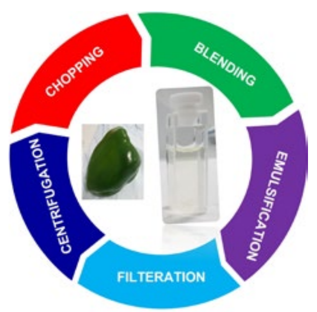
Dr S M Mhatre and Prof C.-T. Liang, National Taiwan University



2D hybrid perovskites materials for photonics and optoelectronics

3D organic-inorganic metal halide perovskites are well known for optoelectronic & photonics applications due to their exceptional physical properties, solution processability and cost-effectiveness. However, the lack of environmental stability highly restricts them from practical applications. We developed a unique class of 2D hybrid perovskite self-assembled multi quantum-well single crystalline materials with outstanding stability. Using 2D hybrid perovskites, we demonstrated a stable photodetector performance with high responsivity and specific detectivity. Our research results are potential in advancing the field of hybrid perovskite for next generation photonics and optoelectronics.

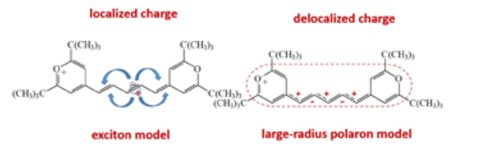
R. K. Ulaganathan, R. C. Murugesan, C.-Y. Lin, A. Subramanian, W.-L. Chen,Y.-M. Chang, A. Rozhin, R. Sankar. Stable Formamidinium-Based Centimeter Long Two-Dimensional Lead Halide Perovskite Single-Crystal for Long-Live Optoelectronic Applications. *Adv. Funct. Mater.* 15, 2112277, (2022).



Food Photonics: The extraction and spectroscopy of food pigments

We demonstrated a unique strategy to extract various plant food pigments, such as chlorophylls, carotenoids and phenolic compounds by the high-speed shear-force mixing of fresh green and red bell peppers (capsicum annuum) in an aqueous medium. An advanced FLuorescence Excitation-emission (FLE) mapping and optical absorption analysis from the optical grade aqueous bell peppers dispersion allow simultaneous probing of chlorophylls, phenolic compounds and carotenoids by their characteristic spectral features. The demonstrated sampling protocols and spectroscopic analysis will be highly beneficial to obtain advanced spectroscopic databases from different food materials for express food assessments and quality control.

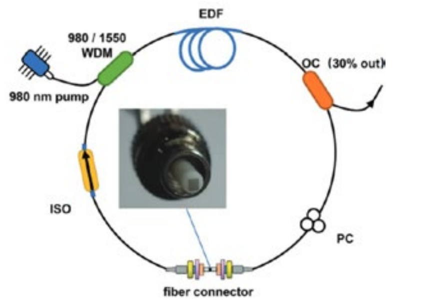
C.M. Raghavan, M.T.A. Choudhury, A. Rozhin. 2D Excitation-Emission Fluorescence Mapping Analysis of Plant Food Pigments. *Food Chemistry*, 418, 135875 (2023).



Excited state relaxation in cationic cyanines studied by time-resolved spectroscopy

This work reports on establishing a novel model of relaxation for carbon chain-based molecules of dye characterised by symmetric and non-symmetric structures. The carbon chain in such symmetric and non-symmetric charge localisations is close to polymethine and polyene conformations, respectively. Combined quantum-chemical calculations and time-resolved spectral measurements allowed us to characterise the symmetric and non-symmetric structures in the ground and excited states with specific peaks of transitions and lifetimes. The features of the polymethine structure of the dye were attributed to large-radius polaron formation, whereas for the polyene structures the model of excitons formed on the double bonds of the carbon chain can be used to analyse the relaxation pathways. The proposed model is characteristic for pentamethine cyanine dyes with the symmetric and non-symmetric distribution of cationic charge at the carbon chain between the terminal groups in the ground and excited states.

Yu.P. Piryatinski, A.B. Verbitsky, A. Dmytruk, M.B. Malynovskyi, P.M. Lutsyk, A.G. Rozhin, O.D. Kachkovsky, Ya.O. Prostota, V.V. Kurdyukov'. Excited State Relaxation in Cationic Pentamethine Cyanines Studied by Time-Resolved Spectroscopy. *Dyes and Pigments*, 193, 109539 (2021).



Carbon nanotubes saturable absorber for mode-locked erbium doped fibre laser

Carbon nanotube-polymer composite films are widely used in photonic and optoelectronic applications to produce ultrashort optical pulses in a laser cavity. However, such films may suffer from severe degradation in humid environments, resulting in a loss of regular pulse generation. To address this issue, we have fabricated surfactant-free carbon nanotube-styrene methyl-methacrylate polymer composite films that act as saturable absorbers. These films are used to demonstrate a self-starting passively mode-locked erbium-doped fibre laser that can generate ~1 ps pulses. Experimental measurements and numerical simulations confirm the effectiveness of the saturable absorber in generating ultrashort pulses. Moreover, the composite film can survive fully immersed water conditions for up to 30 days and can still mode-lock the laser after being soaked for two days, indicating the humidity-resistant capability of the film.

Y. Bao, L. Dai, J. Jiang, Z. Huang, Q. Huang, A. Rozhin, C. Mou. Humidity Resistant Carbon Nanotubes-Styrene Methyl-Methacrylate Polymer Composite for Ultrafast Laser. *Advanced Optical Materials*, 10 (18), 2200461 (2022).

Optoelectronics and Biomedical Photonics

The Laser and Biomedical Photonics Research Group is at the forefront of cutting-edge experimental and theoretical research in high-power and ultrashort-pulse compact lasers, spanning the visible, near-IR, mid-IR and THz spectra ranges.

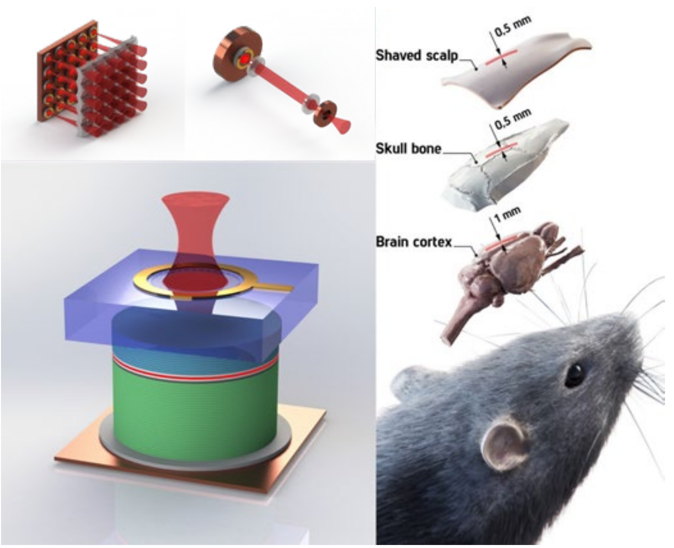
We are pushing the boundaries of photonic technologies, with a particular emphasis on creating the next generation of tools and applications for the fields of biology and medicine. Our primary research focus is on the development of compact CW and ultrafast semiconductor quantum-dot and quantum-well-based lasers, particularly in the 1 – 1.3μm spectral region, as well as quantum cascade lasers (2.7 – 3.4μm and 10-18 μm), with applications in biomedical imaging and nonlinear frequency conversion to the visible, mid-IR and THz spectral regions.

We are also dedicated to advancing ultrafast fiber lasers for biophotonics, specifically targeting the transparency windows of biological tissues, including the 700–950 nm, 1–1.3 μm, and 1.6–1.8 μm ranges.

Our research endeavours also encompass the development of room temperature, ultra-compact and portable THz sources in the 0.3 – 1.5 THz region, with applications in safety and security, quality control, biophotonics and medical imaging. Our investigations into the interactions of high-power and ultrashort-pulse lasers with various materials aim to enhance the process of diagnosing and treating challenging health conditions faced by society.

Working in close partnership with companies and organisations across Europe, our group has successfully developed new imaging technologies, non- and minimally-invasive diagnostic tools and treatments. These advancements represent critical steps towards effectively managing a wide range of common age-related, cardiovascular and neurological conditions and complications.

Our group has also made significant progress in developing a non-invasive laser-based multimodal diagnostic system that utilises the Doppler-shift effect, tissue oximetry and fluorescence spectroscopy. This system has proven effective in our research on the diagnosis of various cardiovascular diseases, complications related to heart failure, inherited skin diseases (scleroderma), solid cancers and type 2 diabetes foot disorders. We continually strive towards improving the availability of photonics-based technology both within and beyond the medical field.



Grants and awards

- £ 230,000 - Scaff-Net
- € 3.6m - NEUROPA
- € 4.7m - AMPLITUDE
- € 5.2m H2020 - PULSE
- £ 1m EPSRC - Compact THz based systems for neuroscience applications
- £ 1.7m EPSRC - Advanced optical frequency comb technologies and applications
- € 2m - PLATFORMA (finished)

Academic staff:

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Dr Dmitrii Stoliarov

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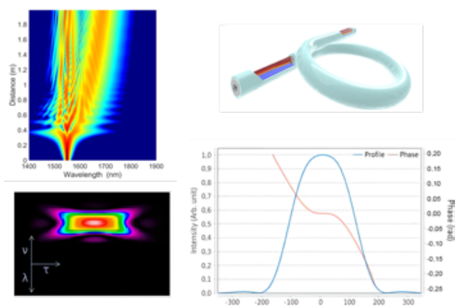
Ms Diana Galiakhmetova

Ms Eleni Farmaki

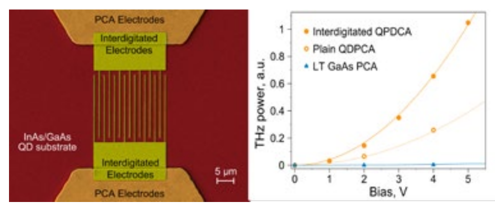


Amplitude: Wavelength tunable femtosecond fiber laser

We constructed an all-polarization-maintaining (PM) fibre laser based on a mode-locked master oscillator and a chirped pulse amplification (CPA) system. Using this laser system with an output power of 300 mW, we investigated the power, spectral and polarisation characteristics of the Raman-shifted soliton in a low-birefringence large-mode-area photonic crystal fibre (LMA PCF). We discovered that by adjusting the pump pulse polarization we could tune the central wavelength of the output spectrum across the otherwise unreachable 1600-1700 nm range of Er-doped fibre lasers while maintaining a constant output power. Circularly polarised pulses had decreased peak power compared to linearly polarised pulses with the same energy. The system generates sub-100 fs pulses with 10 nJ energy and a tunable central wavelength of 1600-1700 nm. We then frequency-doubled the 1600-1700 nm radiation using a PPLN crystal with high conversion efficiency, resulting in sub-200 fs pulses with a spectrum tuning range of 812-850 nm and up to 5.1 nJ pulse energy. The conversion efficiency reached 55% at 1685 nm, and the second harmonic generation (SHG) power stability was within 2.5% rms. These laser properties hold promise for multiphoton imaging of biological tissues.

Stoliarov, D., et al. "Fibre laser system with wavelength tuning in extended telecom range." Optical Fiber Technology 72 (2022): 102994.

Koviarov, A., et al. "Highly efficient frequency doubling of 1700 nm ultrashort pulsed fiber laser in PPLN bulk crystal." Nonlinear Frequency Generation and Conversion: Materials and Devices XXII. SPIE, 2023.



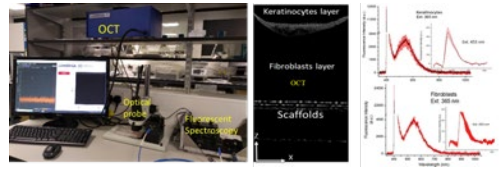
Compact THz generation: QD based interdigitated photoconductive antennas for enchanced THz generation

The terahertz (THz) region of electromagnetic spectrum is of great interest for various applications including sensing, imaging and astrophysics. It is especially good for biological imaging and the detection of dangerous material, primarily due to its non-ionising quality. Therefore, a reliable and efficient compact source of THz generation holds great promise.

Our research group works in this direction using semiconductor materials. Recently, we investigated QD-based photoconductive antennas wherein interdigitated electrodes were introduced within gap of usual bow-tie electrode configuration. These interdigitated QD PCAs were investigated using time-domain spectroscopy (TDS). The performace of when interdigitated QD PCAs is comapred with LT GaAs and plain QDPCA showed a three-fold increase in THz generation at the same optical pumping condition.

Yadav, A. et al. Intergation of Interdigitated Electrodes to Quantum Dot Based Photoconductive Antenna Unconventionally Enhances Pulsed Terahertz Generation. International Conference Laser Optics (ICLO) 2022 (IEEE 2022 - Proceedings). https://doi.org/10.1109/ICLO54117.2022.9840021

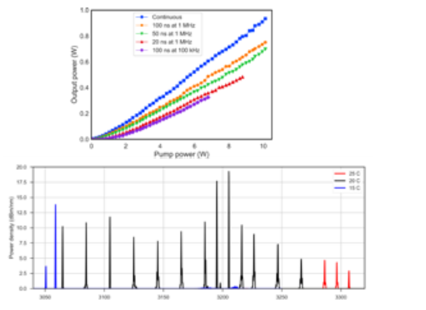
Gorodetsky, A. et al. Enhanced THz Generation from Interdigitated Quantum Dot Based Photoconductive Antenna Operating in a Quasi-Ballistic Regime. Under review at IEEE JSTQE (2023).



Platforma: Peripheral nervous system tissue engineering for medical and cosmetic testing applications

Platforma is a commercially-driven collaboration to produce novel high-content phenotypic platforms for screening cosmetics, pollutants and new therapeutics. We propose to create purpose-built, 3D modular human tissues supported by laser-printed bio-compatible scaffolds from which morphological and metabolic status of the cells can be monitored. Each tissue module will consist of multiple different cell types. Two main modules will be developed: a skin-sensory module and a muscle-motor module.

The project resulted in the development of a reliable, compact and affordable combined Fluorescent Spectroscopy and OCT imaging system for the morphological and metabolic assessment of human tissue models. The work was recognised by EC's Innovation Radar as a very promising innovation.



Mid-IR tunability and amplification

The mid-IR region of 1.9 μm – 3.5μm can be covered with GaSb-based compact semiconductor lasers. GaSb-based emitters in the cascaded quantum well (QW) configuration offers a gain bandwidth of ~ 100 nm. Such lasers have demonstrated output power levels of several hundreds of mW.

Our research on such emitters focused on tunability of emission and amplification for higher output power. We demonstrated a wavelength-tuning of ~ 250 nm from such devices with variation of temperature and operation regime from 3.055 μm to 3.305 μm. We also demonstrated amplification of 2800 nm using Er-doped fiber amplifier when the seed semiconductor laser is electrically operating under continous wave and pulsed (nanosecnd) regime. We noticed that the amplifier gain is limited by self-lasing in the fiber.

Chichkov, N. B. et al. Amplification of GaSb-Based Diode Lasers in an Erbium-Doped Fluoride Fibre Amplifier. *IEEE Photonics Journal*, 15, 1-7 (2023).

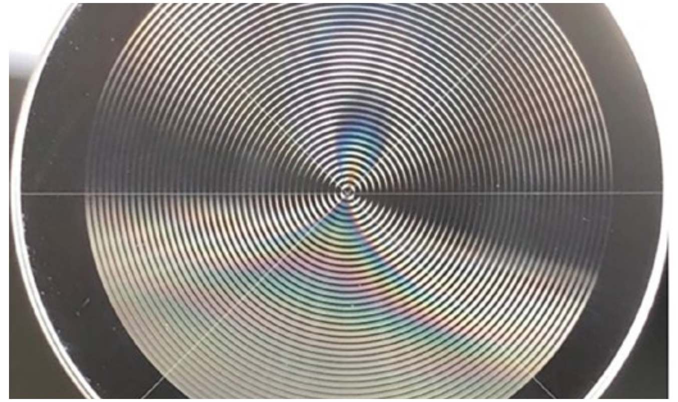
Chichkov, N. B. et al. Wavelength-Tunable, GaSb-Based, Cascaded Type-I Quantum-Well Laser Emitting Over a Range of 300 nm. *IEEE Photonics Technology Letters*, 30, 1941-1943 (2018).

Laser Material Processing

AiPT is a world-renowned research institution that has made remarkable strides in the field of laser material processing. With a strong focus on using UV and femtosecond lasers to micro-fabricate photonic devices in optical fibres and planar substrates, AiPT has received consistent grant awards for laser facilities, which have contributed to its success in achieving high-level research. These grants include the solid-state UV laser, funded by the Wolfson Foundation, and the upcoming femtosecond laser, granted by the EPSRC core equipment award.

One of AiPT 's primary research achievements has been the advancement of fibre gratings fabrication technologies using both UV and femtosecond lasers, and their potential applications. Through its research, AiPT has achieved great success in various fibre gratings, including tilted gratings and gratings in novel optical fibres of various geometries, such as single mode, few-mode multimode, D-shaped and multicore fibres. These developments open up a host of opportunities for applications in optical sensing, fibre laser technology, and optical communications.

AiPT's Laser Material Processing group has made significant progress in micro-fabricating new photonic devices using ultrafast femtosecond lasers. Thanks to their high peak power and ultrashort duration, femtosecond lasers have become an indispensable tool for the microfabrication of photonic devices. The group has used a list of femtosecond lasers based on Ti:Sapphire regenerative amplifiers or Yb-doped fibre lasers and amplifiers with different characteristics including wavelength, power and repetition rate. Different laser-matter interactions are utilised, such as two-photon absorption-based polymerisation, index modification and direct ablation. These photonic devices have numerous potential applications in diverse fields including sensing, food safety, agriculture, healthcare and medicine. AiPT's research in laser material processing continues to advance the development of new photonic devices with exciting potential applications. Overall, AiPT's ground-breaking research has contributed significantly to the advancement of laser material processing technology and its potential applications in various fields.



Grants and awards

- "Photonic Fibre Gas Sensor Fabrication by Two- Photon Polymerization Techniques" £211,000 2023-2025
- H2020-MSCA-RISE-2019 "Integrated Photonic-Nano Technologies for Bioapplications" (IPN-Bio) €1 million; 2020-2025
- H2020-MSCA-IF-2019 NanoIP-BioS "Advanced 2D-Material Integrated Photonics Technologies for Bio Sensing" €225,000; 2021-2023
- UK Royal Society Advanced Newton Fellowship project "Advanced Laser Heterodyne Feedback and Fiber SPR Technology for Bio-Sensing Applications" £110,000; 2019-2023
- Royal Academy of Engineering Visiting Professor scheme – "Engineering Employability, Professionalism and Ethics" £30,000; 2020-2021
- DfE In-work Skills Training (to develop courses in mechatronics, digitisation for manufacturing, sustainable engineering, professional engineering and electrification technology) £483,000; 2021-2022

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Dr Bing Sun

Dr Egor Manuylovich

Dr Elena Turistyna

Dr Kaiming Zhou

Dr Namita Sahoo

Dr Vladimir Osipov

Dr Yang Lu

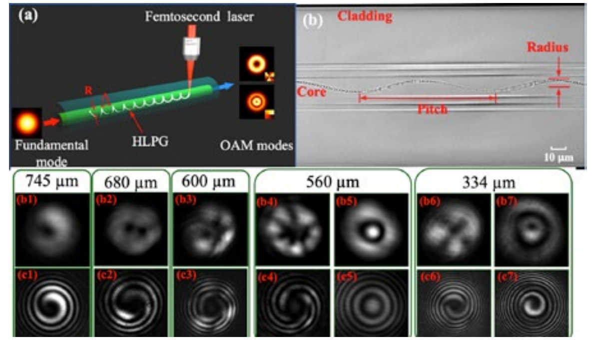
Visiting researchers:

Professor Ana Rocha

Miss Liliana Sousa

Mr Chen Jiang

Mr Jiangying Xia



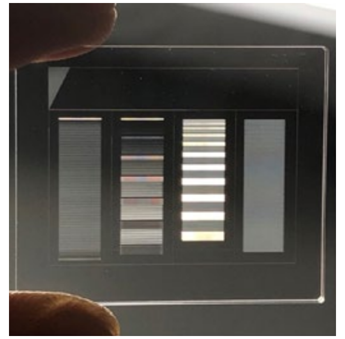
Fibre grating inscribed with UV and femtosecond laser

Femtosecond laser inscription is a technique that inscribes structures inside optical fibres using ultrashort pulses and high peak power. It can work with fibres of different materials and geometries, and allows the flexible inscription of various types of structures. AiPT demonstrated the inscription of helix long-period gratings using this technique, which can facilitate the instigation of the orbital angular momentum (OAM) mode for next-generation optical communication with high capacity and mode-division multiplexing (MDM). The helix structure is inscribed by irradiating the core region with a highly focused femtosecond laser while the fibre moves in a spiral path. The resulting helix mode converter can convert the fundamental mode to high-order core mode and OAM mode with a unique helical phase profile. Femtosecond laser inscription is a promising technique for advanced optical fibres and innovative communication systems.

Broadband and Stable Linearly Polarized Mode Converter Based on Polarization-Maintaining Fiber Long-Period Grating. Jiang, C., Liu, Y., Wan, Y., Lin, Y., Mou, C., Ma, Y. & Zhou, K., Aug 2022, *Optics and Laser Technology*. 152, 108159;

Femtosecond Laser Inscribed Parallel Long-Period Fiber Gratings for Multi-Channel Core Mode Conversion. C Jiang, K Zhou, B Sun, Z Wang, Y Wan, Y Ma, C Mou, L Shen, L Zhang, Optics Letters 47 (13), 3207-3210;

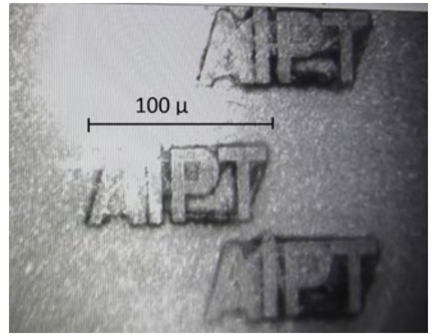
Line by Line Inscribed Small Period Long Period Grating for Wide Range Refractive Index Sensing, J Wang, F Shen, X Shu, K Zhou, H Jiang, H Xia, K Xie, L Zhang, *Optics Communications* 508, 127821.



Femtosecond laser inscribed calibration phantoms for optical coherence tomography

Optical coherence tomography (OCT) is a powerful imaging system allowing non-invasive high-resolution real-time in-vivo imaging, widely used in ophthalmology and dermatology. However, there is no global standard to calibrate and compare OCT systems. OCT phantoms act as 3D optical rulers and calibration tools for different OCT systems. At Aston, femtosecond laser direct writing is used to fabricate OCT phantoms, including a universal planar phantom to assess performance in resolution, point spread function (PSF), sensitivity and distortion. A non-planar phantom detects distortion and validates post-processing correction algorithms. Different designs are validated for accurate and consistent fabrication of these calibration phantoms. These OCT phantoms offer a standard for performance comparison across OCT systems and can aid in improving diagnostic accuracy and quality.

Femtosecond Laser Inscribed Advanced Calibration Phantom for Optical Coherence Tomography (OCT); Lu, Y., Gordon, N., Coldrick, B., Ibrahim, I., Mezentsev, V., Robinson, D. & Sugden, K., 28 Feb 2020, Advanced Fabrication Technologies for Micro/Nano Optics and Photonics XIII. von Freymann, G., Blasco, E. & Chanda, D. (eds.). SPIE, 1129205. (Proceedings of SPIE - *The International Society for Optical Engineering*; vol. 11292).



Two photon polymerisation

Multiphoton direct writing is a femtosecond laser-based photonic technology that enables the fabrication of any designed 3D micro-devices with features on submicron-relevant length scales. This method is used to manufacture polymer-based micro-optical and micro-fluidic elements with free-form 3D topographies, which can be utilised for the development of precise, micro-sized and low-cost micro-sensors. AiPT has designed and assembled an original setup for multi-photon lithography to fabricate micro-optical elements directly at the end-face of optical fibres. Combining mature fibre optics technology and modern nano-photonics offers new horizons for low-cost and high-precision sensors. The technique of femtosecond laser structuring of photosensitive materials will be applied to various acrylate and epoxy materials to develop fibre-based gas sensors for CO_2, CH_4, NH_3 and other gases. Direct 3D laser writing offers many possibilities for the design of novel optical systems and efficient light transformations. The flexible manufacturing of micro-optical and microfluidic elements for innovative devices and systems will have wider applications beyond food, agri-tech, and biomedical fields.

RESEARCH FOCUS

Dr Morteza Kamalian-Kopae

Dr Morteza Kamalian-Kopae specialises in stochastic signal processing and nonlinear systems dynamics. Morteza completed both a BSc and MSc in communication engineering in Iran and joined Sant'Anna School of Advanced Studies as a visiting researcher in 2014. He completed his PhD at the Aston Institute of Photonic Technologies in optical communication in 2018.

Morteza's research has always involved processing stochastic signals, where information is extracted from distorted and perturbed symbols. Techniques to estimate unknown characteristics of such signals are well-developed for linear systems, including filters and wireless communication channels. However, in nonlinear systems such as optical fibre, particular provisions are required to ensure these techniques are still effective. One of these techniques is the nonlinear Fourier transform (NFT), where the propagation of light in the nonlinear fibre is turned linear in another space. In the EPSRC project UNLOC, this feature is used to design new communication systems that do not suffer from the nonlinearity of fibre [1,2]. NFT can also be used to derive models for unknown nonlinear systems such as lasers, where invariant characteristics of the system are identified and used to explain its dynamics [3].

During his postdoc in the EPSRC project TRANSNET, Morteza worked on the application of machine learning in designing optical components and signal equalisation in optical communication. His emphasis is on solutions with reduced computational complexity [4,5]. Low-complexity DSP techniques are crucial in the future generation of optical communication systems, including long-haul transoceanic links, short-reach metro networks and data centre interconnects.

His recent research focuses on designing optical computers with high processing speed, low power consumption and compact implementation among key advantages over electronic counterparts. In the H2020 ITN POSTDIGITAL project, with his PhD student Diego Arguello Ron, Morteza is investigating the use of multicore/multimode fibres in designing data processing platforms. Another platform for optical computing is microresonators, where nonlinearity can be achieved with low power, making it a potential power-efficient computing setup. Morteza is exploring this path with his PhD student Negar Shabaani.

Morteza is a fellow of the Higher Education Academy and his teaching activities include digital communication systems and information theory, wireless communication systems, mobile data networks and 5G signal processing courses.

Key publications:

1. Kamalian, Morteza, et al. Periodic Nonlinear Fourier Transform for Fiber-Optic Communications, Part I: Theory and Numerical Methods. *Optics Express* 24.16 (2016): 18353-18369.
2. Kamalian-Kopae, Morteza, et al. Full-Spectrum Periodic Nonlinear Fourier Transform Optical Communication through Solving the Riemann-Hilbert Problem. *Journal of Lightwave Technology* 38.14 (2020): 3602-3615.
3. Sugavanam, Srikanth, et al. Analysis of Laser Radiation using the Nonlinear Fourier Transform. *Nature Communications* 10.1 (2019): 5663.
4. Ron, Diego Argüello, et al. Experimental Implementation of a Neural Network Optical Channel Equalizer in Restricted Hardware using Pruning and Quantization. *Scientific Reports* 12.1 (2022): 8713.

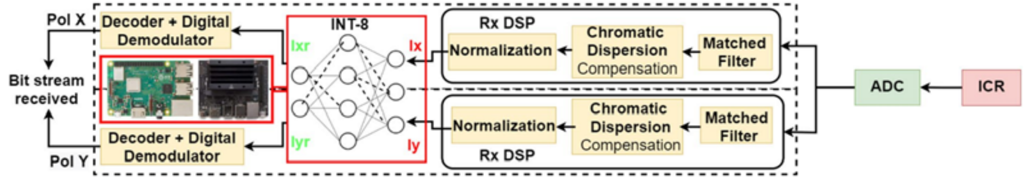


Figure 1. complexity-reduced NN-based equaliser implementation on resource-limited hardware [4]

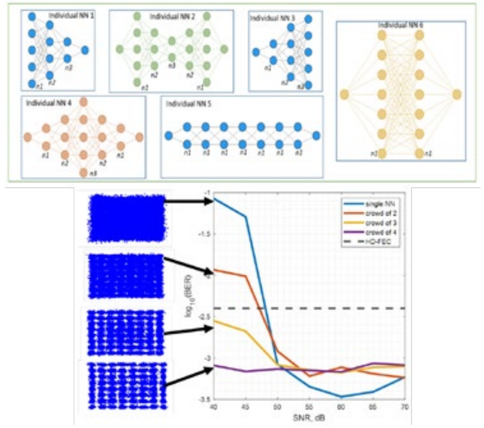


Figure 2. noise-resistant implementation of NN-based equalisers [5]

Dr Auro M Perego

Dr Auro M Perego is a Royal Academy of Engineering (RAEng) Research Fellow at AiPT with a five-year project (2020-2025) called "Novel Tuneable Dissipative Optical Frequency Combs: From Visible to Mid-Infrared".

Auro is passionate about nonlinear light waves dynamics, self-organisation and instabilities in their manifold ramifications: from fundamental physics to engineering applications. He is currently building his independent research group at AiPT where he is the main supervisor of two PhD students: Minji Shi and Negar Shaabani Shishavan.

His main research interests include the investigation of optical frequency combs generation in nonlinear driven optical resonators, especially focusing on novel techniques for achieving controllable spectral properties.

In collaboration with his AiPT colleague Dr Morteza Kamalian, he is exploring the potential of nonlinear resonators for optical computing. Auro is also working on optical parametric amplification, investigating nonconventional approaches based on coupled nonlinear waveguides to achieve broadband amplification with flat gain profile and potential applications in optical communications.

Another of his research interests is the investigation of novel techniques for generating light pulses in fibre lasers, especially targeting the challenging mid-infrared spectral region in a collaboration with Dr M Chernysheva from Leibniz Institute of Photonic Technologies (Jena, Germany) through a Royal Society International Exchanges Project. In the field of pulsed lasers, he works with his colleague at AiPT Dr Hani Kbashi to develop optical sensing solutions for civil engineering applications based on optical frequency combs and mode-locked fibre lasers. His passion for fundamental physics leads him to investigate the theory of laser mode-locking in the quest for developing a universal formalism capable to capture the laser dynamics on various temporal scales and to describe quantum coherence effects.

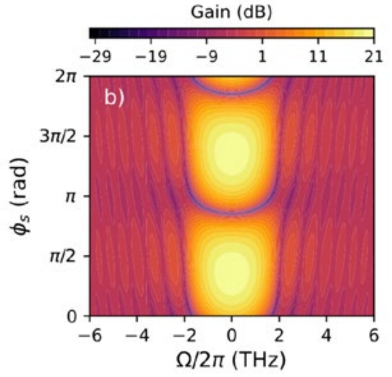
Key publications:

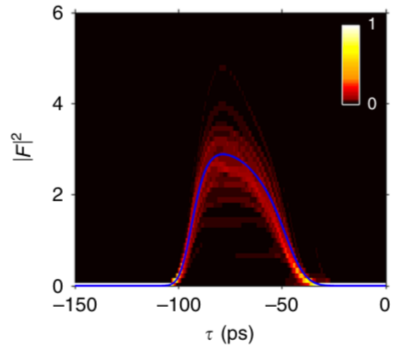
1. A. M. Perego, A. Mussot and M. Conforti. Theory of Filter-Induced Modulation Instability in Driven Passive Optical Resonators. *Physical Review A* 103, 013522 (2021).

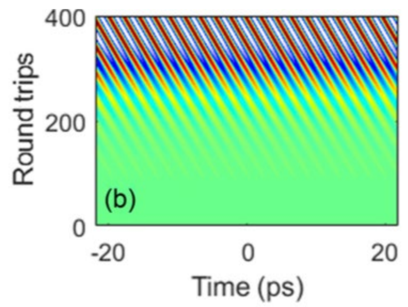
2. T. Bunel et al. Observation of Modulation Instability Kerr Frequency Combs in a Fiber Fabry–Pérot Resonator. *Optics Letters* 48, 275 (2023).

3. M. Shi, V. Ribeiro and A. M. Perego. On the Resilience of Dual-Waveguide Parametric Amplifiers to Pump Power and Phase Fluctuations. *Applied Physics Letters* 122, 101102 (2023).

4. A. M. Perego et al. Coherent Master Equation for Laser Modelocking. *Nature Communications* 11, 311 (2020).







Dr Gabriella Gardosi

Gabriella Gardosi is an early career research associate at AiPT. She has a BSc in Applied Physics and a PhD in Photonics completed at Aston University. Since 2017, Gabriella has worked on the surface nanoscale axial photonics(SNAP) technological platform led by Professor Misha Sumetsky. Starting out as a research placement student, six years later Gabriella has been named among the 100 people at the "cutting-edge of photonics evolution" the 2023 Photonics100 by Electro Optics Magazine.

She has recently been awarded the prestigious Leverhulme Trust Early Career Fellowship at AiPT, the first of its kind at EPS. The interdisciplinary research project will commence in September 2023 and will run for 3 years with the project title 'Ultraprecise sensor to Measure Interactions between Food and Packaging Materials'.

Gabriella's key discovery during her doctoral studies was a new fabrication method of ultralow-loss photonic microresonators. Her method incorporates microfluidics into the SNAP platform in order to better use thermal methods to create the microresonators under development. She discovered that, by growing the microresonators via "slow optical cooking," [1] sub-angstrom precision in the variation of the microcapillary's effective wall thickness could be achieved. This new technique could unlock smaller 'slow light' devices, which in turn are key for the development of more advanced quantum, photonic computing and telecommunication systems. Gabriella's work has brought the goal of picometre-precision in microresonator fabrication within reach [2] and could also surpass it entirely. Her goal now is to develop this technique for the fabrication of frequency comb microresonators, which require a parabolic profile shape.

Gabriella is also exploring the direction of sensing applications in food technology via ultra-sensitive whispering gallery mode microfluidic sensors. Her recent proof-of-concept experiment demonstrated nonlocal sensing of refractive index changes within the capillary fibre by detecting the translation of the water edge moving along the section of microcapillary fibre containing a 2 mm long microresonator by monitoring the local microresonator spectrum near its centre. In addition, this technology can potentially be inverted to develop reconfigurable microphotonic circuits – devices that control light by fluids at the microscale opening up the development of reconfigurable microphotonic devices for optical signal processing applications. [3]

This year, Gabriella is chairing FreQomb, the academic workshop on Frequency Combs, which will invite international speakers and is due to be held at AiPT at the tail end of 2023.

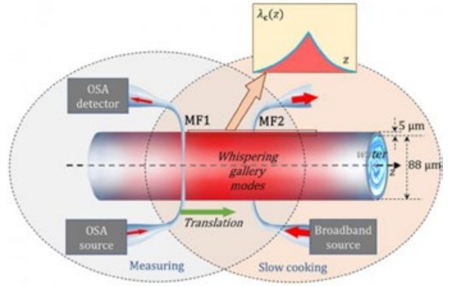
Aside from research, Gabriella is an advocate for women in STEM. In a recent interview for Electro Optics magazine she stated: 'Sometimes it bothers me to be the only woman in the room. It causes me to spend more time thinking about how to conduct and present myself. That can become a real mental drain when I just want to focus on the science. In that position, things can amplify in your mind and set you back. Conversely, the smallest kind word or act can mean the world. So, I try to carry that idea with me for others.'

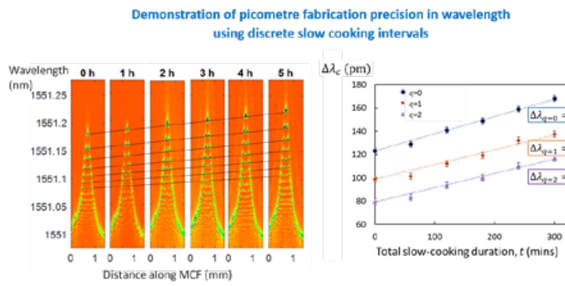
Key publications:

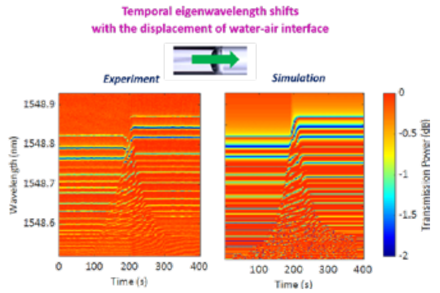
1. G. Gardosi, B. J. Mangan, G. S. Puc, and M. Sumetsky. Photonic Microresonators Created by Slow Optical Cooking. *ACS Photonics* (2021).

2. G. Gardosi, B. J. Mangan, and M. Sumetsky. Picometer-Precise Post-Processing of Optical Microresonators via Slow-Cooking. *Conference on Lasers and Electro-Optics* (Optica Publishing Group, 2022), p. JW3A.49.

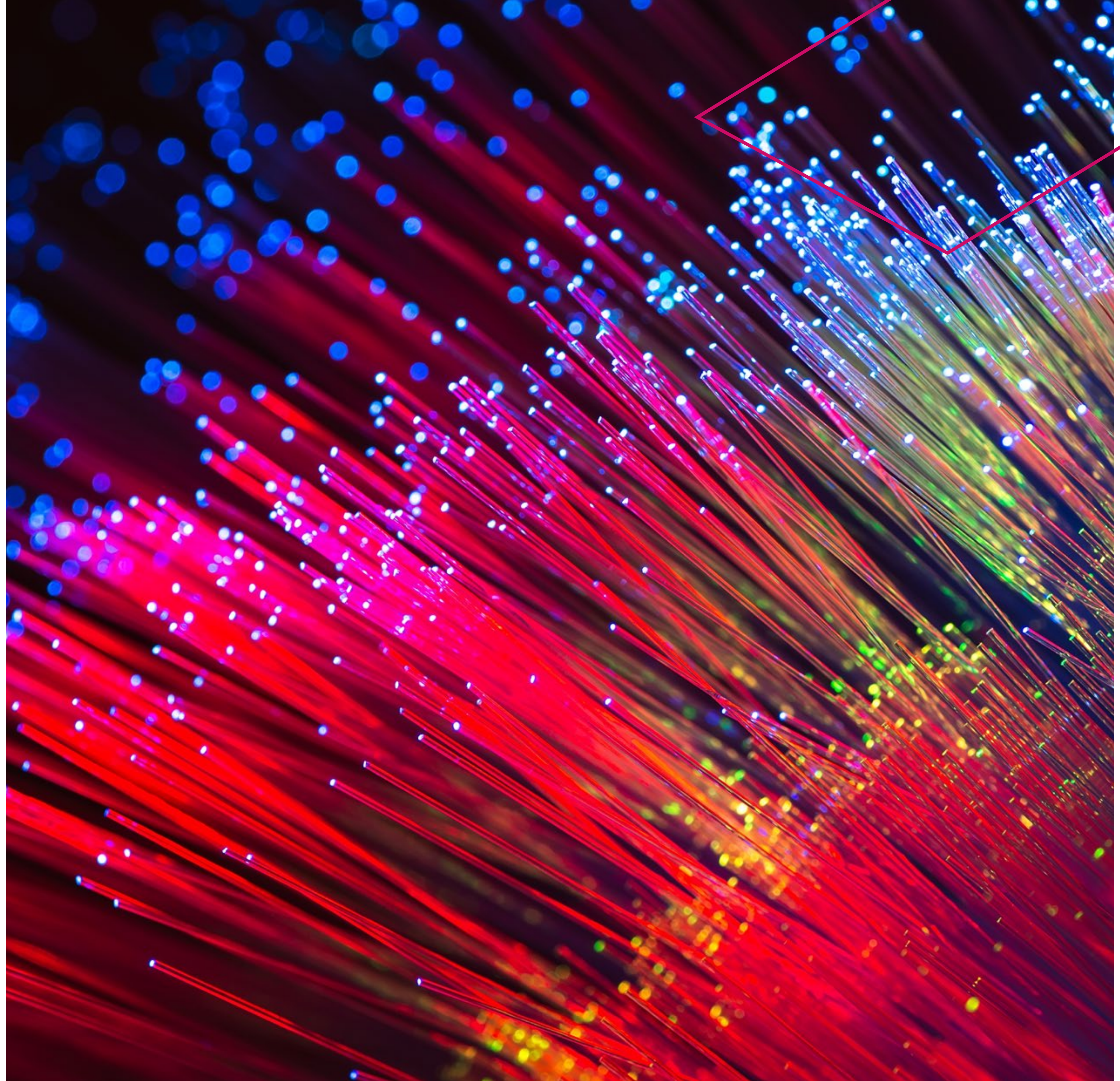
3. G. Gardosi and M. Sumetsky. Translation and Reconfiguration of SNAP Microresonators Using Optofluidics. *Photonics West* (SPIE, 2023), p. 12407-12.







RESEARCH PORTFOLIO



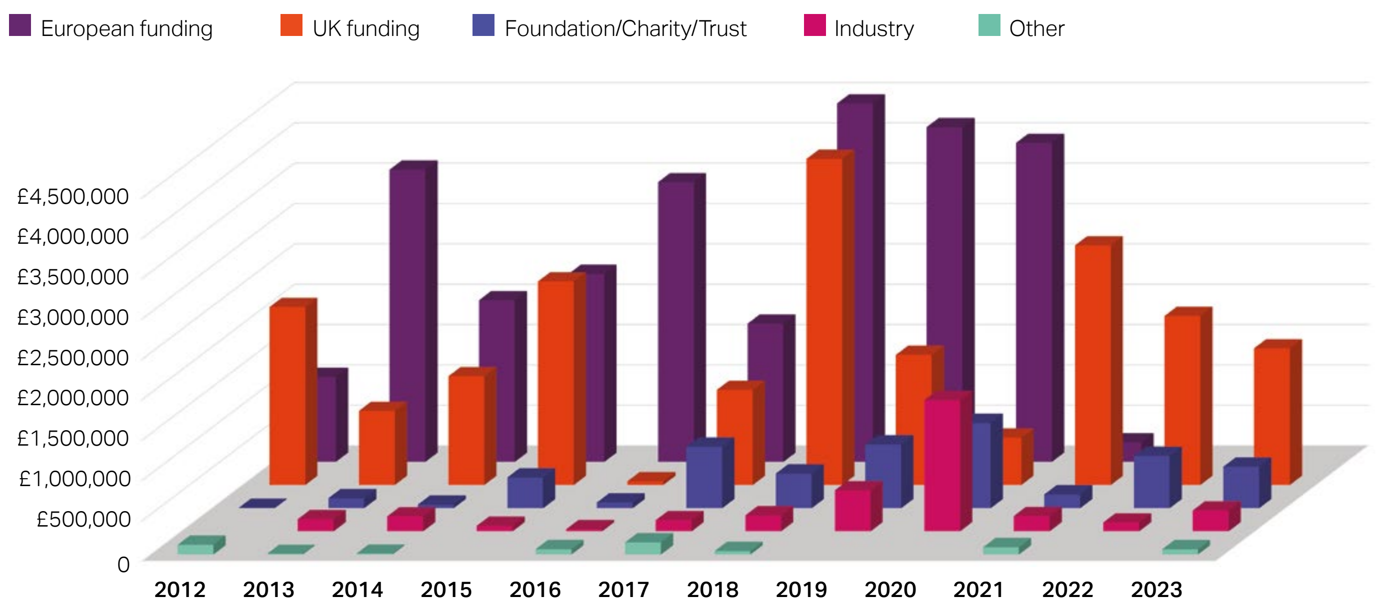
Funding 2012-2023

AiPT has an impressive portfolio of project funding, industrial and international collaborations, five spin-out companies, highly cited research papers and 60 patents – all demonstrating excellence in the field.

AiPT maintains active and fertile collaborations with industrial companies and academic institutions throughout the world and has won sustainable funding for research and training from the Engineering and Physical Sciences Research Council (EPSRC), Knowledge Transfer Partnerships (KTP), the Royal Society, EU Framework programmes (FP7. H2020), industry and other sources as illustrated below.

The diagram below illustrates the change in AiPT's external funding mix since 2012. Following the withdrawal of the UK from the European Union, and its consequential uncertainty about access to the European Commission funding, the funding portfolio was reshaped away from EC funding and towards various UK funding bodies.

AiPT external funding mix (2012-23)



* The diagram includes projects awarded from 2012 to 2023 (fiscal year).

EPSRC project "Advanced Optical Frequency Comb Technologies and Applications"

The international centre-to-centre interdisciplinary collaboration "Advanced Optical Frequency Comb Technologies and Applications", led by Aston Institute of Photonic Technologies aims to develop a new advanced optical frequency comb (OFC) technology with a broad research programme spanning from new fundamental nonlinear science-based concepts and designs to demonstrations of practical applications including metrology, telecommunications and sensing for the food industry.

The £1.6 million project has been awarded by the Engineering and Physical Sciences Research Council (EPSRC), part of UK Research and Innovation (UKRI). Objectives of the project include the development of new concepts and designs of OFC and building international collaborations in the format of a joint research centre with Universite Cote d'Azur and Lille University (both in France), and industrial project partners including BAE Systems (USA), Arden Photonics (UK), Xtera (UK), OFS (USA), Thales (France), NKT Photonics (Denmark), Eblana Photonics (Ireland), Pilot Photonics (IE), Highways England (UK) and Branscan (UK). This collaboration offers a critical mass of complementary expertise across nonlinear science, laser science and technology, high-speed optical communications, fibre-optic device engineering, optical signal processing, micro- and nano-photonics, nonlinear photonics, metrology, bio-medical applications and photonics for food industry.

Project website:

https://combs.astonphotonics.uk

People:

Professor Andrew Ellis

Professor Edik Rafailov

Professor Misha Sumetsky

Professor Nick Doran

Professor Sergei Turitsyn

Professor Wladek Forysiak

Associate Professor Sergey Sergeyev

Dr Auro Perego

Dr Dmitrii Stolyarov

Dr Egor Manuylovich

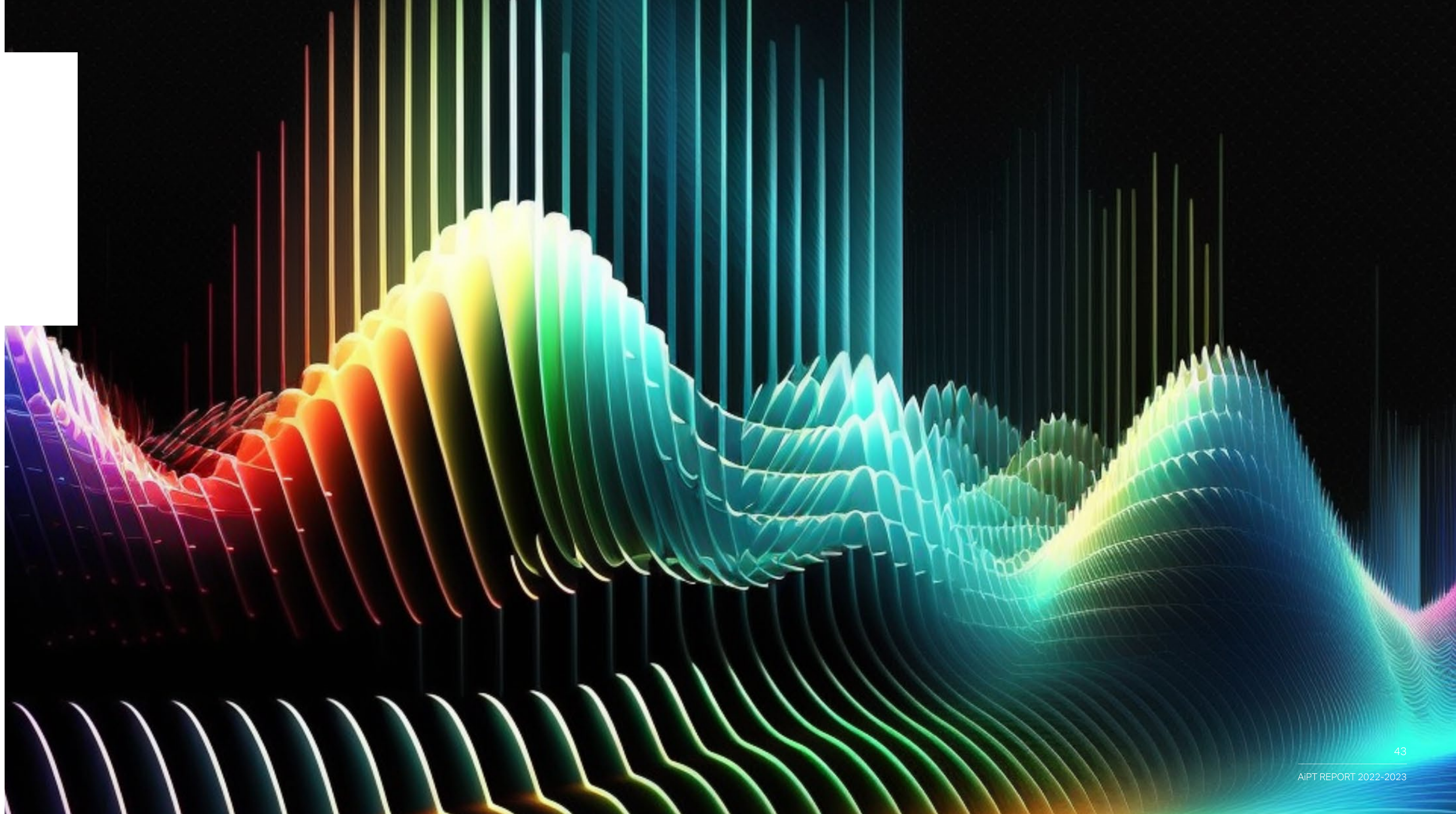
Dr Gabriella Gardosi

Associated members:

Dr Hani Kbasi

Dr Vlad Dvoyrin

Alberto Rodrigues Cuevas



MSCA ITN project MONPLAS

MONPLAS is an Horizon 2020 Initial Training Network project that began in January 2020. It's a collaboration between eight beneficiaries and nine partners, ten being academic or public research institutes, and seven being private companies.

The project is coordinated by AiPT, and between 2021 and 2023 it organised numerous MONPLAS training, dissemination and outreach events for its 14 early-stage researchers (ESRs), who are all enrolled as doctoral candidates at European universities. The focus of their research work is the improvement of analytical technologies and their applications for the characterisation and enumeration of micro and nanoplastics in various media.

Their work is motivated by micro and nanoplastics having been recently found in our soil, tap water, bottled water, beer and even in the air we breathe, but with little being known about their origins, types and concentration levels, and – more importantly – their effects on human health. Indeed, there is growing concern about the potential health risks that micro and nanoplastics pose to humans, either through ingesting the harmful bacteria they pick up when coming from wastewater plants, or just through injury and death of cells through contact, possibly through breaking down into nanoplastics first and then being absorbed by cells.

MONPLAS targets a step change in our ability to detect micro and nanoplastics, to allow for the first ever inline detection method for the positive release of water based products, to reveal their origins and their effect on human health. This substantial change will come about through undertaking research that combines various scientific areas including microfluidics (asymmetric field-flow fractionation), photonics (FTIR spectroscopy, photoluminescence, SERS, microRaman), other analytical techniques (pyrolysis-gas chromatography – mass spectrometry) and toxicology.

For cohort, or network-level, training, there have been six technical and transferrable skill training workshops, the first four being online due to COVID-19, and the final two held as hybrid events. In addition, Luca Maurizi (ESR 11, Aalborg University) and Aisha Bibi (ESR1, Aston University) have organised MONPLAS satellite symposia at two international conferences, Micro 2022 in November 2022 and ICCE in June 2023, respectively:

As of March 2023, with one year in the project to go, the dissemination, outreach and exploitation output of MONPLAS could be summarised by the following:

- 11 Journal papers
- 1 Book chapters
- 30 Conference papers
- 31 Other dissemination
- 76 Web / social media activities
- 63 Other outreach activities
- 9 Exploitation activities

The Microplastics Conference of 2022 (Micro 2022)

Micro is a biennial conference on the theme of micro (and nano) plastics. In 2022, as well as 2020, it was organised on a nodal basis due to COVID-19. Aalborg University hosted the MONPLAS node as the project's first satellite symposium. That year, 40 local nodes presented over 500 online presentations, including 13 from the MONPLAS ESRs, which led to the **Lanzarote Declaration, MICRO 2022 for the UN Treaty on Plastic Pollution.**

The 18th International Conference on Chemistry and the Environment (ICCE)

ICCE is a biennial conference under the auspice of the Division of Chemistry and the Environment (DCE) of the European Chemical Society (EuChemS) that covers the disciplines of toxicology, analytical chemistry, microbiology, geosciences and other related disciplines such as micro and nanoplastics. At this year's ICCE MONPLAS organised a one-day satellite symposium entitled 'Latest developments in analytical technologies and their applications for micro and nano plastic characterisation', where 13 ESRs and three supervisors presented their latest work.

Meanwhile, MONPLAS has also hosted other dissemination and outreach events such as:

- Four roundtable discussions between industry, academic experts and the ESRs on various aspects of micro and nanoplastics. The discussions and sharing of results and technology with end-users have allowed the ESRs to hear first-hand the end-user's perspective on micro and nanoplastics, thus focusing their efforts on the ultimate goal of generating research that can be translated.
- Workshops with other ITN projects with micro and nanoplastic synergies such as H2020 Limnoplast, H2020 AQUAplast and H2020 SOPLAS so that each group of ESRs can inspire each other towards greater research.

MONPLAS has also participated significantly in outreach via:

- Various project Open Days, schools outreach and STEM female events hosted by the beneficiaries.
- Monthly ESR progress vlogging on its own website and weekly thematic posts by the ESRs on social media including LinkedIn, Facebook, Instagram and Twitter.

The Royal Academy of Engineering project "Fibre Before The Fibre"

AiPT at Aston University, alongside the University of Glasgow and the University of the Witwatersrand, is leading a project aimed at developing a new way to access the internet before the deployment of power cable or optical fibre.

Called the 'Fibre Before The Fibre Project', it is a two-year collaboration aimed at bridging the digital divide in informal settings communities in South Africa. The collaboration is being run by lead investigator Dr Mitchell Cox at the University of the Witwatersrand in Johannesburg, South Africa, alongside co-investigators Prof Martin Lavery at the University of Glasgow and Prof Andrew Ellis from AiPT, Aston University, who came up with the concept around seven years ago.

Professor Ellis and Professor Lavery had been originally exploring the idea of creating sustainable photonics to address the digital divide in Sub-Saharan Africa, and published a road-map on how to do this. When an opportunity came up with the South African university, they were able to create the Fibre Before the Fibre Project, providing the internet performance of a fibre connection without the need to installed cables.

The Royal Academy of Engineering has provided £80,000 towards the project, with the majority being utilised in South Africa. The project involves the development of low-cost, long-range, high-speed wireless optical communication technologies that can provide the internet performance of a fibre connection without the need for installed cables. This project will connect communities who don't currently have an existing fibre infrastructure.

Part of the project is the development of an off-grid energy system in South Africa, which has the potential to power entire villages using multiple sources, including solar panels and batteries. A 3D-printed wireless communication system is also being developed in Glasgow, which will use off-the-shelf components. The system will link anchor sites such as schools via a wireless optical line-of-site signal to nearby fibre sources in affluent suburbs a few kilometres from these sites.

Professor Andrew Ellis, deputy director of the AiPT, said they would then be examining the impact the connectivity would have on children's education within the area.

"While this isn't a high-funded project, we know the impact of this both locally and globally could be huge, and so many of us here are doing this on a pro bono basis. It's a very fulfilling project to be working on and we are proud to be able to do our part in something which really is going to affect the lives of hundreds of thousands of people.

Our role in the project is to look at the impact and educational benefit it will have to the school children who will finally be able to access the internet. We believe it will create a huge benefit for communities who currently have no access to water, electricity or communications infrastructure, so it really is pioneering work we are conducting. In parts of South Africa where there is a huge digital divide between rural and urban areas where children don't even have the basics, and so for them it's not just a few weeks without an education supported by the internet, but it's months and years. We will therefore be looking at the 12 months after the installation of the products to the schools and being able to see what benefits it will have."

Horizon 2020 MSCA-ITN Innovative Training Networks

In recent years, AiPT has coordinated eight Horizon 2020 Initial Training Network (ITN) projects: ETNs WON, POSTDIGITAL, MEFISTA and MONPLAS, European Industrial Doctorate MOCCA (with Thales), REAL-NET (with Infinera and Orange), MENTOR (Infinera and Telecom Italia) and FONTE (with Nokia Bell Labs). These projects covered various topics in the photonics area – from machine learning in photonics to optical frequency combs.

FONTE

Fibre Optic Nonlinear Technologies

H2020-MSCA-ITN-2017 MSCA-ITN-EID.
EC-GA: 766155

PI: Professor Sergei Turitsyn

PM: Christiane Doering-Saad

FONTE was focusing on the development of disruptive nonlinear techniques and approaches to fibre-optic communications beyond the limits of current technology. Successfully finished in 2022.

MOCCA

Multiscale Optical Frequency Combs: Advanced Technologies and Applications

H2020-MSCA-ITN-2018 MSCA-ITN-EID.
EC-GA: 814147

PI: Associate Professor Sergey Sergeyev

PM: Felicita Tramontana/Natalia Manuilovich

MOCCA was focusing on developing a new generation of optical frequency comb techniques. Successfully finished in 2023.

REAL-NET

REAL-time monitoring and mitigation of nonlinear effects in optical NETworks

H2020-MSCA-ITN-2018 MSCA-ITN-EID.
EC-GA: 813144

PI: Professor Sergei Turitsyn

PM: Martina Passini/Natalia Manuilovich

REAL-NET is focusing on developing the new artificial intelligence-based approach and related signal processing techniques, and their successive utilisation for the new nonlinearity and noise-immune optical transmission systems.

MEFISTA

Multi-scale fibre-based optical frequency combs: science, technology and applications

H2020-MSCA-ITN-2019 MSCA-ITN-ETN.
EC-GA: 861152

PI: Associate Professor Sergey Sergeyev

PM: Martina Passini/Karola Woods

MEFISTA is focusing on novel techniques for generating specialised laser waveforms, mid-infrared tuneable dual-comb sources and the manufacturing of mode-locked fibre lasers. A special focus will be placed on the use of frequency combs in laser radar/LIDAR in autonomous cars.

POST-DIGITAL

Post-Digital Computing

H2020-MSCA-ITN-2019 MSCA-ITN-ETN.
EC-GA: 860360

PI: Professor Sergei Turitsyn

PM: Adriana Svetozarova

POST-DIGITAL is focusing on merging disruptive neuromorphic computational technologies and their applications.

WON

Wideband Optical Networks

H2020-MSCA-ITN-2018 MSCA-ITN-ETN.
EC-GA: 814276

PI: Professor Wladek Forysiak

PM: Tatiana Kilina

WON is covering all topics and expertise from the design and development of photonic components, novel digital signal processing algorithms and system modelling to network and control management.

MENTOR

Machine LEarning in optical NeTwORks

H2020-MSCA-ITN-2020 MSCA-ITN-EID.
EC-GA: 956713

PI: Professor Sergei Turitsyn

PM: Karola Woods

The aim of MENTOR is to design the next generation of high-capacity optical networks, which are a key enabler of the global telecommunication infrastructure. Increasing demand (+ 20% per year) requires a boost in capacity and calls for operators to reduce the cost per transmitted bit. The search for a solution is leading researchers in the direction of machine learning techniques. In fact, machine learning is the technique of choice to tackle this kind of complex technical problem.

MONPLAS

The training of early-stage researchers for the development of technologies to monitor concentrations of micro and nanoplastics in water for their presence, uptake and threat to animal and human life

H2020-MSCA-ITN-2019 MSCA-ITN-ETN.
EC-GA: 860775

PI: Dr Daniel Hill

PM: Miriam Messiha

The project identified a need to develop suitable technologies that are robust, easy to use and inexpensive for performing standardised measurements, as well as training engineers for method development and operation.

EDUCATION AND TRAINING

Why do a photonics PhD at Aston Institute of Photonic Technologies (AiPT)

Doing a PhD at AiPT means receiving a solid education for an academic or industrial career, with immersion in cutting-edge scientific and engineering research varying from high-speed optical communications and lasers to bio-medical photonics and machine learning. You'll work alongside world-leading scientists, have access to state-of-the-art photonics labs and facilities as well as a top-level international academic and industrial network.

Studying for a PhD at AiPT, you will gain a solid grounding in photonics, a key enabling technology that will open up a wide range of careers in academia or industry.

AiPT produced outstanding alumni across sectors from the top academic posts to industry, including JLR, BT, Intel, Nokia-Bell Labs, BAE Systems, Infinera, Ericsson, Thales, Airbus and many others.

Excellence in PhD education

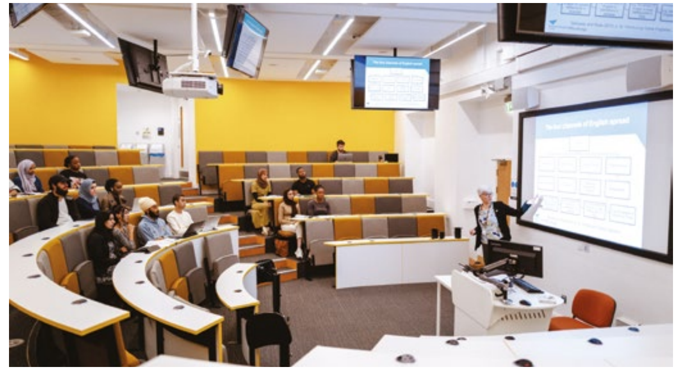
Our excellence in PhD education has been recognised by the European Commission (EC), who awarded AiPT the coordination of eight H2020 Initial Training Networks, covering 69 PhD students, making it the sixth most successful European university and the top UK university in coordinating European ITNs.

We are also the sixth most successful university in Europe and the top University in the UK, winning the coordination of H2020 European Industrial Doctorates (with 18 months' immersion in the industry), clearly demonstrating the high quality of our cohort-based PhD training regime.

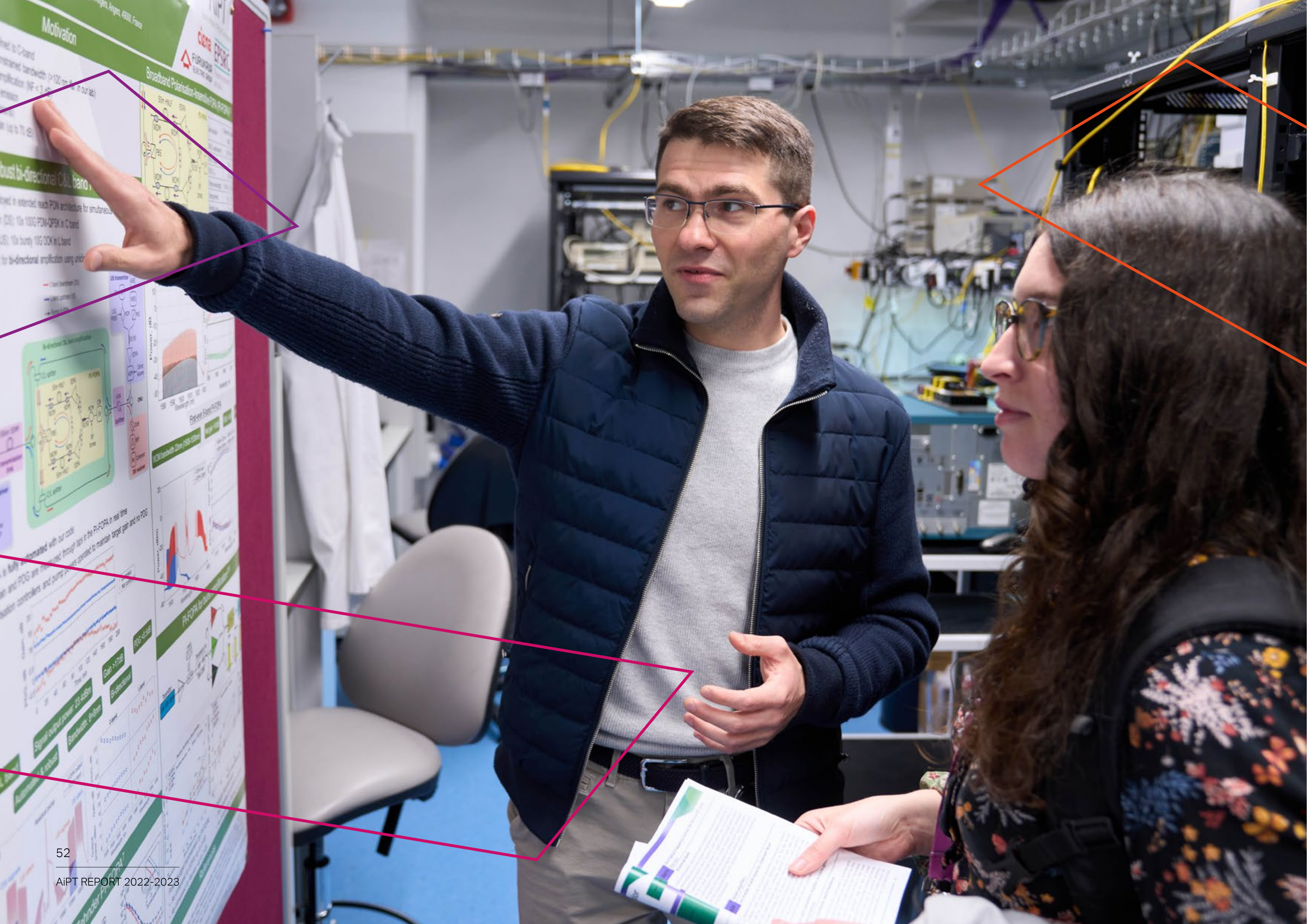
For detailed description and how to apply information, please visit: **phd.astonphotonics.uk**

Current PhD projects opportunities

- Highly integrated coherent optical fibre communications
- Compact multimode photonic system for in situ cancer diagnostics
- Laser technologies in developing advanced human stem cell models
- Machine learning for optical communications
- Photon sensitive laser detection
- Smart photonic sensing for resilient civil engineering infrastructures
- Mid infrared fibre device, sensor and sensing technology
- Real-time digital backpropagation for fibre-optic communication systems
- High capacity optical transponders for next generation communication systems



AiPT REPORT 2022-2023



Current PhD students and Projects

Aisha Bibi
Title: Fast and specific detection of micro and nanoplastic by flowthrough plasmonic sensing
Supervisor: Dr Daniel Hill

Alberto Rodriguez Cuevas
Title: Distance ranging and target recognition in harsh weather conditions based ellipsometric lidar (ELIDAR)
Supervisor: Associate Professor Sergey Sergeyev; Dr Auro Perego

Arooj Khalid
Title: Modern photonics technologies for bio-medical theragnostic
Supervisor: Professor Edik Rafailov, Dr Sergei Sokolovski

Atif Syed Igrar
Title: The detection and characterization of micro- and nano-plastics in beverages and food using PI, absorption/transition spectroscopic systems
Supervisor: Dr Alex Rozhin

Diana Galiakhmetova
Title: 'Development of novel compact ultrashort pulse lasers for biomedical applications
Supervisor: Professor Edik Rafailov

Diego Argüello Ron
Title: Implementation of neural networks and machine learning techniques
Supervisor: Professor Sergei Turitsyn, Dr Morteza Kamalian-Kopae

Dini Pratiwi
Title: 'All-raman optical amplification for next generation ultra-wideband optical networks (ARGON)
Supervisor: Professor Wladek Forysiak

Egor Sedov
Title: Machine learning for performance improvement of long-haul end-to-end optical transmission systems
Supervisor: Professor Sergei Turitsyn

Geraldo Gomes
Title: Soft- and hardware implementation of neural networks based analogue and digital signal processing techniques for high-speed optical communications
Supervisor: Professor Sergei Turitsyn

Karina Nurlybayeva
Title: Machine learning in application of optical communication
Supervisor: Professor Sergei Turitsyn

Long Hoang Nguyen
Title: Machine learning-based signal processing techniques in advanced optical fibre systems
Supervisor: Professor Sergei Turitsyn

Mariia Bastamova
Title: Applications of broadband polarisation-insensitive fibre optical parametric amplifiers
Supervisor: Professor Andrew Ellis

Mike Anderson
Title: Researching the role of field programmable gate arrays (FPGA´S) in the design and manufacturing of super channels transceivers
Supervisor: Professor Wladek Forysiak

Minji Shi
Title: Theory and numerical simulation of optical frequency comb generation in nonlinear resonators
Supervisor: Dr Auro Perego

Mohammad Hosseini
Title: Novel Digital Signal Processing Techniques for Nonlinear Fibre Systems
Supervisor: Professor Sergei Turitsyn, Dr Yaroslav Prylepskiy

Negar Shaabani Shishavan
Title: Low Footprint Computing with Light
Supervisors: Dr Auro Perego, Dr Morteza Kamalian-Kopae

Nelson J Castro Salgado
Title: Machine Learning Enabling Non-Linear Equalization in High-Capacity Fibre Systems
Supervisor: Professor Sergei Turitsyn; Associate Professor Stylianos Sygletos

Qing Wang
Title: Vector Soliton Breathing Dynamics
Supervisor: Associate Professor Sergey Sergeyev

Sasipim Srivallapanondh
Title: Complexity Reduction and Data Augmentation for Deep Machine Learning-Based Optical
Supervisor: Professor Sergei Turitsyn

Stepan Bogdanov
Title: Optical Communications using Finite-Genus Solutions and Neural Networks Processing
Supervisor: Professor Sergei Turitsyn

Victor Vassiliev
Title: Frequency Comb Generation in a Micro Resonator using the Surface Nanoscale Axial Photonics Platform (SNAP)
Supervisor: Professor Misha Sumetsky

Pedro Freira

I have just successfully completed a PhD programme as an Early Stage Researcher within the highly competitive and prestigious Horizon 2020 REAL-NET European Industrial Doctorate Training Network. This aims to create an adaptive, intelligent optical network, providing capacity when and where it is needed to transform the next-generation digital communications infrastructure.

Applying traditional NN techniques to optical fibre transmission requires modification and achieving 99% accuracy, which is considered exceptional in other areas (such as image recognition), but falls short in optical transmission-related problems. Therefore, more stringent conditions must be imposed on NN architectures to achieve a higher learning quality of 99.99% accuracy, which is necessary for ultra-low-error tasks in optical communications.

Designing efficient NN structures to meet these ultra-high accuracy requirements is less explored and prone to training and performance issues. Thus, my thesis aims to bridge the gap between machine learning and optical communication fields by designing a solution that has three conceptual pillars:

i) good and reliable performance

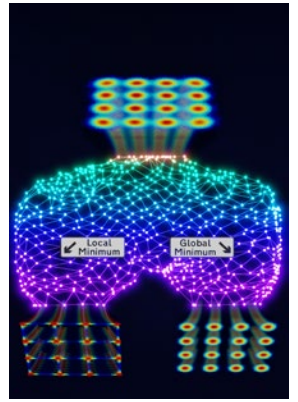
ii) acceptable computational complexity

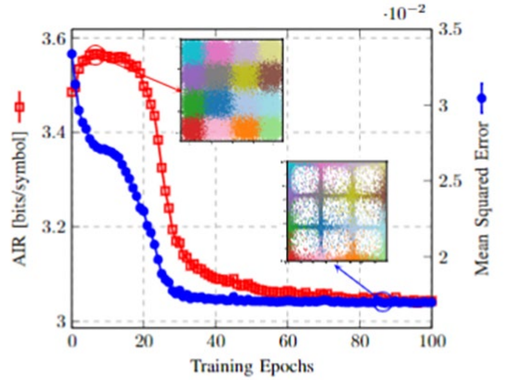
iii) configuration flexibility.

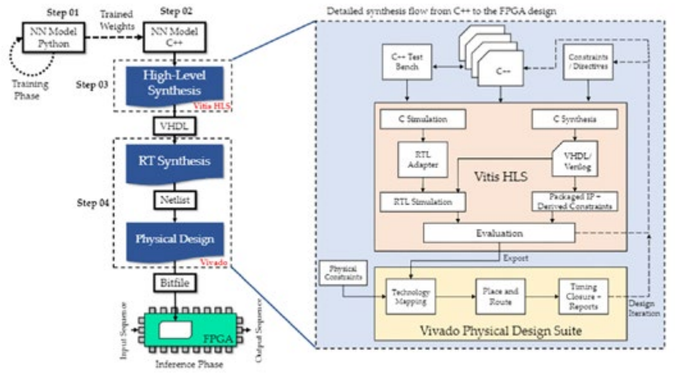
My thesis aims to bridge the gap between machine learning and optical communication fields

Awards:

1. Awarded IEEE Photonics Society Graduate Student Scholarship (2022)
2. High Score ECOC Paper 2022
3. Invited Paper IEEE Journal of Selected Topics in Quantum Electronics
4. Invited ECOC Paper 2023







Aisha Bibi

My journey at AiPT commenced with my Erasmus Mundus Joint Master's in Photonics Integrated Circuits, Sensors and Networks (PIXNET), a two-year master's programme that involved my presence at Aston University in the first year and at Scuola Superiore Sant'Anna (Pisa, Italy) in the second year.

During the programme, I developed a keen interest in photonic sensing and its applications, which prompted me to undertake my PhD in the European Commission funded H2020 Initial Training Network (ITN) project, MONPLAS, at AiPT, under the supervision of Dr Daniel Hill and Professor David J Webb.

Microplastics in the environment and their impact on various life forms within it are major concerns for environmental organisations worldwide. However, the lack of standardised techniques for the characterisation and enumeration of micro and nano plastics has resulted in limited qualitative and quantitative understanding. The objective of my PhD project is to develop a method for the reliable and reproducible quantitative measurement of micro and nanoplastics in water through the use of surface enhanced Raman spectroscopy (SERS).

Raman spectroscopy is a popular non-invasive and non-destructive technique used for microplastics detection, but its conventional version is inadequate for nanoplastic detection due to its diffraction limit. SERS, a Raman spectroscopy variant, enhances the Raman signal using metallic nanostructures, with the enhancement strongly dependent on the metallic nanostructure or particles used, as well as the gap between adjacent nanoparticles and their geometry. Therefore, I have been working on synthesising SERS substrates that are based on different sized and shaped nanoparticles and investigating their potential for detecting nanoplastics. Following surface modification to develop hydrophobic SERS substrates, I have experimentally demonstrated the lowest limit of detection of nanoplastics in water by a simple technique through use of these substrates.

As an Early-Stage Researcher (ESR) in an ITN project, I have had the opportunity to undertake secondments at other institutes within the consortium, including Queen's University Belfast on multiple occasions and there is an imminent secondment to take place at Leibniz Institute of Photonic Technology (IPHT) in Jena this year. As my project is interdisciplinary, these secondments are invaluable as they give me the chance to work in state-of-the-art laboratories of institutions with expertise different domains.

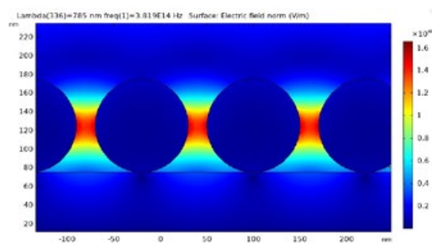
ITN MONPLAS also entails consortium-wide activities such as training and networking events that have provided the ESRs with an opportunity to expand their knowledge and skills. As an ESR within the project, I am currently involved in organising one such event, a Satellite Symposium that will take place within the framework of the ICCE2023 conference in Venice (Italy) this June. The Symposium will include lectures from MONPLAS supervisors on topics related to micro and nanoplastics. The ESRs will present their ongoing research and will be involved in a roundtable discussion on the toxicological impact of micro and nanoplastics. In the roundtable, we will engage with a panel of four experts in that field to discuss the challenges involved and the potential solutions that our work may provide.

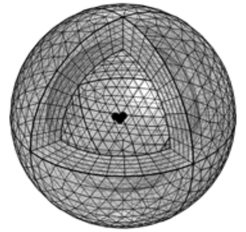
In addition to my research work at AiPT, I have been an active officer of the Aston SPIE/Optica Student Chapter since 2021 and was elected as the President of the chapter for the year 2023. The aim of the chapter is to provide a platform for students to discuss problems, potential solutions and form and strengthen collaborations. To this end, it organises various workshops, seminars and other STEM-related outreach events.

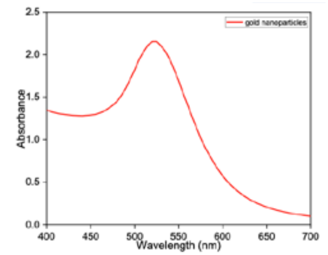
AiPT has come to feel like a second home to me, where I have found friends who are like family, and on occasion colleagues and senior researcher gather in the third-floor common room of the North Wing to have discussions over tea. Such gatherings help to refresh and offer fresh perspectives on research questions that are preoccupying the mind.

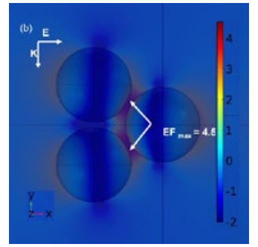
Key Publications:

- Aisha Bibi, Udit Pant, James Tate, Daniel Hill, Cuong Cao. Salt-Induced Aggregation of Gold Nanoparticles for Sensitive SERS-Based Detection of Nanoplastics in Water". Proc. SPIE 12430, *Quantum Sensing and Nano Electronics and Photonics* XIX, 1243012; doi: 10.1117/12.2650251.
- Aisha Bibi, Ali Can, Udit Pant, Gary Hardiman, Daniel Hill, Christopher Elliott, Cuong Cao. A Review on State-of-the-Art Detection Techniques for Micro- and Nano-Plastics with Prospective use in Point-of-Site Detection. *Comprehensive Analytical Chemistry*, Elsevier, 2023, ISSN 0166-526X; doi: 10.1117/12.2650251.

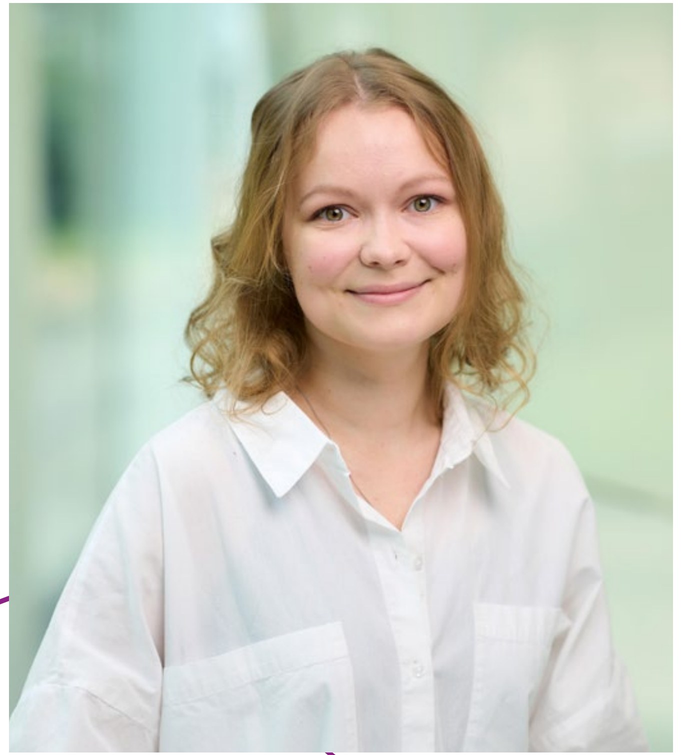








AiPT PhD student Diana Galiakhmetova talks to us about her experience working in AiPT and the latest on her research into neurological diseases.



Why did you decide to undertake your research at Aston University?

I decided to undertake my research at the Aston Institute of Photonics (AiPT) due to the institute's global reputation for conducting cutting-edge research in the field of optics and photonics.

During my time at Aston University, I was able to gain insights into the forefront of photonics research by observing the work of AiPT research groups. This experience allowed me to delve into the most current and significant topics in the field, such as optical communications technology, biophotonics, and applications of laser technologies in diverse areas, including agriculture and nanomaterials. The two months spent at Aston University greatly contributed to my understanding of the exciting possibilities in this field, making it the perfect choice for pursuing my research goals. The choice of Aston University for my PhD degree was driven by my desire to be exposed to the latest advancements in photonics and to collaborate with experts who are at the forefront of these developments.

What topic is your research surrounding?

Brain diseases can cause communication problems between brain cells, leading to memory loss, difficulties in daily tasks, and disabilities. Scientists use special light-sensitive molecules to restore brain function. They attach these molecules to neurons using a drug delivery system. However, a big challenge is getting light to reach these molecules in the brain through the skin and skull.

Our team is working on a solution. We are developing a compact laser that emits a specific kind of light. This light can pass safely through the skin and skull without causing harm. It's strong enough to activate the light-sensitive molecules in the brain and stimulate neurons effectively. This non-invasive approach means we can treat brain diseases without surgery, avoiding the risks associated with brain operations.

By advancing this technology, we can provide better healthcare for people with dementia and other brain diseases, offering them a brighter future without invasive procedures.

Why did you decide to focus on neurological diseases, and why do you think it's important to raise awareness?

I chose to focus on neurological diseases because I have always been deeply fascinated by the enormous potential of laser technology in the medical field to improve the quality of life for patients and their families. Neurological diseases are one of the major global health problems, with more than 50 million people suffering from Alzheimer's and dementia. The impact of these diseases is measured not only in human suffering but also in the enormous economic burden they impose, exceeding a trillion pounds a year.

By focusing my efforts on developing non-invasive tools to treat these neurological disorders, I am committed to contributing to cutting-edge research and innovative treatments that can help millions of people around the world.

What have been your biggest achievements whilst at Aston to date?

During my PhD study at Aston University, I was fortunate to have the opportunity to take part in various research grants and awards. What made this experience even more special was the tremendous support I received from my colleagues and friends at Aston University. Their encouragement and assistance played a crucial role in my academic journey.

Some of the list of opportunities I have been able to get involved include:

- Winner of the Best Elevator Pitch Award at the VI 'Photonics Meets Biology' Summer School and Workshop, Spetses, Greece, July 2022;
- The first-place winner JBO/NEUROPHOTONICS 3-Minute Poster Competition at the Conference SPIE Photonics West, San Francisco, USA, January 2023;
- Best Open Research Case Study, Open Research Award at Aston University 2023;
- Winner of the PhD Poster Competition at the Aston Institute of Photonic Technologies Open Labs event;
- Winner of the Aston Three Minute Thesis Competition 2023

I am incredibly grateful to the university for the great opportunity to participate in various events and student competitions. Their support has been significant in my academic and personal growth, and I sincerely appreciate the experience and knowledge gained through these valuable opportunities.

What significance has AiPT played in your research project?

The opportunity to collaborate with world-known experts in Photonics has been an invaluable experience for me. Learning from these masters, working in well-equipped labs, and engaging with a friendly and cohesive collective have contributed to a highly productive and inspiring research environment. Moreover, participating in diverse seminars has further expanded my knowledge in the field of optics and photonics, enhancing the depth and breadth of my scientific expertise.

What skills and knowledge did you gain at Aston which has helped you with your research?

I acquired a diverse set of skills and knowledge, ranging from critical thinking to oral communication and work presentation. Aston provided me with a comprehensive understanding of various research methodologies and approaches. I learned how to design and conduct research studies, make an effective literature review, collect and analyse data, and independently explore different approaches to advance my research.

Aston placed significant emphasis on my communication skills. Presenting research findings, participating in seminars, and conferences, and engaging in academic discussions allowed me to enhance my ability to articulate ideas clearly and concisely. I learned the importance of networking, connecting with other researchers, and collaborating on interdisciplinary research projects.

I am committed to contributing to cutting-edge research and innovative treatments that can help millions of people around the world.

Doctoral theses awarded in 2020-2023

Student	Supervisor	Award year	PhD Thesis Title
Anastasiia Vasylchenkova	Professor Sergei Turitsyn, Dr Yaroslav Prylepskiy	2020	Nonlinear Fourier Transform in application to long-haul optical communications
Pavel Skvortcov	Professor Wladek Forysiak	2021	Optimization of Digital Coherent Transceivers for Optical Communication Systems
Nasir Garba Bello	Professor Edik Rafailov	2021	Realisation of an efficient Terahertz source using Quantum dot devices
Chandra Bhanu Gaur	Professor Nick Doran, Professor Andrew Ellis	2021	Fibre Optic Parametric Amplifiers For Transient Limited Optical Fibre Systems
Igor Kudelin	Professor Sergei Turitsyn	2021	Mode-locked fibre lasers for ultrafast gyroscopic measurements
Yang Lu	Professor Kate Sugden	2021	Femtosecond Laser Inscribed Calibration Phantoms for Optical Coherence Tomography
Namita Sahoo	Dr Kaiming Zhou, Professor Lin Zhang, Professor David Webb	2021	Advanced fibre gratings in near- and mid-infrared region and their applications for structure monitoring and biosensing
Marie Aimee Zandi	Professor Kate Sugden, Dr David Benton	2021	Novel concepts in laser detection technology
Abdallah Ali	Professor Andrew Ellis	2021	Kerr nonlinearity in optical communication systems
Gabriella Gardosi	Professor Misha Sumetsky	2022	Slow Cooking of Photonic Microresonators
Vladislav Neskorniuk	Professor Sergei Turitysn	2023	Deep learning methods for nonlinearity mitigation in coherent fiber-optic communication links
Pedro Freira	Professor Sergei Turitysn	2023	Machine Learning Techniques for Nonlinearity Mitigation in Optical Coherent Systems
Aleksandr Donodin	Professor Sergei Turitysn	2023	Bismuth-doped fibre amplifiers for multi-band optical networks
Pratim Hazarika	Professor Wladek Forysiak	2023	Performance Evaluation of Raman Amplifiers in Fibre Optic Communication Systems
Ray Paulami	Professor Edik Rafailov	2023	Novel Mid-IR light sources for emerging applications

Erasmus Mundus Joint Master Degree projects SMARTNET and PIXNET

The most important outcome of our two MSc programmes has been our graduates. AiPT has provided training to 53+63 graduates in the highly demanding fields of optical and 5G wireless networking, integrated photonics, digital signal processing, artificial intelligence and big data. Our graduates represent a robust European workforce, receiving a genuine mixture of cross-disciplinary academic and industrial training.

In addition, the mobility between the participating universities (SMARTNET : Aston University (AiPT), UK; Télécom SudParis (TSP), France; University of Athens (UoA), Greece; PIXNET: School of Advanced Studies Sant'Anna (SSSA), Italy; Aston University (AiPT), UK; Osaka University (OSAKA), Japan; and Technische Universiteit Eindhoven (TUE), The Netherlands has offered a much broader selection of courses and focuses upon areas that a single university alone would not be able to provide.

Another important outcome has been the active dialogue we established with our associated partners in tailoring the training programme and the MSc projects to practical challenges and needs. Our programmes exemplified how we handled the collaboration with industry, integrating industrial placements in our curriculum and enabling many industrial internships for our students.

Last but not least, the programmes have had an impact at both a UK National and European level. SMARTNET/PIXNET focused on training highly skilled specialists in integrated photonics and next generation telecommunication systems, where UK and Europe have an increasing need for a skilled workforce. We provided highly-quality training activities aligned with the UK/EU needs and mixed with innovation, industrial and business communities to make a broader economic and societal impact.

Our student employment statistics can evidence the level of our programmes' success. 48% of our students found PhD scholarship positions in academia (20% of the under the prestigious Marie Curie doctoral training schemes) and 33% of them secured industrial positions within the first year of their graduation.

Our students expressed their satisfaction towards the Master's activities and their decision to enrol the SMARTNET and PIXNET programmes. They were satisfied with the university resources, laboratory sessions, the lecture's expertise and the consortium's connection with the industry. They highly appreciated that they were performing studies on hot topics in leading European universities and the opportunity to complete internships with industrial leaders in telecommunications. They were also satisfied with the provided services and the friendliness of the administrative and teaching staff. Some students also value the opportunity to meet many people from different sources and learn about their cultures.

PIXNET

53 ASTON graduates

SMARTNET

62 graduates overall (ASTON, TSP, UoA)

35 graduates from ASTON

80% Distinction, 15% Merit
(AiPT students 2018-2021 a.y)

48% of our graduates continues in academia (20% as Marie Curie Fellows) and 33% in industry

SMARTNET and PIXNET are two prestigious Erasmus Mundus Joint Master Degree programmes.

SMARTNET

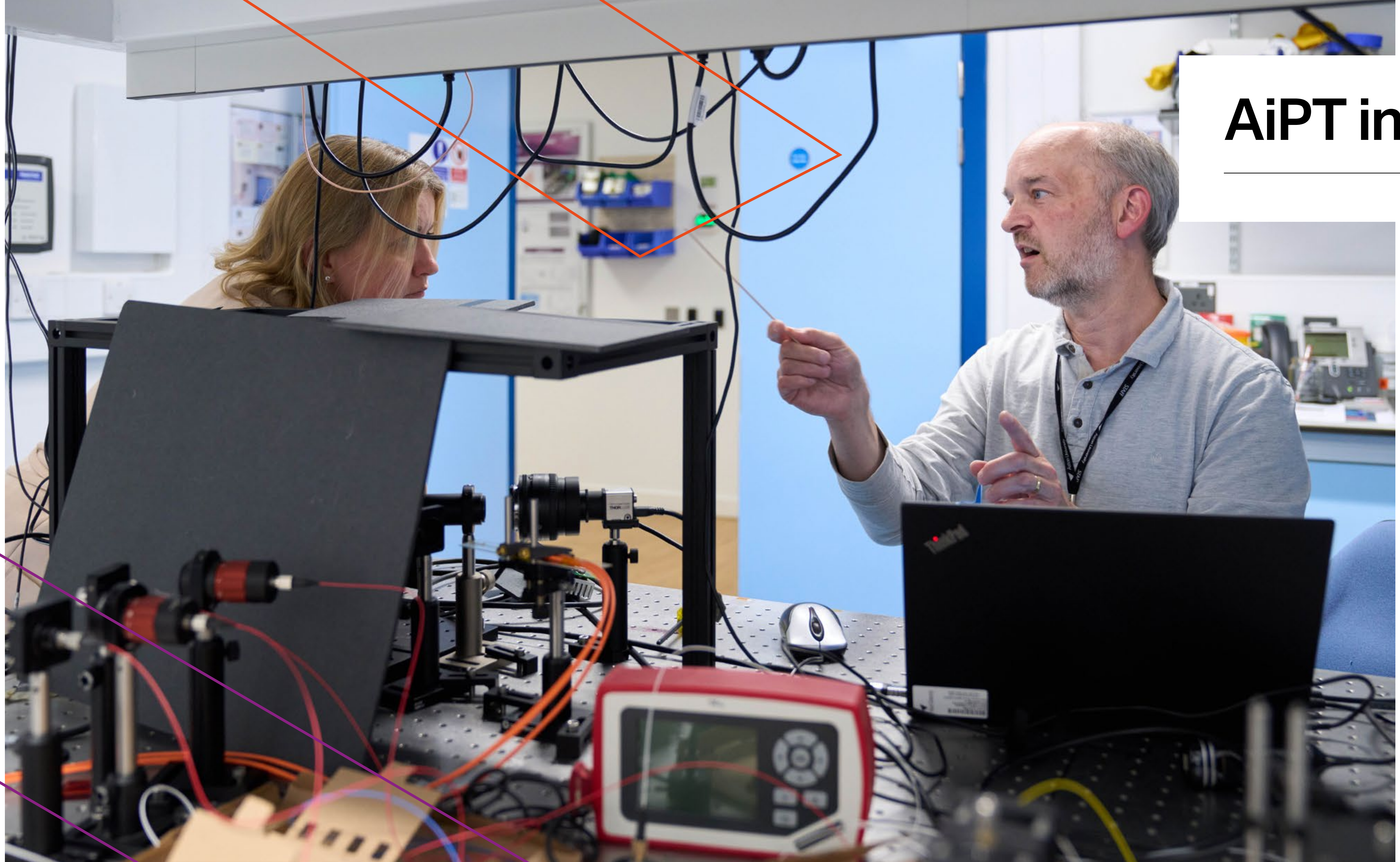
The Smart Telecom and Sensing Networks

Two-year joint master degree programme with the goal to provide training in the inter-disciplinary fields of photonic and 5G wireless technologies for data communication, sensing and big data processing.

PIXNET

Photonic Integrated Circuits, Sensors and NetworksT

Two-year programme (120 ECTS) aimed at training talented students in the design, creation and assessment of innovative integrated devices based on photonic technologies. The set of learning outcomes include the theoretical design of system/ network devices, the design and simulation of a photonic integrated circuit, fabrication in a clean room facility and the packaging and final testing of the prototypes.



AiPT industrial collaboration

AiPT's expertise can help companies develop new capabilities, products and services in various photonics technology applications. UK-based companies and SMEs can benefit from support provided by multiple projects and grants that facilitate knowledge transfer and enhance business-relevant research and collaboration.

Successful industry-academic partnerships align motivations and expectations into joint projects that benefit both parties. Industry motivation to collaborate includes:

- Accessing interdisciplinary scientific capabilities to solve complex industry problems
- Accelerating the product development phase of R&D activities
- Increasing the chance of accessing public funding
- Gaining access to highly skilled professionals.

AiPT's motivation to collaborate is driven by the need to develop practical applications of research results, which directly impact society, increase the chances for future collaboration opportunities and advance and widen its research agendas.

By working closely with the industry and the Research and Knowledge Exchange (RKE) department, the AiPT team has facilitated new avenues for collaboration such as joint industry focused PhDs , Knowledge Transfer Partnerships, Fellowships and research council grant support, Innovate UK collaborations and established connections for research impact.

The Wolfson Foundation

The Wolfson Foundation continuously supports AiPT. After establishing a Wolfson Centre for Photonics for Food and Agri-tech, it gave AiPT another grant for equipment to support the development of AiPT's excellence in the photonics field. The Wolfson grant has boosted AiPT's research in photonics and the science of light – particularly within the food and agri-tech industries. With the new equipment, AiPT is carrying out ground-breaking research to solve real-world issues, a focus which lies at the heart of Aston's research strategy.

In September 2022, Chief Executive of the Wolfson Foundation, Paul Ramsbottom OBE, visited Aston University's world-renowned photonics department. The tour was led by Professor Sergei Turitsyn, director of AiPT.

Professor Turitsyn said: "The Wolfson Foundation grant provided an important initial impetus for expanding our research on applications of photonics technologies in the food industry and agriculture sector."

Food quality and safety are among the significant challenges facing humankind, and we are happy that advances in photonics are opening up the technology opportunities that might revolutionise the food and agri-tech industries. It is a remarkable feeling that light science and technology developed in the Wolfson Centre might help to solve important social problems making a positive impact on us all.

The Wolfson Foundation's chief executive, Paul Ramsbottom OBE said: "I enjoyed my visit to see some of the impressive photonics research. We were pleased to contribute funding to these new facilities, which will allow their researchers to explore how the technology could be applied to meet challenges in food production and food safety."

The Wolfson Foundation awards grants to support and promote excellence in the fields of science and medicine, the arts and humanities, education and health and disability. The majority of grants from the Wolfson are for capital infrastructure such as buildings (new build and refurbishment) and equipment. The aim of the foundation is to promote excellence in each category/field they fund and their decision-making is rigorous, with funding being provided on the basis of expert peer review.

From left to right: Prof Aleks Subic, Vice-Chancellor & Chief Executive of Aston University, and Paul Ramsbottom OBE, the CEO of the Wolfson Foundation
www.wolfson.org.uk

AGRI project

AGRI
Agri-tech Growth and Resources for Innovation

The Agritech Growth and Resources for Innovation (AGRI) project was a support program aimed at providing assistance to SMEs, operating in the agri-tech/food & drink industry, based in the Shropshire and Telford & Wrekin region to enhance their productivity and efficiency by breaking down barriers to innovation. The program was a knowledge exchange support initiative developed jointly by Aston University and Harper Adams University. The support was free of cost and is funded by the European Regional Development Fund (ERDF).

The program offered two stages of support, the first providing 12 hours of business innovation support, and the second stage offers longer-term support of a minimum of 60 hours. The project has successfully supported over 160 businesses, with the goal of implementing innovative measures to enhance their productivity and efficiency.

The project was developed to address identified barriers to innovation and growth in the agri-food industry and has facilitated the development of a network for peer advice and SME collaboration. The program has been running since early 2017 and is set to end in June 2023.

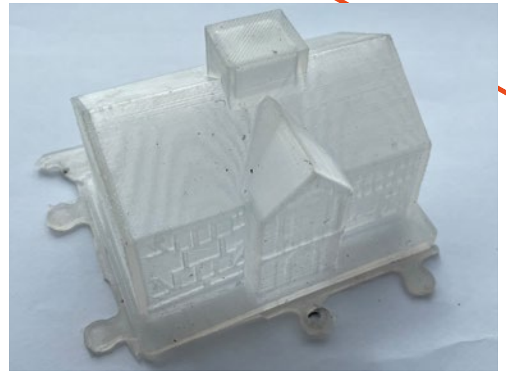
Aston University brought its expertise in photonics and materials, new product development, enterprise resource planning, engineering, 3D printing, and sensor systems design and development to the project.

Case Study:
Niche Patisserie at the Black Gate

Background:
Located in the border town of Oswestry, Shropshire, The Black Gate restaurant stands as a testament to exquisite patisserie and bakery offerings, thanks to Executive Pastry Chef Adam Cleal, a semi-finalist in Bake Off The Professional's 2019. The restaurant is housed in a unique Grade 2 listed building, playing a significant role in the business's marketing and advertising.

Challenge:
Adam aspired to design a signature patisserie that symbolized the Black Gate and could be modified for different seasons and occasions.

Solution:
The AGRI project, utilizing CAD modeling, 3D printing, and silicon moulding, crafted a bespoke mould for Niche Patisserie in the iconic shape of The Black Gate.



Enabling Technologies and Innovation Competences project

Between August 2018 and January 2022, in collaboration with the Aston Institute of Materials Research, AiPT ran the Enabling Technologies and Innovation Competence Challenge (ETICC) project, a £2.8 million business support initiative that was part-funded by the European Regional Development Fund.

The project aimed to address a range of obstacles to innovation in small and medium-sized businesses, including limited resources, expertise and funding, as well as supporting regional businesses through a number of unexpected challenges posed by Brexit, COVID-19, new emission requirements and more. The project provided support to regional businesses in developing their innovation competences through the application of key enabling technologies such as photonics, advanced manufacturing, industrial biotechnology, nanotechnology, advanced materials and nanoelectronics.

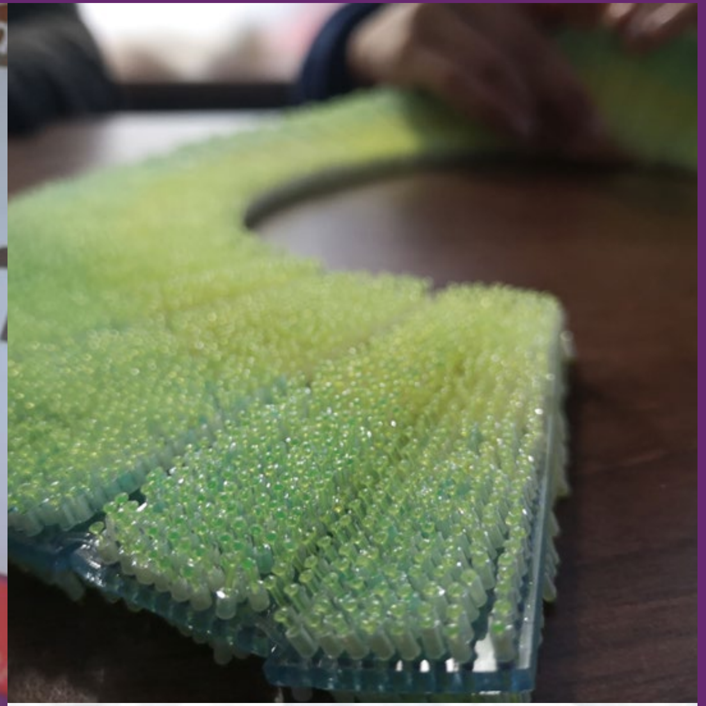
Enabling technologies have diverse applications across multiple industries, helping tackle societal challenges and developing products ranging from low carbon technologies to clean energy and medical devices. Moreover, they work together to facilitate technological advances; for instance, the development of advanced manufacturing systems requires the integration of nanotechnology and photonics technology, a combination of nano electronics and photonics technologies allowed the development of the atomic force microscope which, in turn, allowed scientists to study tiny particles and develop the field of nanotechnology. Aston University has capability in all six enabling technology areas but has particular expertise in nanotechnology, industrial biotechnology, advanced manufacturing systems and photonics and is working to blend the use of these technologies.

The ETICC project complemented the West Midlands Science and Innovation Audit and its focus on supporting regional growth by identifying key market strengths and cross-cutting enabling competencies, including advanced manufacturing and engineering, digital technologies and data and systems integration, which were highlighted as key ingredients of innovation success. Both regional stakeholders and supported businesses acknowledged the value of ETICC to the West Midlands region, facilitating innovation, collaboration and access to funding opportunities.

The project successfully supported 123 small and medium-sized businesses in the Birmingham and Black Country areas, enabling them to develop approximately 50 new products, secure new opportunities and gain access to collaborative R&D projects and additional funding. The project also strengthened AiPT's ties with the industry and increased its knowledge of many industry sectors locally, leading to long-term relationships with businesses and a number of collaborative R&D projects between Aston University and businesses supported through the Enabling Technologies project. The project actively collaborated with other funded business support projects in the region, contributing to the wider impact of the West Midlands' innovation ecosystem on the local economy.

The ETICC project aided the development of AiPT's links and long-term relationships with the local business community, leading to the development of a number of collaborative Innovate UK applications. In 2022, the project was awarded The West Midlands Innovation Award in the category "Innovation Organisation".

Building on the strength of ETICC and previous projects such as Big Data Corridor and Innovative Product Support Service, AiPT is now adapting its business support offer to the new funding framework of the UK Shared Prosperity Fund and developing new industry support project proposals in collaboration with other regional stakeholders.



Interview with Dr Antonio Napoli

Infinera

Dr Antonio Napoli holds a Ph.D. degree from the Politecnico di Torino, Italy, received in 2006. He is currently employed at Infinera, where he works on XR Optics, a revolutionary technology for long-distance data transmission. Dr Napoli has authored or co-authored seven patents, 83 journal and 170 proceeding articles, and a book chapter, showcasing his expertise in digital signal processing, wide-band systems, modeling, and machine learning/artificial intelligence. He is a key scientific collaborator for AiPT in multiple MSCA Doctoral Networks coordinated by Aston University.

How did you start to work with the AiPT Team?

A few years ago, Professor Sergei Turitsyn and I were examiners at the PhD defence at TPT Telecom Paris Tech. Over dinner, Sergei and I discovered our many common research interests and a shared professional approach. I was immediately struck by Sergei's warm and outgoing personality, as well as his intelligence, and I knew instantly that he was the type of partner I needed for my work. Moreover, I also realised that the entire AiPT team shared Sergei's approach and values. During that dinner, Sergei explained the focus of AiPT's work with EC funding, particularly with the Horizon 2020 Marie S. Curie projects, and I found it very interesting for my own work at Coriant/Infinera in general. From that point on, I was eager to participate in writing the proposals with the AiPT team.

How do you see the collaboration with AiPT contributing to Infinera's innovation and product development?

AiPT/Aston is a very significant collaborative partner for our organisation. It is our preferred university to collaborate with, owing to its numerous strengths. AiPT has solid and effective leadership exemplified by Prof Sergei Turitsyn, alongside the best management team I have ever met (Tatiana, Christiane, Karola, Martina, etc). This, combined with AiPT's academic programs, helps to attract excellent students. Our collaboration with AiPT enables us to enhance our innovation leadership and provide indirect benefits to our future products in various ways. For Infinera, collaboration within MSCA projects is not geared towards product development, but it is more about learning something that we don't know well or it is not yet clear whether it is realisable. When designing new research proposals, the AiPT team never imposes the topic. Instead, they are opened for co-creation, which, as a result, strengthens our collaboration. As an industrial partner, we are always involved in the PhD student selection process and interview panels, and it is another example of the trust and transparency we have established. Talking about technical & research achievements, the work of all the ESRs in our joint ITN projects is excellent, e.g. Mohammad Hosseini from REAL-NET did some important research for us as we were doing similar studies with a heuristic approach – which was accepted at a major conference, while he obtained a more general analytical formulation.

What was the best breakthrough or achievement that has resulted from the collaboration between Infinera and AiPT so far?

The work of our first two PhD students from Aston, Pedro Freire and Mohammad Hosseini. Pedro has contributed significantly to our understanding of the applications of artificial intelligence and machine learning in the field of digital signal processing, while Mohammad has significantly helped to investigate applications of next-generation point-to-multipoint optical networks. Pedro also helped us to understand what can and cannot be done with AI/ML when applied to digital signal processing.

What benefits does Infinera expect to gain from collaborating with us, and how does this fit into Infinera's overall strategy and goals?

As I have already mentioned, AiPT is the best possible partner for us in the academic world. With AiPT, we constantly learn and discover new topics and we work with an amazing partner and its students. The advantages that we have gained from this partnership are significant, ranging from the co-supervision and training of exceptional engineers to the exploration of forward-looking topics that are currently being explored by their students. And one of the biggest reasons why this happens is the quality of the mentorship of the senior academics at Aston – they trust their students and encourage delegation, which results in a streamlined and effective workflow.

What do you see as the key benefits of collaborations between the academic and industrial sectors?

We learn new things; we explore new topics that are or might become important in the near or far future; we can have an almost homegrown set of talents. I cannot stress it enough how much we value the strong and flexible interaction with Aston and transparency in work and collaboration.

What do you think is the biggest challenge facing OptCom researchers today?

Great question. I think the field is less attractive at the moment as it can be evinced by the difficulty in finding students. To some extent, we might need a 3rd wave of services from the final customers - i.e., ourselves - to achieve the predicted bandwidth demand so that a breakthrough technology will become mandatory, and this will help to revitalise the field. There is a continuous request for more services and consequently for more capacity, in particular after the pandemic. Many people work from home, so one might need a better connection everywhere. The traffic grows much faster now and closer to the user, where the growth of IP data is much higher than, e.g., in backbone networks. In these network segments, costs and, now, energy consumption, become the key-factors in the development and design of new optical systems.

What key piece of advice would you give to a young scientist just starting out in their career?

In my opinion, they need to connect the dots. So sometimes, try not to be overly focused on a single topic, but try to see beyond the horizon. Another very important thing is to keep building your network and maintain good relationships with everyone you encounter in your career. In one sentence: never burn bridges with anyone. Additionally, it's wise to approach every person you meet in your life with the assumption that they are good. While there might be unfriendly individuals, you can address such situations later.

AiPT seminar series 2022-2023

Throughout 2022-2023, the AIPT team continued to organise a series of dynamic scientific seminars remotely and on-site. These engaging seminars covered a diverse range of topics, encompassing the exploration of experimental and theoretical challenges within the field of photonics and the unveiling of photonics' transformative potential in industrial applications. The seminars provided a platform for insightful discussions and knowledge exchange, fostering advancements in the evolving world of photonics.

Trends in scientific publishing
by Mr Oliver Graydon, Chief Editor of Nature Photonics, UK (April 2023)

Computation with degenerate optical parametric oscillator network
by Professor Hiroki Takesue, NTT Basic Research Laboratories, NTT Corporation, Japan (March 2023)

Nd doped fiber for E-band amplification
by Dr Leily Kiani, Lawrence Livermore National Laboratory (LLNL), US (March 2023)

Fiber lasers activity at Tampere University
by Dr Regina Gumenyuk, Tampere University, Finland (March 2023)

Long wavelength InAs-based quantum cascade lasers
by Professor Alexei Baranov, Research Director, IES - Institut d'Electronique et des Systèmes Université de Montpellier, France (March 2023)

Tissue spectroscopy for the development of noninvasive cancer detection
by Professor Luís M. Oliveira, Porto University, Portugal (February 2023)

Fibre optic sensing to inform underground construction operations
by Professor Brian Sheil, Laing O'Rourke, University of Cambridge, UK (February 2023)

Universal light encoders: artificial intelligence hardware for machine vision, sensing, and universal metrology
by Professor Andrea Fratalocchi, KAUST University, Saudi Arabia (January 2023)

Translational of Biophotonics and Laser Applications to Clinical Applications
by Professor Dr Ronald Sroka, LIFE-Centre at Department of Urology at Hospital of University of Munich, Germany (November 2022)

Components for multi-core fiber transmission systems based on long period gratings
by Dr Ana Maria Rocha, Instituto de Telecomunicações (IT), Portugal (November 2022)

Ultra-high capacity optical free-space communications
by Dr Gil Fernandes, Instituto de Telecomunicações (IT) Portugal (November 2022)

System experiments with SDM fibers
by Dr Benjamin Puttman, National Institute of Information and Communications Technology, NICT, Japan (September 2022)

Phononic frequency combs
by Dr Adarsh Ganesan, US National Institute of Standards and Technology, US (February 2022)

EVENTS

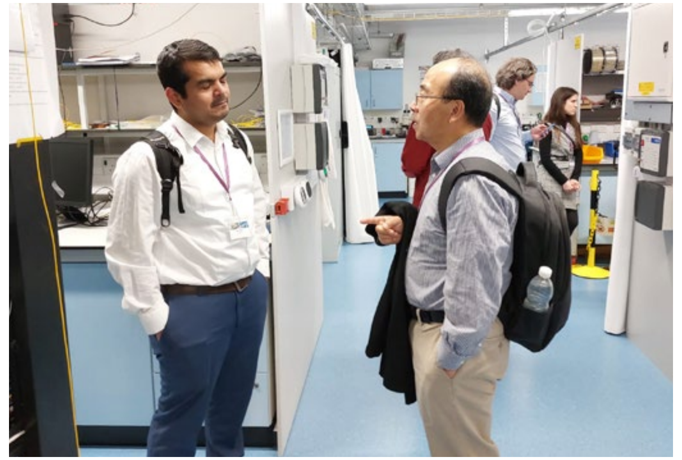
2nd International AiPT Workshop

Advances in UWB Optical Fibre Communications: Potential, Challenges, Solutions

On 18-19 May, the 2nd International AiPT Workshop, "Advances in UWB Optical Fibre Communications: Potential, Challenges, Solutions" took place. The workshop focused on the key challenges in optical communication, emphasising band-limited optical transmission systems.

As well as the talks and presentations, the event hosted technical discussions on state-of-the-art coherent technologies, including experts from both academic and industrial backgrounds. They addressed the potential of capacity enhancement from the perspective of novel fibre (Corning, Southampton University), network equipment and subsystem development (Infinera, Nokia Bell Labs, ADVA), intelligent data processing (Fraunhofer HHI, Bristol University), network operation (British Telecom, Deutsche Telecom), and others. We were honoured to host plenary talks by Dr Ming-Jun Li, a corporate fellow at Corning Incorporated (USA), and Dr David Neilson from Nokia Bell Labs USA, along with many other speakers and guests from BT Group, Deutsche Telekom, Infinera Germany, KDDI Corporation, Fraunhofer Heinrich Hertz Institute HHI, UCL, University of Bristol, University of Southampton, and the University of Stuttgart.

The workshop provided a strategic direction for tackling challenges in coherent optical communications, bridging academic and industrial partners to tailor novel research for developing next-generation optical networks. Dr. Aleksandr Donodin and Dr. Pratim Hazarika organized the event, with support from the RKE Impact Fund, Marie Sklodowska Curie H2020 project ETN WON (GA814276), EPSRC TRANSNET Programme Grant EP/R035342/1, and project ARGON EP/V000969/1.



AiPT Open Labs Event 2023

On June 7th, the Open Labs Event delved into the cutting-edge world of photonics with AiPT researchers who gave talks about their latest achievements, shared insights at interactive poster sessions, and showcased innovative technologies through live demonstrations in our laboratories.

The event aimed to promote more interaction among institute members and openly exhibit research activities, providing an opportunity to learn about each other's research and demonstrate AiPT Lab activities to senior management, colleagues from around the university, and an invited group of industrial collaborators. The event opened with a presentation of the newly appointed AiPT Professor Richard Hogg, as well as review talks from our researchers, such as Associate Professor Stelios Sygletos, Dr Auro Perego, Dr Gabriella Gardosi and Dr Pedro Freire. In the Open Labs session, researchers were available to discuss their research, demonstrate technologies, and explain concepts. In line with our objectives, presentations were designed to accommodate non-experts in the field, focusing on explaining the motivation, general principles, and broader impacts of each research topic.

Moreover, the event provided an opportunity for the AiPT senior management to express their gratitude to two esteemed individuals who played crucial roles within the Electrical and Electronic Engineering department (EEE) and AiPT and who recently retired. Firstly Professor Lin Zhang, an Emeritus Professor, for her immense contributions to the development of the Photonics Research Group and AiPT, and Secondly Mrs. Helen Yard, for her outstanding support to the Institute and its members.

AiPT Workshops

During 2021-2023, AiPT organised and co-organised numerous international events, both in person and in online/ hybrid formats, focusing on rapidly developing areas of photonics, from nano-photonics to optical communications. Prestigious events included:


Optical Frequency Combs Workshop

Optical Frequency Combs Workshop (April 2022)

Chaired by AiPT's researcher Auro Perego, this workshop brought together leading international researchers working in optical frequency combs science and technology, allowing in-depth discussion of its fundamentals, applications and future opportunities. During the two-day event, distinguished invited speakers covered topics including the recent development of innovative sources based on lasers, waveguides and microresonators, novel nonlinear dynamics effects in optical resonators, and diverse applications of optical frequency combs in astronomy, quantum technologies and photonic computing.


UWB Workshop

Beyond Ultra-wideband Optical Communications (May 2022)

This diverse and interactive workshop addressed the hurdles of transmission bandwidth limitations in optical communication systems. Chaired by AiPT's members Mingming Tan and Wladek Forysiak, it brought together device manufacturers and subsystem developers (such as II-VI), full system providers (such as Nokia), and research institutes (such as NIT, ORC and AiPT). Together, workshop participants from academia and industry explored possible solutions for broadening the bandwidth and increasing data capacity.

AiPT's Annual Christmas Research Conference

Every December, AiPT organises its Annual Christmas Research Conference, which is an exceptional event bringing together academic and research staff to present their projects, achievements, collaboration and future plans. This event provides a unique opportunity for researchers to share their knowledge, ideas and expertise with peers across AiPT.

AiPT's Annual Christmas Research Conference not only serves as a platform for researchers to showcase their work, but also facilitates networking opportunities within the entire AiPT community. The conference brings together individuals from various fields and research groups within AiPT, allowing them to connect and build relationships with colleagues they may not have had the chance to interact with previously.

Following the formal presentations, the conference includes a range of casual networking activities that bring together the entire AiPT community. These activities are designed to encourage everyone to socialise and interact with one another in a relaxed setting. The activities include Mastermind, sketches, quizzes, a foosball tournament, a tea ceremony and a craft fair, ensuring that there is something for everyone to enjoy and participate in.

H2020 MSCA-ITN Events

Funded by the European Commission under the Horizon 2020 framework, AiPT currently coordinates eight doctoral training networks: European Training Networks (ETNs) WON (GA 874276), MEFISTA (GA 861152), POST-DIGITAL (860360), MONPLAS (GA 860775), and European Industrial Doctorates (EIDs) FONTE (GA 766115), REAL-NET (GA 813144), MOCCA (GA 814147), MENTOR (GA 956713).

Together with our academic and industrial partners, AiPT is educating 64 PhD students, who benefit from a huge variety of training events and synergistic opportunities in the network. The collaborative effort of organising these events proved to be a significant advantage, enabling AiPT to offer a large and diverse range of intense scientific training events across many topics. Most events were open to external participants, including AiPT graduate students and staff. Between 2021 and 2023, the Doctoral Training Networks organised 30 advanced scientific training events in diverse topics including:

2021

- Introduction to photonic reservoir computing (online)
- Nano and integrated photonics (online)
- Neuromorphic photonics (Trento/Italy and online)
- Digital signal processing in optical fibre communication (Telecom Paris Tech/France)
- Machine learning techniques and challenges (online)
- Frequency comb applications (Lille/France and online)
- Field dynamics in micro-resonators and active cavities (Sapienza University Rome/Italy)
- Parametric interaction in photonic crystals (online)
- Optical networking digital light reading (online)
- Design challenges for next generation optical networks (online)
- Machine learning techniques and research challenges (online)
- Machine Learning Techniques (Technical University of Denmark/Denmark)
- Photonic reservoir computing for optical communications, (Trento/Italy and online)
- Summer School: Novel nonlinear substrates for neural networks (Besancon/France)
- Progress online adaptation of conceptor-controlled neural networks (Besancon/France)
- ECOC 2021 Special event on wideband optical networks (Bordeaux/France)

2022

- Current and future trends for optical communication systems (Technical University of Denmark/Denmark and online)
- Optical frequency combs workshop (Aston University/UK)
- Machine learning photonics (Como/Italy and online)
- Integration of novel materials into silicon photonics (AMO, Germany)
- Summer School: Frequency combs in mode-locked lasers and fibre resonators (Universitat Politecnica Catalunya/ Spain)
- Current and future trends for optical communication systems (Technical University of Denmark/Denmark)
- Scaling up systems and application complexity in analog neuromorphic and physical computing (Groningen/Netherlands and online)
- Integrated photonic reservoir computing for telecom applications (online)
- Workshop collocated with ITG Expert Group KT 3.1: Modeling and simulation of photonic components and systems, led by the WON partner Fraunhofer HHI (online)
- The Microplastics Conference of 2022 (Micro 2022)

2023

- Numerical implementation of Baysian filtering for signal equalization and demodulation (Technical University of Denmark/Denmark)
- Optical frequency combs and LIDARs for self-driving cars (Aston University/UK)
- Application roadmap for neuromorphic technology (Brussels/Belgium)
- Advances in UWB optical fibre communications: Potential, challenges, solutions (Aston University/UK)
- Symposium on Latest developments in analytical technologies and their applications for micro and nano plastic characterisation within the 18 International Conference on Chemistry and the Environment (ICCE)

AiPT Optica & SPIE Student Chapter Events

Light Design and Illuminate

To acknowledge the impact of light and the importance of its research in our lives, attendees were asked to engage in lighting LED candles at various locations throughout the University during the day.

IDL – Photonics Fair / Girls into Electronics, 30 May 2022

The Chapter members hosted an International Day of Light Photonics Fair, specifically for high school students who were visiting Aston University. The fair showcased various optics and photonics demonstrations, interactive videos that helped explain concepts, science-themed quizzes with sustainable prizes to commemorate the Year of Glass, and other educational activities. The visiting students particularly enjoyed playing laser reflection games and handling diffraction filters they had not seen before. Their enthusiasm for these instruments and devices was truly inspiring.

IDL Outreach

An outreach table was set up in the university's entryway to promote the International Day of Light Summit. The Chapter members demonstrated small optics-based experiments for students using Optica kits and gave out optics-related gifts.

Transferable Skills Workshop, March 2023

Along with the technical and research seminars, on 7-8 March 2023, the Chapter organised a series of training sessions focused on transferable skills, such as grant writing, research funding, and fellowship project writing. These sessions offered valuable insights and knowledge to the members, which could be beneficial in their future academic pursuits and professional careers beyond their time in the chapter.

Chapter Officer's Team 2023. Left to right: Qing Wang, Mariia Bastamova, Aisha Bibi, Prof David Webb, Alberto Rodriguez Cuevas

During 2021-2023, the Chapter organized regular seminars featuring distinguished external and internal speakers who delivered engaging talks on a wide range of topics, including fibre optic parametric amplifiers, quantum photonics, nanoparticle lattices, optical communication systems, pathogen detection, and microplastic detection, such as:

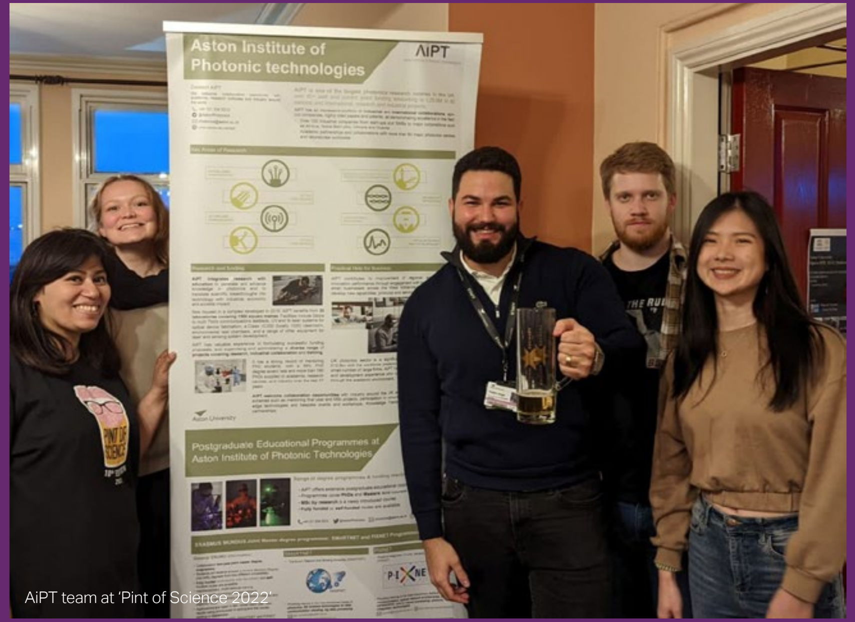
- Dr. Chandra Gaur: 'Fibre Optic Parametric Amplifiers for Deep-Reach Access Networks'
- Dr. Avik Dutt: 'Synthetic Dimensions: harnessing internal degrees of freedom of light for quantum, nonlinear and topological photonics'
- Dr. Nathaniel Kinsey: 'Epsilon-Near-Zero Materials – Making Photon Talks'
- Dr.Justus Ndukaife: 'Opto- Thermo-Electrohydrodynamic Tweezers: A New Paradigm for Nano-Optical Trapping and Analysis of Single Molecules'
- Dr. Jun Guan, 'Design of Plasmonic Nanoparticle Lattices for Engineered Nanolasing'
- Dr. Yiming Li, 'Mode Division Multiplexing: An Ultra-fast free space optical communication system'
- Dr. Dinesh Dhankar, 'Optical techniques and Instrumentation for pathogen and impurities detection'
- Dr. Mahmood Abu-Romoh, 'Digital converters for high-speed optical communication systems'
- Mr. Elliot London, 'Nonlinear interference generation in wideband and disaggregated optical networks'
- Aisha Bibi: 'Microplastic detection using photoluminescence spectroscopy.'
- Syed Atif Iqrar:'Microplastic detection using Raman spectroscopy.'
- Prof . Scott Diddams: 'Synthesizing light'
- Dr. Florent Bessi: 'Mach-Zehnder Fiber Optical Parametric Amplifier for Dual-Polarization Wavelength-Division-Multiplexed Signals Amplification'
- Diana Galiakhmetova: 'Evaluation and modelling penetration depth of NIR irradiation generated by tunable USP laser in ex vivo samples of mouse head'
- Dr Daniel Hill: 'How much Microplastics is in your Pint'

International Women's Day roundtable – Beyond Doctoral Studies, 11 March 2022

The Chapter organised an all-day hybrid event to commemorate International Women's Day, celebrating Women in STEM Careers. Invited speakers across genders talked about their career trajectories in academia, industry and publishing after completing their doctoral studies, as well as the challenges and detours they made along the way.

The event was opened with welcome addresses from the Chapter Advisor and President. Stimulating speakers like Matilde talked about her move from a degree in philosophy to software engineering and helping girls to code, and Rebecca, who quit her degree to specialise in engineering education and outreach. The school Deputy Dean, Professor Kate Sugden, spoke about the significance of impetus towards STEM in early education for girls and women. The event was held in a conference format, with coffee breaks and lunch for speakers and attendees to intermingle. There was also a hybrid open session at the end of the day to urge an interactive discussion between attendees and speakers. This occasion provided an excellent opportunity for participants to learn about various career options after completing their PhDs and listen to many inspiring and motivational anecdotes from some of the field's top experts.

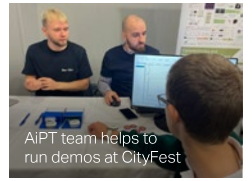
OUTREACH



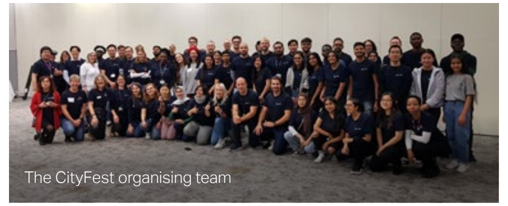
AiPT team at 'Pint of Science 2022'

Pint of Science 2022

AiPT members, together with the Aston OPTICA Student Chapter, collaborated with the Pint of Science festival to promote optics and photonics to a diverse general audience. They organised a Tech Me Out event under the festival banner, which included two talks and a photonics outreach table. The outreach table provided the audience with a hands-on experience with small optics devices, helping them understand the underlying concepts that combine to create current and future technologies.



AiPT team helps to run demos at CityFest

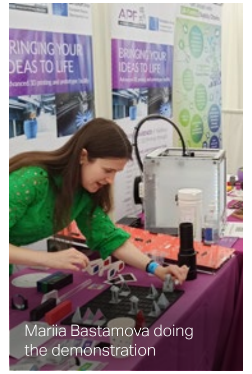


The CityFest organising team

CityFest 2022

A one-day showcase was held to demonstrate technologies that will contribute to future smart city life, from autonomous robots and augmented reality to self-driving cars and the latest ideas in sustainable living. It featured a mixture of hands-on demonstrations and workshops presented by research engineers in the fields of artificial intelligence, robotics, machine vision, transport, logistics, energy, sustainability and telecommunications. Although coordinating the event presented a significant challenge, AiPT Professor David Webb led a diverse team of professional staff, undergraduates, research students, postdocs and academics to deliver it successfully. The event also highlighted inclusivity in engineering and featured a contribution by Women in Engineering, Science & Technology (WEST), an Aston University society that aims to inspire girls and women to study and work as engineers and scientists.

Karina Nurlybayeva doing the demonstration



Maria Bastamova doing the demonstration

The Royal Three Counties Show, Malvern Hills, 2022

The Royal Three Counties Show, England's premiere celebration of the countryside and rural life, took place in June 2022. Taking farming into the future, the new AgriTech Zone at the showground was launched.

Aston team

Girls that Geek event

APF team and Aston University the College of Engineering and Physical Sciences (EPS) students participated in the Girls that Geek event, organised by Midlands Arts Centre. The event was specifically designed for young women from school year seven upwards who are considering their career choices and who would like the opportunity to learn from inspirational speakers. This year's focus was on future employment and career opportunities for young women.

Sasipim Srivallapanondh at the Robot Day

Robot Day Coventry 2023

Robot Day has been created to inspire and educate young people and those who are influential in their lives about STEAM careers through creative workshops, activities, displays, exhibits and talks on robotics, automation and AI.

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BIRMINGHAM UK

AiPT
Aston Institute of Photonic Technologies

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Aston official AiPT page: **www.aston.ac.uk/research/eps/aipt**

LinkedIn page: **www.linkedin.com/company/aston-institute-of-photonic-technologies**

AiPT events page: **events.astonphotonics.uk**

AiPT PhD opportunities page: **phd.astonphotonics.uk**

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