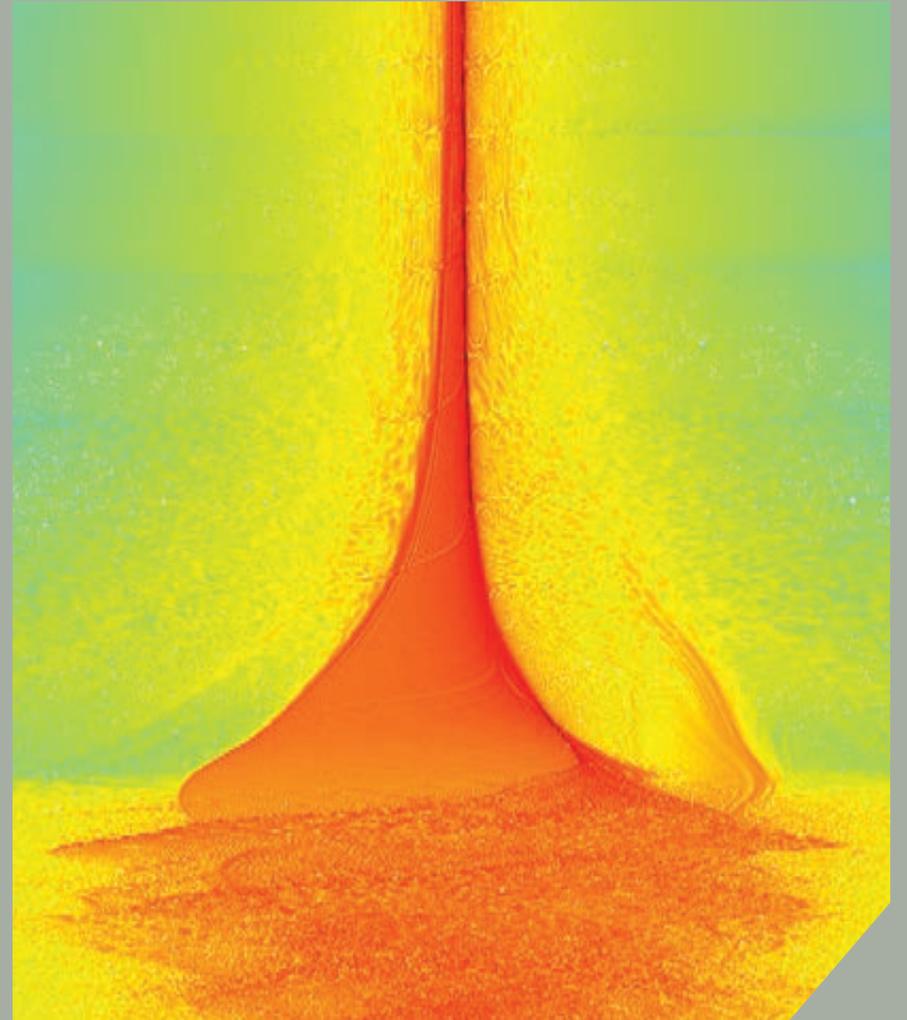


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# AiPT annual report 2013

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# AiPT annual report 2013

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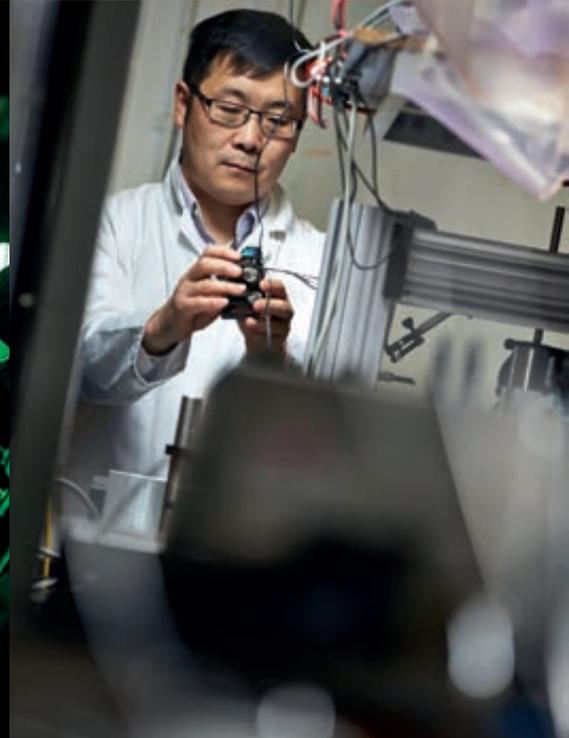
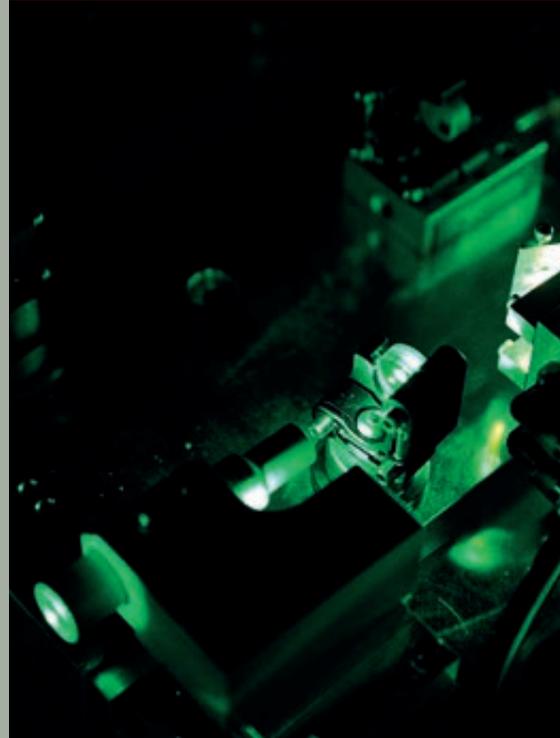
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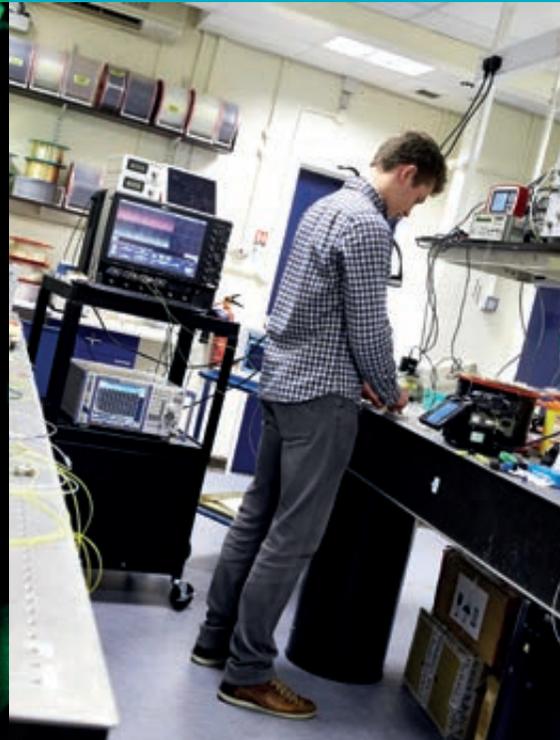
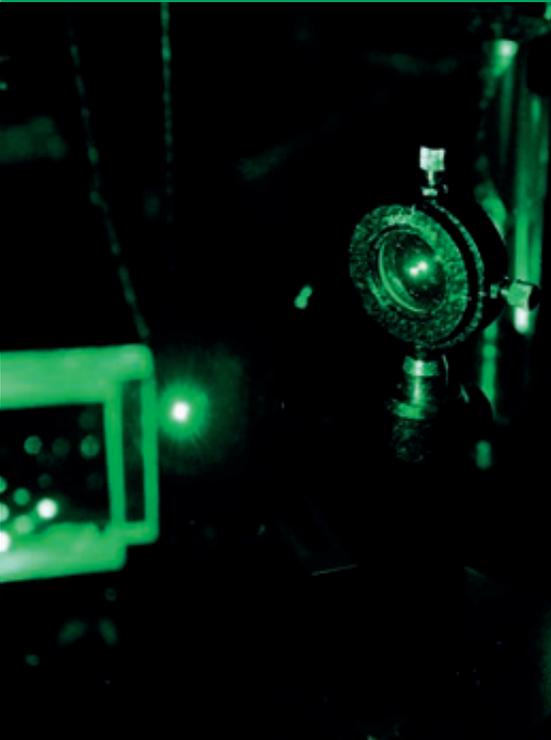
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**Unprecedented  
growth**

# Welcome

Well, here we are. This is our first Annual Report that we have assembled in a period of unprecedented growth. Amazingly, substantial changes in the institute have been continuing as we have been preparing this report. As they say, growth itself contains the feeling of happiness, but it also demands a temporary surrender of stability and security. To appreciate the recent path of developments in the Aston Institute of Photonic Technologies (AIPT), we should look back to 1991, when the Photonics Research Group at Aston University was founded by Professors Ian Bennion and Nick Doran. We have been told that photonics research started at Aston University from nothing in 1991. Well, this sounds almost like in 1991 it was our local Aston photonics Big Bang that defined positions of all stars for many years afterwards.

More than twenty successful years of research have proven the group strength and robustness. In physics, they would say that the structure is stable. It is stable not only against small disruptions that are always around, but also against major perturbations that included, at different moments of time, the departure of the founders themselves. This stability is not by accident. Success over many years has been built on a foundation of right values. Something was done right at the start, and to glimpse into the future, it is useful to have a better understanding of why the Photonics Research Group is a success story.

The international world of research is a huge, non-stationary dynamic system with many degrees of freedom (groups and individuals), pumped with various kind of funding, and living far from thermal equilibrium – a very

interesting system to observe, indeed. It is somewhat fascinating to see the rise and fall of some research groups and stable persistent progress of others, with approximately the same level of funding. What is the most important thing for the success of a research centre? Everybody knows the answer: of course, it is funding, funding and more funding. Is it true? Indeed, the complexity of modern science makes research endeavours increasingly costly. However, the idea that everything in science is defined by funding, for some reason, reminds me of a phrase by Spike Milligan: “All I ask is the chance to prove that money can’t make me happy.”

Funding is, certainly, a necessity, but not a sufficient condition. Who would seriously think that the Bell Labs was the greatest place in the history of science only due to heavy funding? I think, the most important factors are the right people and a creative atmosphere. These are the values on which the Aston Photonics Research Group was founded and this legacy is what I would like to take as my vision of our future development – to attract bright people with ambition and potential to be the best in the world and create an atmosphere that values collaboration over competition and risky ground breaking research over guaranteed success.

This and next year will usher in a period of serious expansion for the AIPT. With the infrangible help of the University and the School of Engineering and Applied Science we will expand and upgrade our laboratories and will extend our activities into the new research areas. It gives me great pleasure and also freaks me out to report that more than 40 new

research staff have been recruited since the inauguration of the AIPT two years ago (How did this happen? I do not know. Honestly. *Accidit in puncto quod non speratur in anno.* What exactly does this Latin means? No idea. I think something close to: “Nobody expects the Spanish inquisition!”). This includes five professors, more than ten Marie Curie Fellows, top level research fellows, many of them with strong industrial background, and talented energetic students. The quality of these new researchers who joined us from across the world is testimony to our strong international reputation and, I hope, to the right and attractive atmosphere created here.

We run more than 40 national and international, research and industrial projects. It would be quite an effort to list all recent awards. I shall leave this business to less successful years. I would like though to mention that Professors Andrew Ellis and Misha Sumetsky have been awarded the high status Royal Society Wolfson Merit Awards. Misha was also elected in 2013 to OSA Fellow. And Andrew was recently awarded a prestigious EPSRC Established Career Fellowship for his project, Petabit Energy Aware Capacity Enhancement. Also Professor Edik Rafailov joined us with twelve new researchers, who are working on five new research projects in semiconductor photonics and bio-medical photonics. The AIPT has gone from strength to strength with a number of new initiatives and activities. Our students have shown leadership qualities through initiating and organising the first AIPT Student Conference on Photonic Technologies. We established in 2013 the AIPT Women Chapter making strong contribution to

the Athena Swan Silver award to the School of Engineering and Applied Science. We have established our first international branch in Novosibirsk State University, increasing our research capacity. AIPT have contributed strongly to the REF submission. Our research growth has a positive extra impact on teaching with many of the fellows and research students being integrated into teaching process. On that foundation we will continue to build our reputation for distinctive high quality research blending cutting-edge fundamental science and technology applications. I hope that our talented and resilient team will continue to build up the creative and attractive atmosphere of discovery of new knowledge and pioneering innovation in the AIPT. Everything else will follow.

**Sergei K. Turitsyn**





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# Highlights

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## Honours and Awards

- ▶ Prof. David Webb was awarded the Royal Academy of Engineering Distinguished Visiting Fellowship grant “Advanced infrared thermography methods for avionics and automotive industry”. This will involve hosting Prof. Boris Vainer from the Rzhanov Institute of Semiconductor Physics (Siberian Branch of the Russian Academy of Science), Novosibirsk, Russia, in 2014. The project will enhance AIPT research in the area of avionics and automotive industry applications.
- ▶ The Royal Society, the UK’s National Academy of Science, awarded Professor Andrew Ellis the Wolfson Research Merit Award for the project “Terabit enabling system technology”. Jointly funded by the Wolfson Foundation and the Department for Business, Innovation and Skills (BIS), the scheme aims to provide universities with additional support to enable them to attract science talent from overseas and retain respected UK scientists of outstanding achievement and potential.
- ▶ Dr. Kate Sugden and Dr. Tom Drew were successful with a KTP application with Optimec Limited. The project will last two and a half years and is worth £171,997 to Aston University. Optimec Limited designs and manufactures soft-contact-lens measuring equipment and intends to work with Aston University to develop a new generation of instruments offering full 3D mapping and advanced metrology.
- ▶ The AIPT was awarded four Marie Curie European and Incoming International Fellowships in 2013. Professors Andrew Ellis, Sergei Turitsyn, David Webb and Lin Zhang will host Fellows selected in a highly competitive contest to undertake research in the areas of optical communications, fibre lasers, polymer fibre technologies and plasmonics. The awards will allow Drs. Naoise Mac-Suibhne, Carlos Marques, Junsong Peng and Junxi Zhang to undertake research for a two-year period at Aston.
- ▶ AIPT Prof. Misha Sumetsky, was elected to become a Fellow of the Optical Society of America (OSA), the highly respected worldwide society for Optics and Photonics. OSA has recognised Prof. Sumetsky as a Fellow for his numerous contributions to the field of optics and photonics including resonance micro/nanophotonics.
- ▶ The OSA Board of Editors has renewed the appointment of Prof. Misha Sumetsky for the second three-year term as a Topical Editor for Optics Letters. This journal provides rapid dissemination of new results in all areas of optics and photonics with short, original, peer-reviewed communications. Optics Letters is consistently ranked as the premier peer-reviewed optoelectronics journal in the world and is among the top-ranked journals in the Optics category. The AIPT is also represented on the editorial board of Optics Express – another top-ranked journal in optics – where Prof. Andrew Ellis serves as an Associate Editor. In addition, Prof. Sergei Turitsyn is a Topical Editor (Nonlinear Effects in Optical Fibers) for the Journal of the Optical Society of America B and is a Member of the Editorial Board of the Scientific Reports (Nature Publishing Group).
- ▶ Dr. Alex Rozhin received an award from the British Council Research Links Programme to host an early career researcher event in Novosibirsk, Russia. The funding will allow Aston to fund 20 early-stage researchers from across the UK to travel to Novosibirsk to network with equivalent early career peers on the Russian side and to attend a two-day event.
- ▶ Prof. Lin Zhang and Dr. Kaiming Zhou have been successful in securing funding from the Technology Strategy Board to work on a research project with Branscan Ltd, Arden Photonics Ltd and Warburtons Bakery to look at the development of distributed UV and near infra-red and fluorescence sensing systems for real-time monitoring of food quality and contamination and process control. The total value of the project is £614,000 with Aston receiving £184,000.
- ▶ Several AIPT researchers including Dr. Elena Turitsyna, Mr. Srikanth Sugavanam, Mr. Nikita Tarasov, Dr. X. Shu, Dr. D. Churkin and Prof. Sergei Turitsyn, together with colleagues from Novosibirsk and the Weizmann Institute of Science, have published a paper entitled “The Laminar-turbulent Transition in a Fibre Laser” in the October issue of Nature Photonics. This publication is the most prestigious journal in its field, with the highest impact factor amongst all the primary research journals in optics and photonics.

### UK Russia partnership to develop new photonics research centre

Russian partnership with Aston to create world innovators.

Aston University and Novosibirsk State University (Russia) are world innovators in the fields of optical communications, fibre optics, lasers and non-linear photonics.

The new collaboration signed between the two Institutions is set to establish the Aston-NSU International Centre for Photonics in Novosibirsk.

The partnership was presented at the 11th Ministerial UK Russia Joint Committee on Science & Technology Cooperation 2013-2015 at the Royal Society in London.

A joint statement on enhanced cooperation in science, higher education and innovation was signed between Minister Vince Cable and Minister Livanov, Russia’s Minister for Education and Science.

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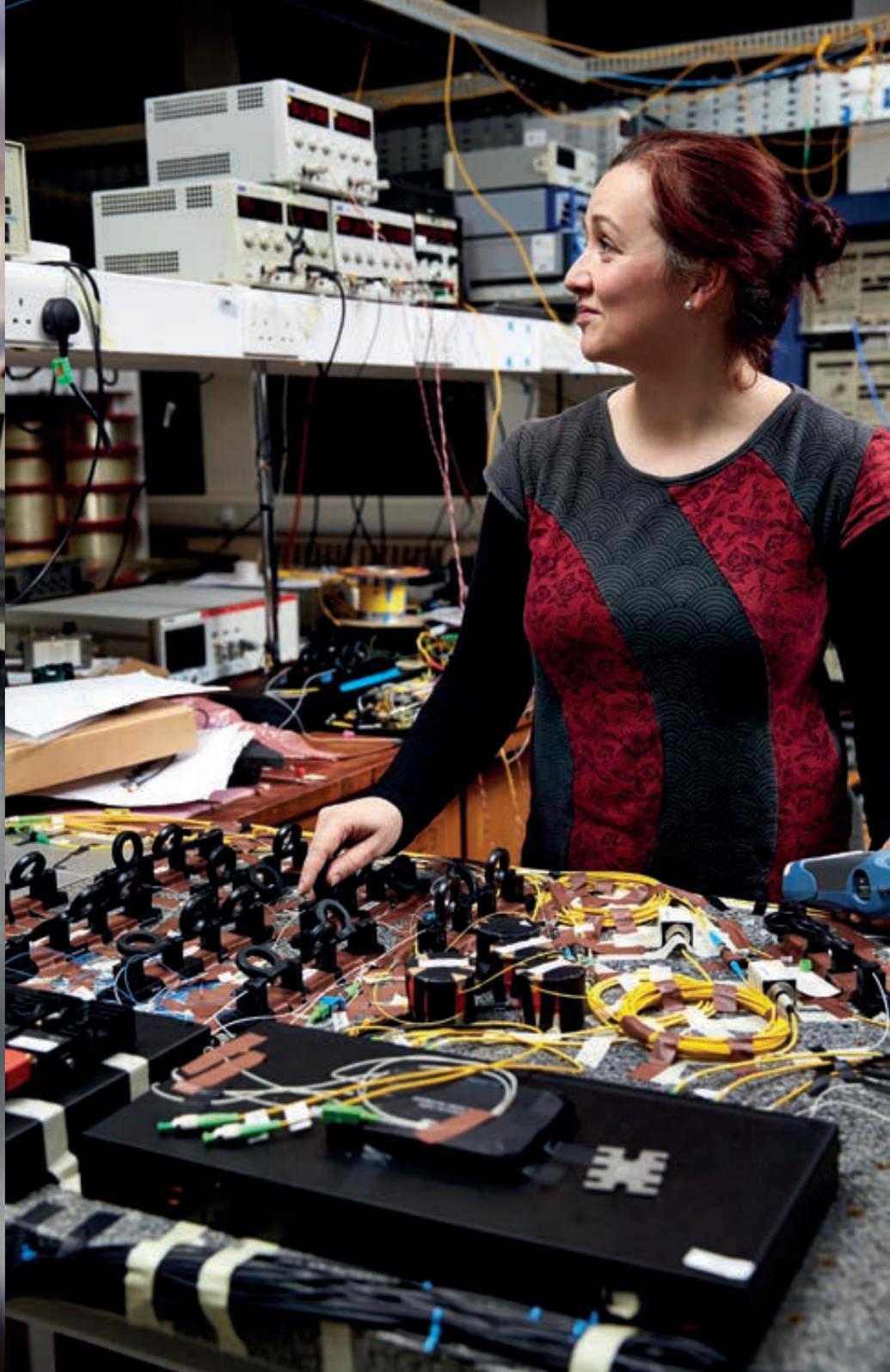
[www.aston.ac.uk/about/news/releases/2013/october/photonics-research-centre](http://www.aston.ac.uk/about/news/releases/2013/october/photonics-research-centre)

### Advanced Workshop in Trieste 15-19 July

Aston Institute of Photonic Technologies in cooperation with European Laboratory for Non-Linear Spectroscopy, Novosibirsk State University, Institute of Automation and Electrometry of Russian Academy of Science, organised an Advanced Workshop on Nonlinear Photonics, Disorder and Wave Turbulence at the Abdus Salam International Centre for Theoretical Physics (Trieste, Italy) in July 2013.

The workshop brought together leading experts in the physics of disordered systems, nonlinear science, wave turbulence, nonlinear photonics and fibre optics to discuss recent progress and synergy emerging at the interface of these research fields.

Link for reference: <http://mesoimage.grenoble.cnrs.fr/IMG/pdf/trieste2013.pdf>



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# People

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## During 2013 the following people were affiliated with the Institute

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**Dr. Stanislav Kolpakov**  
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**Prof. Misha Sumetsky**  
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## Support Staff



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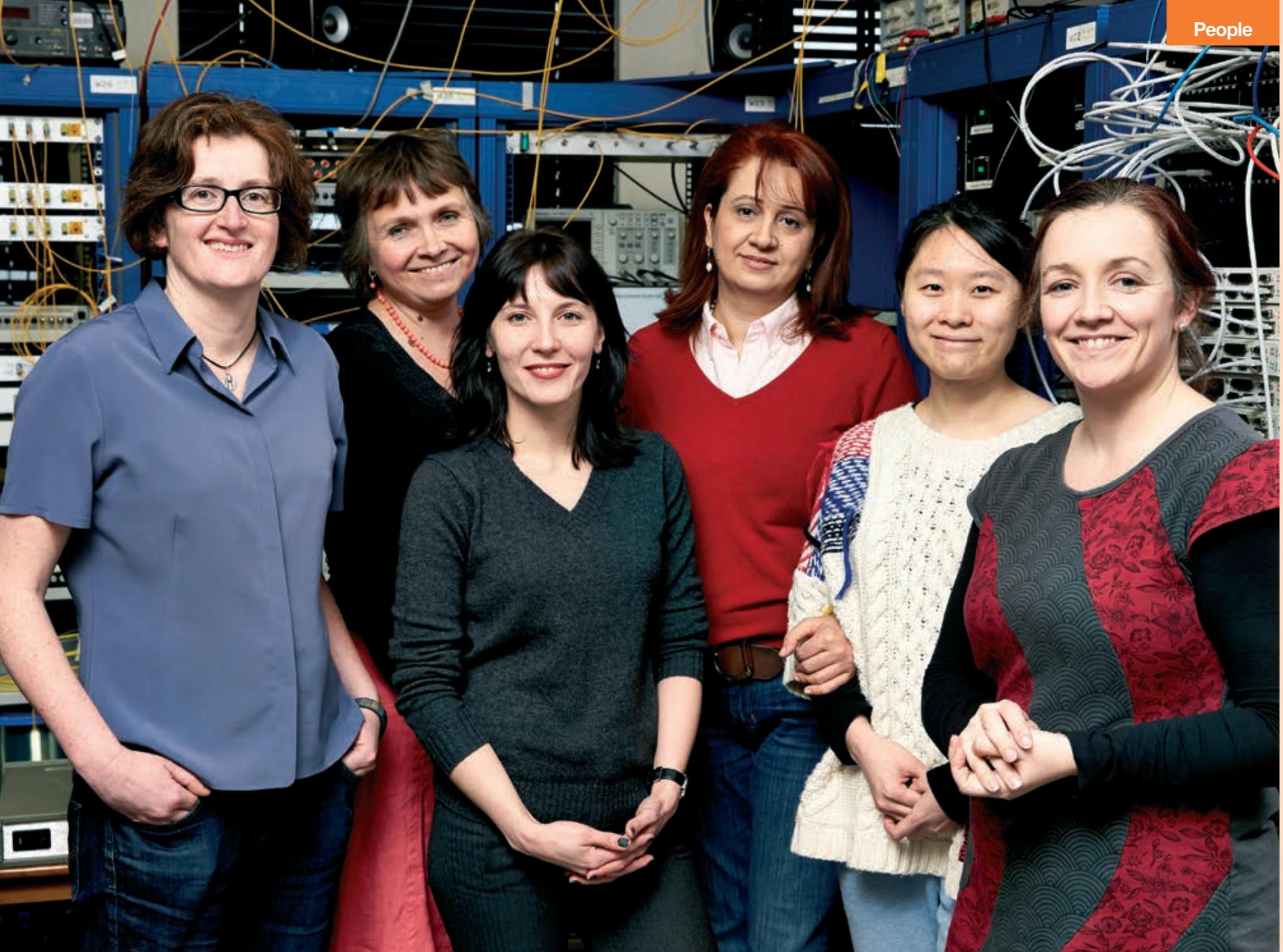
## Research Students



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wangc15@aston.ac.uk

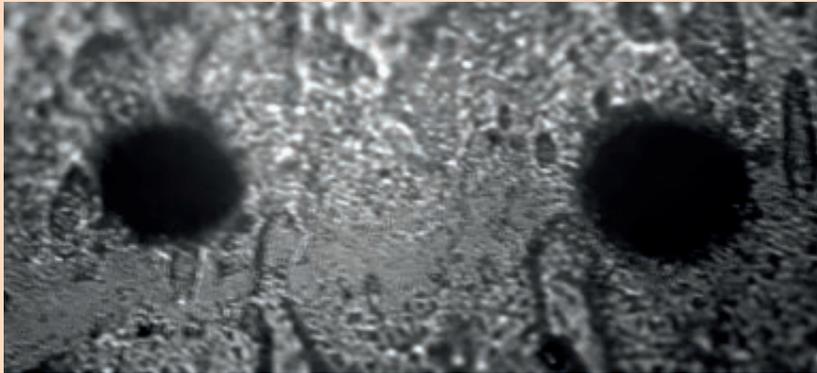
# Visiting Researchers

- ▶ Dr. Vishal Ananad, MAPNET, College of Brockport, State University of New York, USA
- ▶ Dr. Oleg Butov, Kotel'nikov Institute of Radio Engineering & Electronics, RAS, Russia
- ▶ Dr. Stanislav Derevyanko, Weizmann Institute of Science, Israel
- ▶ Dr. Donald Goven, Oclaro Inc, UK
- ▶ Dr. Amyas Holroyd, Oclaro Inc, UK
- ▶ Dr. Yongguang Huang, Chinese Academy of Sciences, Beijing, China
- ▶ Prof. Kyriacos Kalli, Cyprus University of Technology, Cyprus
- ▶ Dr. Hani Kbashi, School of Physics and Astronomy a University of Southampton, UK
- ▶ Dr. Alexei Lanin Institute of Radio-engineering and Electronics of RAS, Russia
- ▶ Dr. Binbin Luo, Chongqing University of Technology, China
- ▶ Dr. Petro Lutsyk, NAS of Ukraine, VE Lashkaryov Institute, Ukraine
- ▶ Prof. Leonid Melnikov, Saratov State Technical University, Russia
- ▶ Dr. Andrey Okhrimchuk, Fiber Optics Research Centre of the Russian Academy of Sciences, Russia
- ▶ Dr. Gbenga Olubodun, Swansea University, UK
- ▶ Dr. Vladimir Osipov, Bayreuth University, Bayreuth, Germany.
- ▶ Dr. Sergey Popov, Institute of Radio Engineering and Electronics RAS (Fryazino Branch), Russia
- ▶ Dr. Anton Skidin, Institute of Computational Technologies SB RAS, Russia
- ▶ Dr. Sergei Smirnov, Novosibirsk State University, Novosibirsk, Russia
- ▶ Dr. Ivan Terekhov, Budker Institute of Nuclear Physics SB RAS, Russia
- ▶ Dr. Kanesan Thavamaran, Newcastle University, UK
- ▶ Dr. Alexander Turchin, Institute of Physics, National Academy of Sciences, Ukraine
- ▶ Dr. Sergei Vergeles, Landau Institute for Theoretical Physics Russian Academy of Sciences, Russia
- ▶ Dr. Joel Villatoro, BIONAND, Malaga, Spain
- ▶ Dr. Igor Yanchuk, NAS of Ukraine, VE Lashkaryov Institute, Ukraine
- ▶ Ms. Anastasia Bednyakova, Institute of Computational Technologies SB RAS, Russia
- ▶ Mr. Anatoli Bukovskyi, NAS of Ukraine, VE Lashkaryov Institute, Ukraine
- ▶ Ms. Maria Chernysheva, Fiber Optics Research Centre of the RAS, Russia
- ▶ Ms. Marta Ferreira, Portugal
- ▶ Mr. Oleg Gorbunov, Institute of Computational Technologies SB RAS, Russia
- ▶ Mr. Jan Hruby, Brno University of Technology, Czech Republic
- ▶ Mr. Xuehao Hu, University of Mons, Belgium
- ▶ Mr. Vladimir Kalashnikov, Vienna University of Technology, Austria
- ▶ Mr. Vladimir Kamynin, Prokhorov General Physics Institute of the Russian Academy of Sciences, Russia
- ▶ Ms. Yulia Mazhirina, State Technical University, Saratov, Russia
- ▶ Mr. Mkhitarian Mkhitar, Moscow Institute of Physics and Technology, Russia
- ▶ Mr. Michael Peeters, Alcatel-Lucent
- ▶ Mr. Semen Ponamarov, VE Lashkaryov Institute of Semiconductor Physics, Ukraine
- ▶ Mr. Alexey Redyuk, Institute of Computational Technologies SB RAS, Novosibirsk, Russia
- ▶ Mr. Martin Slama, Brno University of Technology, Czech Republic
- ▶ Ms. Veronika Tsauryan, Heriot-Watt University
- ▶ Mr. Ilya Vatrik, Institute of Automation and Electrometry SB RAS, Russia
- ▶ Mr. Aleksey Wolf, Institute of Automation and Electrometry SB RAS, Russia
- ▶ Ms. Olesya Yushko, Institute of Computational Technologies SB RAS, Novosibirsk, Russia
- ▶ Ms. Irina Yartukina, Institute of Computational Technologies SB RAS, Russia
- ▶ Ms. Marina Zajnulina, Leibniz-Institut für Astrophysik Potsdam (AIP), Germany



# Focus#1

## Neil T. Gordon



Neil T. Gordon joined the AIPT one year ago to work on the **European Regional Development Fund (ERDF)** programme aimed at industrial exploitation of recent advances in photonic technology. Although the UK has a strong record in innovation during the initial stages of a new technology, it has not always succeeded in efficiently transferring these advances into profitable exploitation by industry. This exciting programme is trying to achieve improved exploitation by investigating how recent advances in photonics technology can be adapted to solve problems for small and medium enterprises (SMEs) in the West Midlands region.

Neil Gordon started his scientific career at the University of St. Andrews where he worked at the Wolfson Institute of Luminescence on the physics of electroluminescent displays,

receiving his PhD in 1981. He then moved to the Royal Signals and Radar Establishment in Malvern (now QinetiQ) to work on infrared sensors and systems. A theme of his work here was to understand sensor performance at a fundamental level and improve sensor performance towards their fundamental limits. Detectors investigated include very low noise avalanche devices; heterodyne laser detectors; large focal plane arrays; dual waveband arrays; and wide bandwidth spectrometer arrays. This work led to his contributing five chapters to various text books in infrared sensors and systems. Later he joined a group investigating the application of computational imaging to large format infrared systems. The idea here was to improve the resolution of the system to below the pixel limit using a spatial light modulator and applying advanced algorithms. During this period at QinetiQ he was appointed a QinetiQ fellow and was elected a fellow of the Institute of Physics.

The ERDF programme funds free consultancy to SMEs in the West Midlands interested in investigating how photonics can be applied to their business. One area which has been of interest to a number of companies is the use of photonic sensors, particularly for applications where conventional sensors cannot be used. Photonic sensors are available to measure a range of physical, chemical and biological properties using light (infrared) rather than electronics. Fibre optic strands rather than wires are used to transport the infrared radiation

to the region of interest and the effect to be measured typically modifies the spectrum or intensity of the reflected beam. The reflected radiation can then be analysed a long way from the sensor. This can be a significant advantage in cases where there is the possibility of fire/explosion or if the sensor is located in a position of high electrical interference. Many of the required components such as low loss fibre, light sources and detectors are widely available due to the development of fibre optic communication systems for the internet. Photonic systems can also be used for accurate metrology and precision laser micromachining using femtosecond lasers. An example is shown in the figure where precision holes and partial holes were produced for a medical application. In many cases, our initial consultancy has led to further development and this may also be partially funded using the Knowledge Transfer Partnership (KTP) scheme or as a competition from the Technology Strategy Board (TSB).

During the first year on this programme, Neil has worked on a wide range of technologies extending from high technology research to simple advice on commercially available components. The AIPT are also collaborating on a number of interesting new projects which will be developed in the coming year.

# Focus#2

## Sonia Boscolo



I studied at the University of Burgundy, Dijon, France where I was awarded the BSc and MPhys degrees in Physics in 1998. I joined the Photonics Research Group at Aston University in 1999, and I received a PhD degree for studies on optical solitons and nonlinear solitary waves in 2002. Since 2002, I have been working with the Photonics Research Group (now the AIPT), where I am currently a Senior Lecturer.

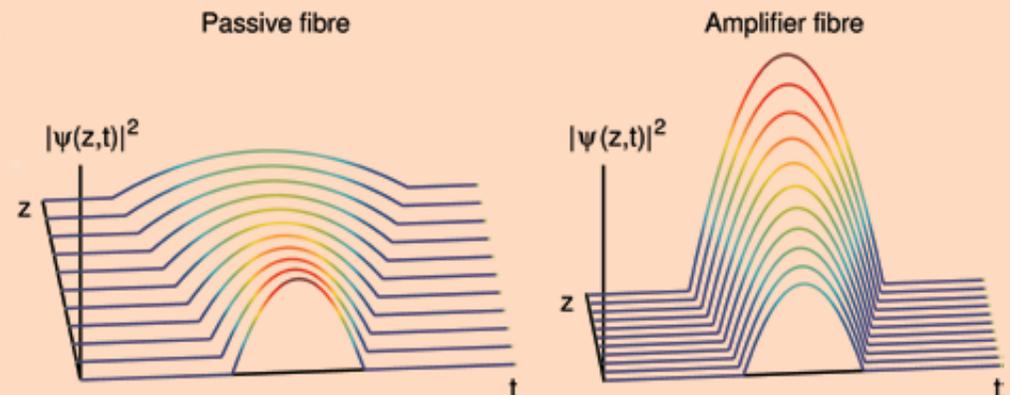
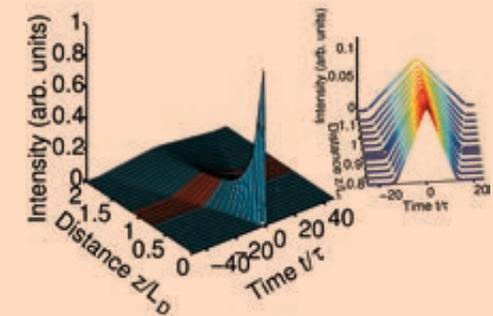
My main research focus is in the field of nonlinear optics and, more specifically, on the exploration of fundamental mathematical theories of modern nonlinear science and their application in the context of fibre-optic communications and laser systems, as well as on the design and modelling of novel nonlinear photonic systems and devices. I have made internationally acknowledged original contributions in the areas of nonlinear wave theory, dissipative solitons, soliton-based technologies for fibre-optics communications, advanced all-optical signal processing techniques for high-bit-rate optical communication systems, all-optical regeneration in fibre transmission systems, optical pulse shaping and signal manipulation, and pulse dynamics in high-power fibre lasers. I have published 50 papers in peer-reviewed academic journals (including five invited review papers and one editorial leading paper), two book chapters, and 81 papers in refereed international conference proceedings. I am currently working on an edited volume on 'Pulse

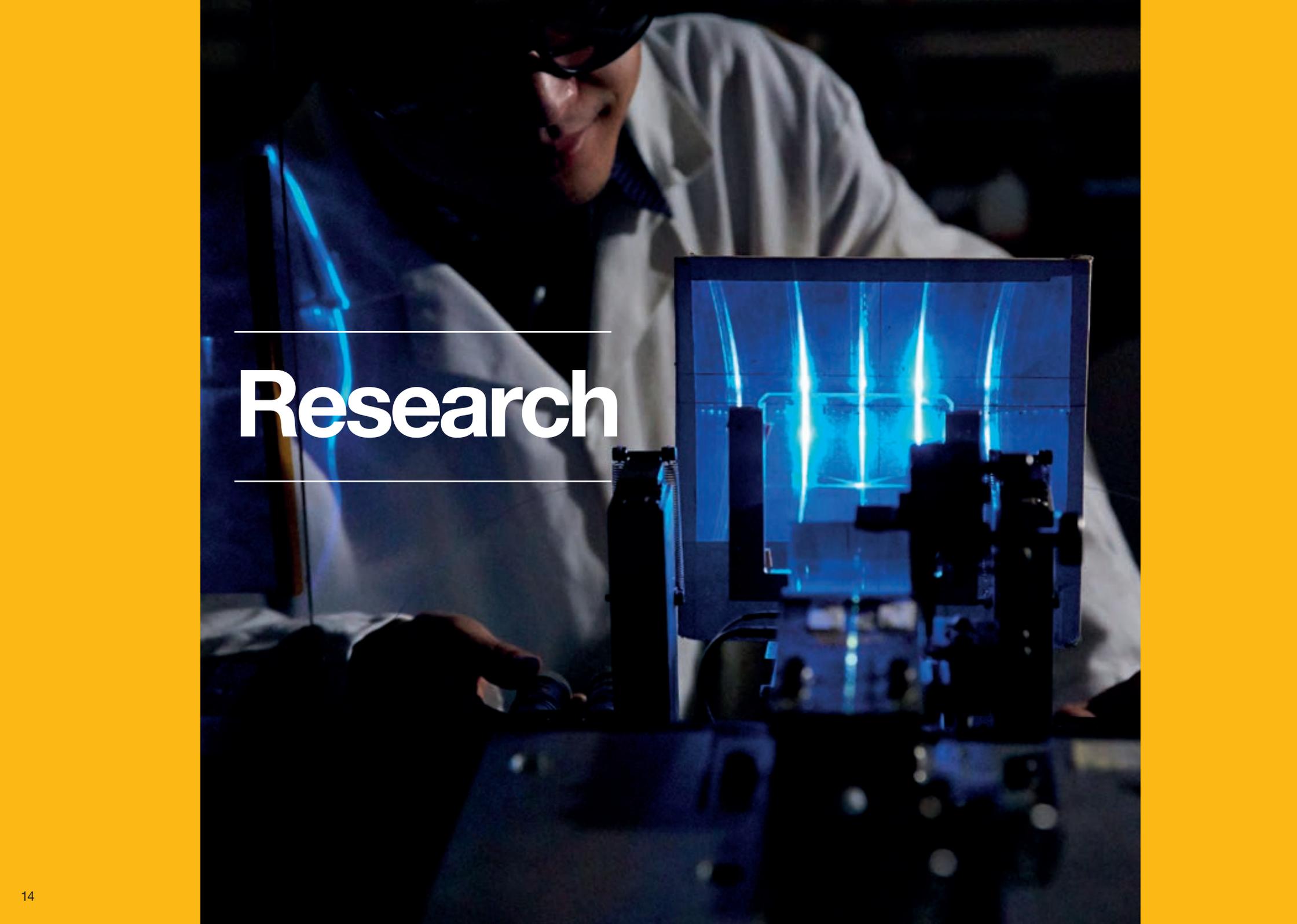
shaping and signal processing using optical fibres' with Prof. Christophe Finot (University of Burgundy) that will be published by Wiley & Sons in 2015. I have also produced three technological patents. Thus far I have made 20 invited presentations at leading international conferences and workshops in the areas of nonlinear physics, applied mathematics and optical engineering, and I will make three more invited presentations this year. I have also given eight invited seminars on my activity and topical lectures at internationally recognized research centres.

I have been the Principal Investigator/British Project Leader on 5 research projects funded by the Leverhulme Trust, the EPSRC and the British Council. I have successfully supervised the work of two postdoctoral researchers (Dr. Brandon Bale and Dr. Mykhaylo Dubov) deployed on my funded projects, and I am currently supervising a PhD student (Mr. Huseyin Karakuzu). I am expecting two more PhD students this year. I have been the organizer of two mini-symposia at international conferences, and a member of the Technical Program Committee for other two international conferences. I serve as a referee for several peer-reviewed academic journals, and I have active international collaborations with several research centres, including the Laboratoire Interdisciplinaire Carnot de Bourgogne of the University of Burgundy (Prof. C. Finot), the Optoelectronics Research Centre of the University of Southampton (Prof. Periklis

Petropoulos, Dr. Radan Slavik, and Dr. Francesca Parmigiani), the University of Brescia, Italy (Prof. Stefano Wabnitz, Prof. Costantino De Angelis, and Dr. Daniele Modotto), and the Ultrafast Optics Laboratory at the Yerevan State University 1, Yerevan, Armenia (Prof. Levon Mouradian), amongst others.

Teaching wise, I teach Computing and Programming and Digital Transmission at both undergraduate and MSc levels, and I supervise Final Year and Masters projects. I have also taken the role of Programme Director for a new undergraduate degree programme in Applied Physics starting next October.





# Research

# Research Portfolio

The AIPT has an impressive portfolio of grant funding, industrial and international collaborations, spin-out companies, highly cited research papers and patents all demonstrating excellence in the field and well working strategy.

The current EU funding includes: **Nine FP7 Marie Curie IIF/IEF projects** (€3.2m) in the field of mid-infrared fibre lasers, communications, mode-locked fibre lasers, photonic materials, nano-science and sensing applications. **Three FP7 IRSES projects** (€1.1m) link AIPT research to the world leading international centers in the areas of photonic materials, laser systems and wireless communication networks. The **FP7 Industry Academia Partnerships and Pathways project** GRIFFON (€1.5m total award, € 685k Aston award) coordinated by AIPT is an example of international academia-industry collaboration in green technology networks. **Two FP7 Initial Training Network** (ITN) project: **ICONE** – Allied Initiative for Training and Education in Coherent Optical Networks and TRIPOD – Training & Research Involving Polymer Optical Devices (€7.2 total award, €1.7m to Aston). **Three FP7 ICT projects**: (€1k) are aligned with CDT activities in integrative photonic technologies and access-network applications. The **ERC Advanced Investigator Project** ULTRALASER (€1.7m) was awarded to AIPT Director Prof. Sergei Turitsyn for groundbreaking concepts in lasers and communications. Recently awarded **EPSRC grants** include: the £4.8m UNLOC Programme Grant with UCL (£2.1m at Aston); Wideband Optical Communication – Systems Using Phase – Sensitive/Insensitive Fibre Optical Parametric Amplifiers (£652k); Grating and waveguide plasmonic sensors (£511k). The **European Regional Development Fund (ERDF)** project (£1.4M) aiming at business assists and collaboration with West Midlands SMEs (40 in the new project and **60 SMEs** assisted in Phase 1). A number of other industrial and international projects include grants/contracts from: The Royal Society, US Air Force, Arden Photonics, Astasense Limited, Oclaro, Rostelecom (Russia), EPSRC KT Challenge, *Knowledge Transfer Partnership* projects, EPSRC CASE studentships, EPSRC Dorothy Hodgkin Award, NATO, the Royal Academy of Engineering, British Council and others. In total, the AIPT have 42 ongoing research projects.

## AIPT European Commission Current Awards

Funder	No. Awards	Total Award Value (€)
European Commission:		
FP7-ICT	3	€ 866,077.35
FP7-TRANSPORT	1	€ 149,999.85
European Research Council Advanced Grant	1	€ 1,659,771.00
Marie Curie – International Research Staff Exchange Scheme (IRSES)	3	€ 476,796.47
Marie Curie – Initial Training Network (ITN)	2	€ 1,685,770.99
Marie Curie – Incoming International Fellowships (IIF)	5	€ 949,923.00
Marie Curie – Intra-European Fellowships (IEF)	6	€ 1,336,172.15
Marie Curie – Industry-Academia Partnerships and Pathways (IAPP)	1	€ 684,879.06
Grand Total	22	€ 7,809,389.87

## Other AIPT Current Awards

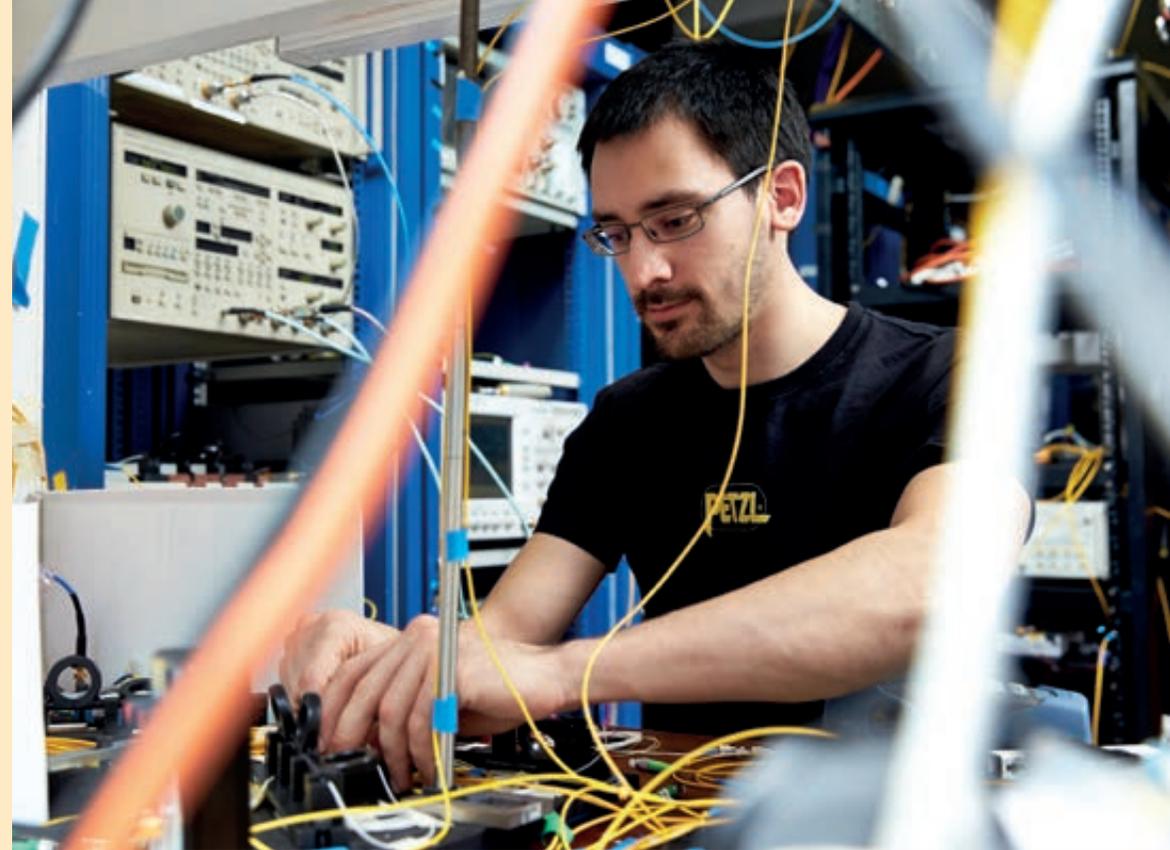
Funder	No. Awards	Total Award Value (£)
ESPRC	4	£4,092,739.50
Leverhulme Trust	1	£221,415.00
Technology Strategy Board	1	£184,000.00
ERDF Fibre Optics Phase 2-Photonics	1	£295,941.50
EC NATO project	1	£190,000.00
Knowledge Transfer Partnerships	3	£449,901.94
The Royal Society	2	£144,700.00
EPSRC Dorothy Hodgkin Postgraduate Award	1	£90,000.00
The British Council	1	£25,000.00
Small industrial contracts	1	£80,000.00
US AIR Force	1	£10,000.00
Russian Ministry of Education & Science	1	£42,110.00
The Royal Academy of Engineering	2	£18,900.00
Grand Total	20	£5,844,707.94

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Research area

# Optical Communications

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Following decades of exponential growth in communication capacity, broadband and internet services have proven to be powerful tools for both economic and social progress. Economically, they feature strongly in National, European and world-wide development plans and form part of a £53.4bn communications market. Increasingly, governments resort to “e-initiatives” to widen participation in government and increase the accessibility of services. For an individual point of view, within the UK alone the 17.6 million UK mobile internet connections and the 73% of homes with broadband connections rely on high capacity core networks. Recent market surveys have revealed that superfast broadband markedly changes internet use widening the benefits in terms of government policy and societal development. Unseen to its users, over 99.9% of this data traffic passes over optical fibres, underlining the importance of this technology. However, the immense volume of data traffic in

use today has led to predictions of a capacity crunch, where the demand for internet capacity exceeds the ability of a single optical fibre to support it. Furthermore, since the energy consumption of the networks supporting the internet now accounts for between 1% and 3% of global energy consumption, a figure which rises to over 8% when the power consumption of devices used to access the internet are included, the environmental impact of the internet is a growing concern.

The Optical Communications Group at Aston University is dedicated to resolving these two key issues, overall network capacity, and energy consumption. The research program includes access networks, where recent calculations for the UK reveal that fibre to the home, with the potential for broadband capacities exceeding 10 Gbit/s could be installed nationwide for a fraction of the cost of a major railway infrastructure.

Aston’s interests extend through to the core of the network and to longest subsea communication systems where the capacity crunch will be felt most keenly. Here as reported on the page opposite, Aston University has demonstrated for the first time that the conventionally accepted communication capacity of an optical fibre may be exceeded. Of course, with access networks continuing to grow in capacity and core networks appearing constrained it is wise to consider if new technologies will be of any benefit. Such technologies include optical super channels with sub channel routing, and spatially multiplexed systems.

## People

### Principle Investigators

Prof. Andrew Ellis, Prof. Nick Doran, Prof. Keith Blow, Prof. David Payne, Prof. Sergei Turitsyn.

Dr. Paul Harper, Dr. Stylianos Sygletos, Dr. Sergei Sergejev

### Research Assistants

Dr. Atalla El-Taher, Dr. Farsheed Farjady, Dr. Ian Phillips, Dr. Mary McCarthy, Dr. Marc Stephens, Dr. Naoise Mac Suibhne, Dr. Elias Gaikoumidis, Mr. Simon Fabbri.

PhD students: Mr. Thai son Le, Mr. Pavel Rosa, Miss Mariia Sorokina, Mr. Mingming Tan.

### Industry Fellow

Dr. Wlodek Forysiak

## Optical Communication Research

Aston University's Optical Communications team seeks to commercialise its research the benefit of the local economy and society as a whole. Dissemination of key messages from its research is of immense importance to the team. To this end we communicate at all levels within society, ranging from Prof. Andrew Ellis attending a Parliamentary event organised by the Industry and Parliament Trust discuss the future to discuss the future of broadband in the UK, through to seminars targeted at a general engineering audience.

Key scientific papers in 2013 included:

Farjady, F., & Doran, N. J. (2013, June). Cost-reduction using non-uniform traffic in optical networks. In *Transparent Optical Networks (ICTON), 2013 15th International Conference on* (pp. 1-4). IEEE.

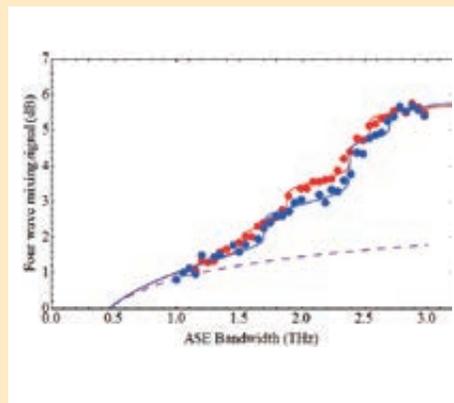
A.D. Ellis, N. Mac Suibhne, S. Sygletos, F. C. Garcia Gunning, "Expressions for the nonlinear transmission performance of multi-mode optical fiber", *Optics Express*, Vol. 21, No. 9, pp22834-22846, (2013).

"Hybrid gain-flattened and reduced power excursion scheme for distributed Raman amplification", A. E. Bednyakova, M.P. Fedoruk, P. Harper, S.K. Turitsyn, *Optics Express*, Vol. 21, Issue 24, pp. 29140-29144 (2013)

"Advanced perturbation technique for compensation of fiber nonlinearity and dispersion impairments in WDM systems using digital backward propagation", L. Xiang, P. Harper, *Optics Express*, Vol. 21, Issue 11, pp. 13607-13616 (2013)

M. Sorokina, S. Sygletos, A. D. Ellis, and S.K. Turitsyn, "Optimal packing for cascaded regenerative transmission based on phase sensitive amplifiers," *Opt. Express* 21, 31201-31211 (2013)

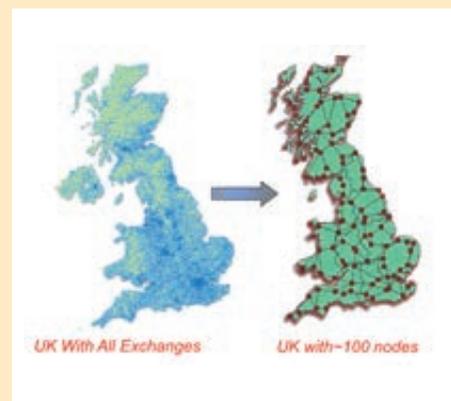
Elena G. Turitsyna and Sergei K. Turitsyn, "Digital signal processing based on inverse scattering transform," *Opt. Lett.* 38, 4186-4188 (2013)



### Spatial multiplexing

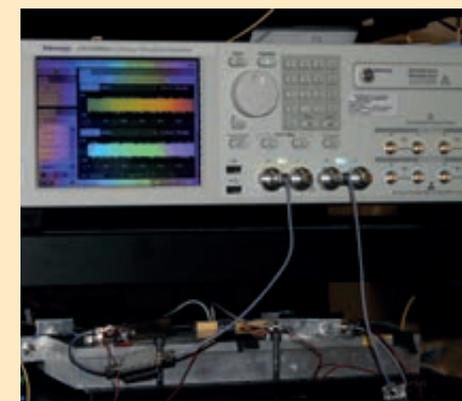
Multi-mode optical fibre was first used commercially in Dorset, 1975. Fibre offered an immense bandwidth increase compared to copper wire based technologies which were reaching their capacity limits. However, attention quickly switched to single-mode fibre, supporting a three decade long growth of capacity. Now, just like copper, single-mode fibres are approaching their maximum capacity. The imminence of a single-mode fibres capacity crunch has reignited interest in multi-mode fibres. The EU projects MODE-GAP, InSpace, and Solas are developing novel designs which offer orders of magnitude increases in capacity. In a recent paper\* Aston University proposed a new method to assess the nonlinear impairments arising from such fibres, proposing that such measurements may be used to determine the total capacity of a fibre link. This simple method uses amplified spontaneous emission and a programmable optical filter to emulate wavelength division multiplexed signals. By varying the emission bandwidth, the onset of new velocity matching processes are readily observed (see figure), and agree with theoretical predictions based on a generalised Gaussian Noise model.

\*A. D. Ellis, N. Mac Suibhne, S. Sygletos, F. C. Garcia Gunning, "Expressions for the nonlinear transmission performance of multi-mode optical fiber", *Optics Express*, Vol. 21, No. 9, pp22834-22846, (2013).



### Optical Access Networks

With the energy consumption of the internet set to enter a period of exponential growth, Professors David Payne and Nick Doran are leading a European wide effort to demonstrate substantial energy savings using passive optical networks. Current access networks, which reach nearly every home in Europe, are based on a network of twisted pairs of copper wires. Due to the limited reach of this transmission medium for high bandwidth signals, they are terminated in local exchanges, each serving customers within a radius of around 10 km and containing power hungry electronic switches. Cascades of switches are used before signals reach the core of the network. In the deep reach passive optical network proposed by the EU project DISCUS, the significantly enhanced reach enabled by optical communications is used to bypass these switches. Detailed studies have revealed for both densely and sparsely populated countries the number of exchange sites may be reduced by a factor of more than 100, resulting in truly substantial savings in cost and energy consumption. Nationwide installation of this technology, at a cost representing a fraction of the cost of a major railway infrastructure, represents the lowest whole life cost of all currently proposed access network configurations.



### Core Networks

Aston's core-network research is focused on optical communication systems that go beyond the limits of current technology, maximise capacity and are tailored to the nonlinear optical channel. Aston University has combined two fundamentally different technologies to demonstrate transmission performance in excess of the nonlinear Shannon limit. Ultra long fibre Raman lasers may be used to convert an optical fibre into a lossless transmission medium. Optical phase conjugation offers excellent compensation of linear signal impairments, such as chromatic dispersion, but the compensation of nonlinear distortions is impaired by fibre loss. By combining optical phase conjugation and ultra long Raman laser based transmission fibres, it was shown to be possible to compensate for 70% of the nonlinear impairments experienced by seven wavelength division multiplexed 100 Gbit/s channels over a transmission distance exceeding 10,000 km.

UNLOC Staff and External Advisory Board members April 2013.

In collaboration with the EU project FOX-C Aston's optical network team is also investigating techniques to enhance the information flow per unit spectrum occupied by signals using either orthogonal frequency domain multiplexing, where the spectra of signals are overlapped, or Nyquist WDM.

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## Research area

# Nonlinear Photonics and Signal Processing

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### Nonlinearity, friend or foe?

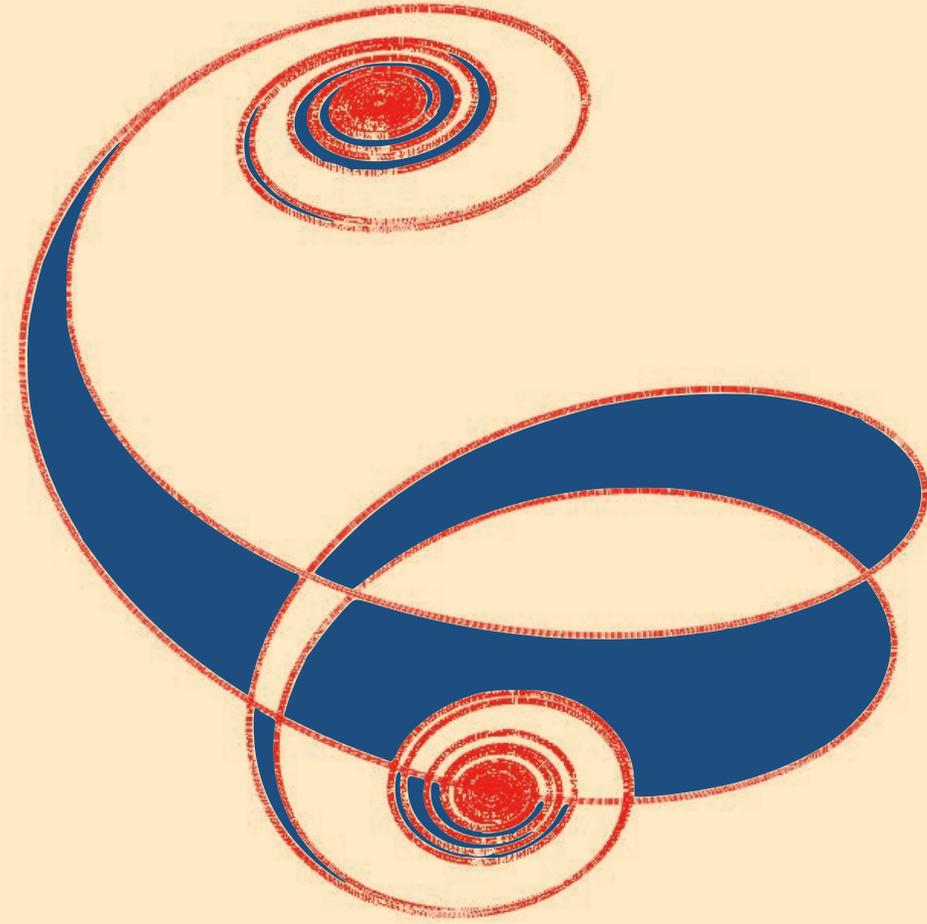
Though nonlinear physics has a rather long history, beginning with the works of Newton and Huygens, science and technologies of the 19th and most of the 20th century have been dominated by linear mathematical models and linear physical phenomena. Over the last decades, there has been growing recognition of physical systems in which nonlinearity introduces a rich variety of fundamentally new properties that can never be observed in linear models or implemented in linear devices. From a practical standpoint, nonlinearity adds to the difficulty of understanding and predicting the system properties. However, with suitable design and control, it is possible to master and exploit nonlinear physical interactions and processes to yield tremendous benefits. The understanding and mastering of nonlinear optical systems has the potential to enable a new generation of engineering concepts.

Although silica exhibits much lower optical nonlinearity than crystals of such materials as lithium niobate or beta barium borate, silica fibres can provide a comparatively enormous interaction length and tight confinement, which offers the long-recognized possibility of using optical fibres for nonlinear interactions. Nonlinear processes that have been exploited in demonstrations and applications include stimulated Brillouin and Raman scattering, as well as aspects of the Kerr effect variously called self-phase modulation, cross-phase modulation, four-photon (four-wave) mixing, cross-polarisation modulation, and parametric gain. Important examples of established and new emerging nonlinear fibre-based photonic technologies

essentially relying on nonlinear phenomena include all-optical signal processing and regeneration in ultrafast telecommunications, optical gating, switching and frequency conversion, optical waveform generation and pulse shaping, optical parametric amplification, Raman amplifiers and lasers, high-power pulsed and continuous-wave lasers, broadband and supercontinuum light sources, and other applications. In this group we consider many aspects of nonlinear response including the fundamental role played in laser dynamics, and the important contribution to the field of optical signal processing and manipulation and to the theory of the capacity of communication systems.

Modern state of the art communication systems are nonlinear. The only question that remains is how you respond to that fact. One possibility is to simply regard the nonlinearity as a performance degradation and try to minimise its impact. A much more intriguing question is whether the nonlinearity can be actively used to improve performance. Much of our work is aimed at harnessing the potential of nonlinear system response.

The AIPT has a well-established track record in the development of novel photonic approaches, techniques, systems, and devices exploiting nonlinear effects in optical fibres. In the papers showcased here we look at fibre lasers and the role of nonlinearity in determining the stable pulse structures that occur. We also look at the implications of nonlinearity on the classical Shannon capacity limit of communication systems.



### People

#### Academic Staff

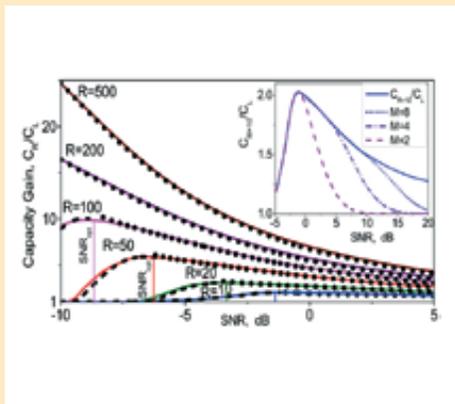
Prof. Sergei Turitsyn, Prof. Keith Blow,  
Prof. Nick Doran, Dr. Sonia Boscolo,  
Dr. Elena Turitsyna

#### Researchers

Dr. Sergey Sergeev, Dr. Chengbo Mou,  
Dr. Marc Stephens, Dr. Zuxing Zhang

#### PhD Students

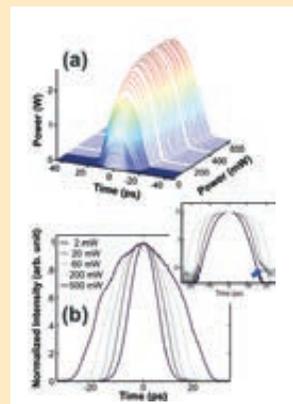
Mr. Son Thai Li, Mr. Huseyin Karakuzu,  
Ms. Maria Sorokina



### New bounds of classical Shannon capacity: regeneration limit

Since Shannon derived the seminal formula for the capacity of the additive linear white Gaussian noise (AWGN) channel, it has commonly been interpreted as the ultimate limit of error-free information transmission rate. However, the capacity above the corresponding linear channel limit can be achieved when noise is suppressed using nonlinear elements. Regeneration is a fundamental concept that extends from biology to optical communications. All-optical regeneration of coherent signal has attracted particular attention. Surprisingly, the quantitative impact of regeneration on the Shannon capacity has remained unstudied. We proposed a new method of designing regenerative transmission systems with capacity that is higher than the corresponding linear AWGN channel, and illustrated it by the regenerative Fourier transform (RFT) for efficient regeneration of multilevel multidimensional signals. The regenerative Shannon limit – the upper bound of regeneration efficiency – was derived.

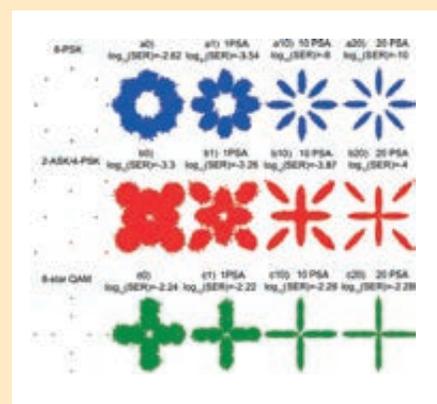
Figure above shows gain (above linear AWGN channel) for the different number of regenerators. The analytical results shown by black lines demonstrate an excellent agreement with numerics (solid coloured lines). The inset shows mutual information gain for M2-rectangular constellations approaching capacity gain.



### Similaritons in fibre amplifiers

This work, which is a part of the research on the use of nonlinear phenomena in optical fibres for the generation and shaping of optical pulses conducted in collaboration with the University of Bourgogne (Prof. C. Finot), presents a detailed experimental characterization of the adiabatic transition process of an initially low-energy Gaussian pulse to the asymptotic self-similar parabolic solution in optical fibre amplifiers operating in the normal dispersion regime. The experimental study coupled with a numerical analysis highlights the various stages of the nonlinear reshaping. The impact of saturation of the gain in the amplifier is also clearly shown, requiring the inclusion of a varying gain along the fibre in the numerical model.

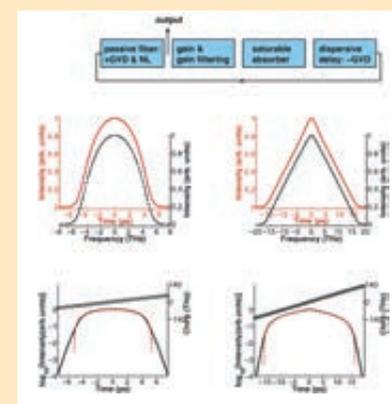
The results presented demonstrate that even though optical amplifier similaritons were highlighted as soon as 2000, there are still some aspects of the nonlinear pulse dynamics that are not fully explored. Many applications, such as optical signal processing and mode-locked fibre lasers, may benefit from this better understanding.



### Optimization of regenerative system

An analytical method for optimizing phase sensitive amplifiers (PSAs) for regeneration in multilevel phase encoded transmission systems. The model accurately predicts the optimum transfer function characteristics and identifies operating tolerances for different signal constellations and transmission scenarios. The results demonstrate the scalability of the scheme and show the significance of having simultaneous optimization of the transfer function and the signal alphabet. The model is general and can be applied to any regenerative system.

We also investigated the transmission performance of advanced modulation formats in nonlinear regenerative channels based on cascaded phase sensitive amplifiers. We identified the impact of amplitude and phase noise dynamics along the transmission line and showed that after a cascade of regenerators, densely packed single ring PSK constellations outperform multi-ring constellations. The results of this study will greatly simplify the design of future nonlinear regenerative channels for ultra-high capacity transmission.



### Review of fibre laser studies

This paper reviews recent theoretical and experimental results and advances made at AIPT. We provide an overview of several new nonlinear mechanisms of pulse shaping that currently drive rapid progress in passively mode-locked fibre lasers, as well as of the previously known soliton and dispersion-managed soliton mode-locking regimes. Specifically, we discuss parabolic self-similar pulse (similariton) mode-locking, a mode-locking regime featuring pulses with a triangular distribution of the intensity, and spectral compression arising from nonlinear pulse propagation. Various experimental methods that are currently used and/or actively studied to realize mode-locked pulse generation in fibre lasers are also discussed, including the use of carbon nano-materials.

Further, we review recent experimental studies unveiling new types of vector solitons with precessing states of polarisation for multi-pulse and tightly bound-state soliton (soliton molecule) operations in a carbon nanotube mode-locked fibre laser with anomalous dispersion cavity.

This work has also benefited from collaboration with the University of Bourgogne (Prof. C. Finot) and OFS Fitel.

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## Research area

# Optical Sensing

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Optical fibre based sensors are transforming industry by permitting monitoring in hitherto inaccessible environments or measurement approaches that cannot be reproduced using conventional electronic sensors. A multitude of techniques have been developed to render the fibres sensitive to a wide range of parameters including: temperature, strain, pressure (static and dynamic), acceleration, rotation, gas type, and specific biochemical species. Constructed entirely of glass, optical fibre devices offer the properties:

- ▶ **Low loss:** fibre attenuation of 0.2 dB/km means that even after traversing 15 km, half of the launched optical power still remains in the fibre. For sensing systems, this translates into the possibility of monitoring locations that are very remote from the control room housing the instrument. Practical examples include monitoring down the bore holes of oil wells and tracking the movement of trains.
- ▶ **Dielectric construction:** made entirely of glass (or occasionally plastic) optical fibres sensors contain no metallic components

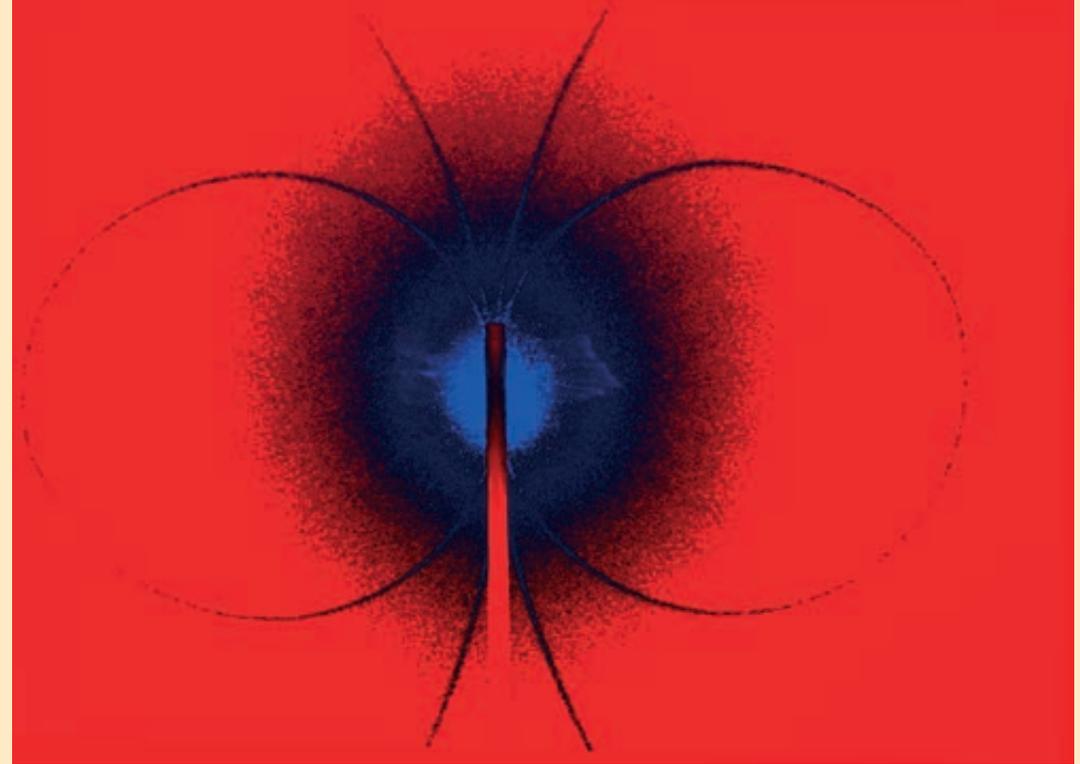
that would render them susceptible to electromagnetic interference. This means they can be used to sense in electrically noisy environments, such as electricity generators or magnetic resonance imaging equipment. Glass fibre can also be used to sense in environments where the temperature may rise towards 1000 °C. More exotic materials can extend this towards 2000 °C.

- ▶ **Small size:** A standard optical fibre is only 1/8 mm in diameter. This means that sensing systems based on optical fibres tend to be of lower weight than equivalent electrical systems – important for example in aerospace applications. More significantly, the small size allows optical fibres to be embedded in modern composite materials, allowing the producing of “smart structures” that are able to sense their environment.
- ▶ **Multiplexing:** Approaches have been developed to addressing many sensors spaced along a single optical fibre; in some cases running into several hundred devices. These multiplexed systems can

offer a cost effective solution to monitoring complex structures. Moreover, a unique class of optical fibre sensors based on light scattering is capable of recovering strain or temperature continuously along an optical fibre that in some cases can reach 100 km in length.

The AIPT has been spearheading developments in this field for more than 20 years, mostly in collaboration with industrial partners ranging from major international companies such as Airbus and BAe Systems, to SMEs, including three companies spun off from the Institute. One of these companies, using technology developed by AIPT staff, is routinely embedding optical fibre strain sensors into wind turbine blades to warn of overload conditions produced, for example, by ice build-up.

The optical sensing team in AIPT draws on expertise in the Institute on computer modelling in order to simulate device performance; they also work closely with the short-pulse laser micro-fabrication team to realise novel lab-on-a-fibre systems.



## People

### Permanent Staff

Prof. Lin Zhang, Dr. Kate Sugden, Prof. David Webb, Dr. Kaiming Zhou

### Research Fellows

Dr. David Saez-Rodriguez, Dr. Thomas Allsop, Dr. Mykhaylo Dubov, Dr. Wei Zhang, Dr. Chengbo Mou, Dr. Neil Gordon, Dr. Joel Villatoro, Dr. Stanislav Kolpakov, Dr. Zhijun Yan, Dr. Qizhen Sun, Dr. Binbin Lou, Dr. Kyriacos Kalli

### Graduate Students

Ms.. Ada Abang, Mr. Graham Lee, Mr. Zhongyuan Sun, Mr. Changle Wang, Mr. Xianchuang Wang, Mr. Marta Ferreira, Mr. Xuehau Hu



### Tilted grating spectrometer

AIPT has theoretically designed and experimentally demonstrated an advanced all-fibre polarisation interference filter formed by a polarisation-maintaining optical fibre cavity structure utilizing two 45° tilted fibre gratings inscribed by a UV laser. These filters can generate modulated transmission of a linear polarisation status. By changing the fibre cavity length, the free spectral range and modulation depth of the filter can be controlled. The filter exhibits a super-high and linear thermal tuning sensitivity of up to 0.6nm/°C, which is almost two orders of magnitude higher than that of normal fibre Bragg gratings. These all-fibre filters are ideal polarisation interference filters for laser and sensor systems enabling high efficiency spectral tuning from a low cost thermal technique.

Tilted fibre gratings have several other exciting applications. They render the fibre sensitive to twist, enabling rotation or torque to be measured. They can also be used to replace the diffraction grating in a spectrometer, allowing spectroscopic measurements of light guided in a fibre to be made using just the tilted grating, a cylindrical lens and a linear CCD array detector.



### TRIPOD

2013 saw the start of this 4-year international collaboration, coordinated by Prof. David Webb of the AIPT. Prof. David Webb has been instrumental in developing polymer optical fibre grating sensing technology and this project brings together international partners capable of covering all aspects of the sensor production process, from initial polymerisation to final sensor testing. The project aims to realise a mature sensing technology ripe for commercial exploitation, and includes partners who will develop novel applications for the devices as well as companies with specific requirements.

Integral to the project is the education of a cohort of high-quality PhD students recruited by the partners, through a series of network wide training events. These will cover both the science & technology underpinning the devices as well as a range of transferrable skills that will provide the PhD students with the best possible start to their careers, whether they be in either the academic or industrial sectors.

The full partners in TRIPOD are Aston University, BAM, the Cyprus University of Technology, the Technical University of Denmark, Ibsen Photonics, Medtronic, Carlos 3rd University Madrid, Marie Skłodowska-Curie University.



### The international dimension

International collaboration provides us with access to the best partners for interdisciplinary projects and also allows us to benchmark our own research to ensure it is of the highest quality. As part of this process, we are pleased to welcome a large number of both leading scientists and promising early stage researchers as visitors to AIPT. Visitors coming to work in the sensing area this year have included:

**Dr. Kyriacos Kalli** – Associate Prof. at the Cyprus University of Technology and an expert on fibre Bragg grating sensors and femto-second laser material processing. AIPT has had a long standing collaboration with Prof. Kalli's group, with whom we have collaborated on several Framework 7 projects.

**Dr. Binbin Lou** – from Chongqing University of Technology, currently working in AIPT on grating based biosensors. The application of photonics to biosensing and medical sensing is a booming research field offering exciting possibilities for improved healthcare.

**Mr. Xuehao Hu** – PhD student from the University of Mons who visited AIPT in October 2013 to learn how to fabricate Bragg gratings in polymer optical fibre. This visit has acted as the seed for a developing collaboration with Mons, which has already resulted in joint publications.



### SAFUEL

Changes to the flight regimes and even the construction of modern aircraft require a rethink of the fuel system to maintain and even enhance passenger safety. SAFUEL (The SAfer FUEL system) is a European Framework 7 project that aims to tackle this issue. AIPT's contribution is to develop novel sensors to quantify the presence of water in the fuel, which can exist either in the form of free water at the bottom of the fuel tank, or dissolved within the fuel.

Small quantities of free water are not of themselves a safety issue, however when the water freezes it can block fuel systems leading in exceptional circumstances to catastrophic failures. Free water also promotes the growth of biological contaminants, which can also block fuel pipes and filters.

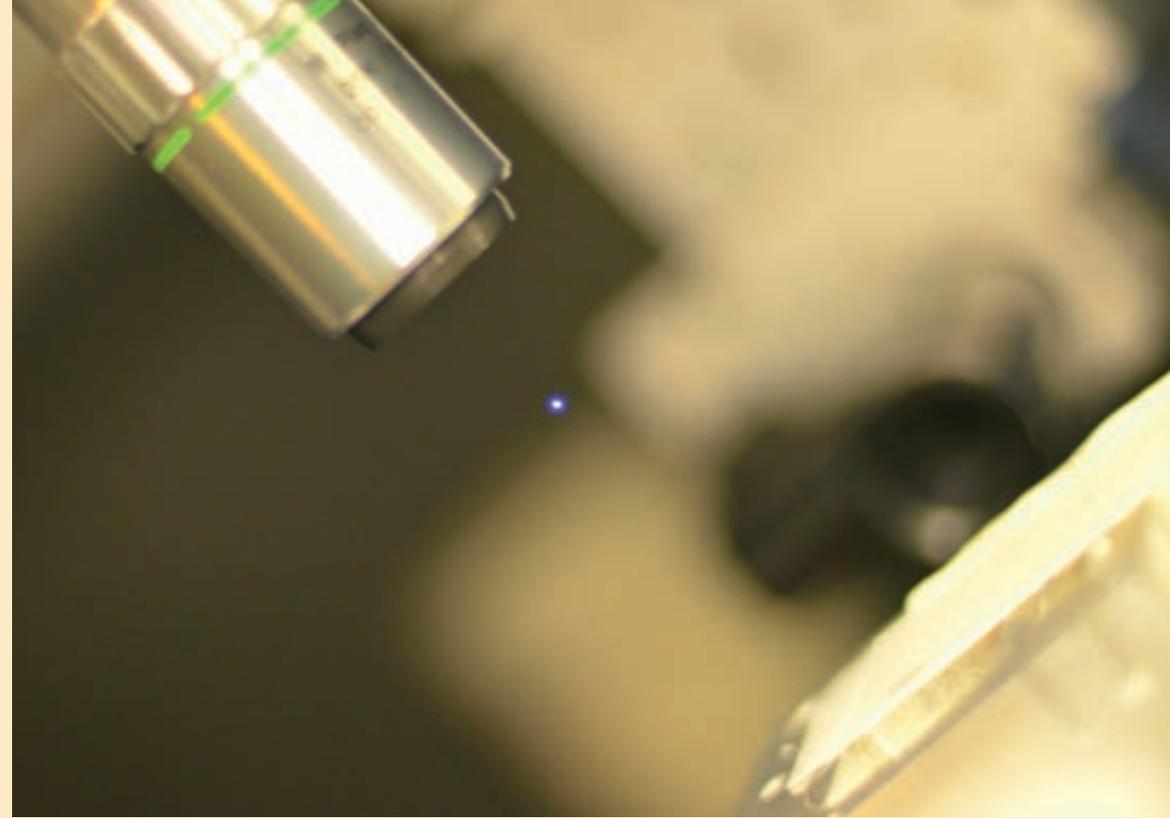
AIPT has developed a way of monitoring dissolved water by exploiting the water affinity of poly(methyl methacrylate) based optical fibres containing fibre Bragg grating sensors. These devices have turned out to be very sensitive, exhibiting wavelength shifts of over 1nm for changes in water content below 100 ppm. The level of free water at the bottom of the fuel tank can be monitored using long period grating sensors.

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## Research area

# Femtosecond Laser Technologies

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Whilst having relatively low average powers femtosecond lasers have exceptionally high peak powers in pulses that last only for tens to hundreds of femtoseconds. When focussed the high peak powers, with an energy density equivalent to that at the surface of the sun, enable materials to be modified at a fundamental level.

The AIPT has three femtosecond laser systems covering a range of repetition rates, peak pulse energies and wavelengths. The variety of systems allows us to work effectively in a number of different areas including the fabrication of fibre Bragg gratings (FBGs), micromachining of optical fibres, material processing of materials such as silica and metals, inscription of waveguide devices in planar material and fabrication of Optical Coherence Tomography (OCT) phantoms for calibration.

In comparison with UV writing method, the femtosecond laser inscription of FBGs has a number of advantages including: being material independent so can be used with non-photosensitive fibres such as those designed for fibre lasers, giving highly localisation of structures within the core resulting in vectorial sensitivity, and high thermal stability up to 800C.

Using an expose and etch process micro holes and slots can be fabricated within the fibre giving direct access to light confined in the core. The combination of inscription and micro-fabrication opens up exciting new design parameters for fibre devices.

The femtosecond lasers have also been used to fabricate structures on the end faces of fibre pigtails – creating two-dimensional diffraction patterns for use in sensing applications.

In planar devices optical waveguides can be inscribed in fused silica and extensive investigations have been undertaken to understand the optimum inscription parameters. Using high-resolution translational stages highly accurate three-dimensional structures can be made in bulk material. This work has been extended to include the inscription of micro-structured waveguides in lithium niobate crystals during collaborative work with researchers at Saratov State University.

As well as inscription and machining the femtosecond lasers can be also used to change the structure of material. Recent work has explored the highly localised transformation of bulk diamond to graphitic material. This leads to the potential fabrication of electronic devices buried within bulk diamond [1].

## People

### Academic Staff

Dr. Kate Sugden, Dr. Vladimir Mezentsev,

### Research Fellows

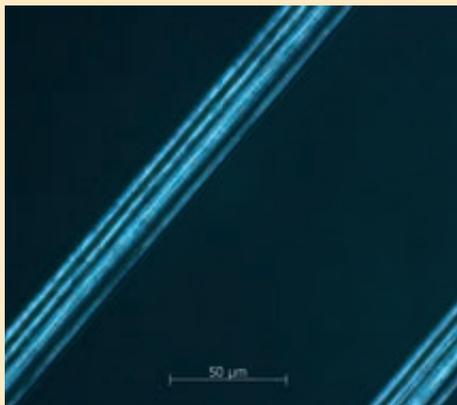
Dr. Mykhaylo Dubov, Dr. Kaiming Zhou,

### Research Students

Mr. Graham Lee

Collaborations: Saratov State University (Russia), INESC Porto (Portugal), Cyprus University of Technology (Cyprus), Institute of Semiconductor – Chinese Academy of Sciences (China), Fibre Optical Centre (Russia), Arden Photonics, Gadata, Kimal, MegiLED.

[1] S Su, J Li, G Lee, K Sugden, D J Webb, and H Ye, "Femtosecond laser-induced microstructures on diamond for microfluidic sensing devices applications", Applied Physics Letters, 2013, 102 (23)



### Direct inscription of lithium niobate

Experimental activity on direct femtosecond inscription in lithium niobate (LN) crystals has been conducted under the framework of Leverhulme Trust research grant RPG-278.

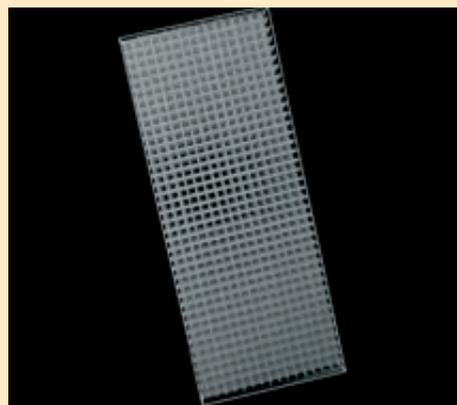
The work involved the mapping of the inscription parameters suitable for producing uniform waveguides in order to optimise transmission loss and refractive index contrast.

Extensive trials resulted in refractive index (RI) values up to ten times greater than achieved by other groups working in this area. Induced refractive index contrasts between the modified and intact volumes of lithium niobate up to -0.02 have been demonstrated.

This development has resulted in promising designs for low loss micro-structured waveguides operating at wavelengths up to 3.5 microns.

H Karakuzu, M Dubov, and S Boscolo, L A Melnikov, Y A Mazhirina "Control of the Properties of Micro-Structured Waveguides in Lithium Niobate Crystal," Mid-Infrared Coherent Sources (MICS) OSA Technical Digest (online), paper: JTh2A.22, 2013.

H Karakuzu, M Dubov, and S Boscolo, "Control of the properties of micro-structured waveguides in lithium niobate crystal." Opt Express, 2013. 21(14): p. 17122-30



### Commercialisation of OCT phantoms

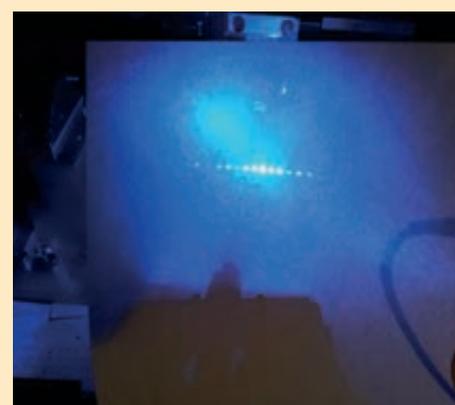
An agreement has recently been reached with Birmingham-based Arden Photonics, who are now selling OCT calibration phantoms designed and fabricated by researchers at Aston University.

OCT is a rapidly expanding measurement technique especially in the medical field with many applications including the measurement of eyes for clinical purposes.

One issue with this technique is the lack of available calibration sources allowing the user to quickly validate the performance of the system and ensure that it is still working optimally.

The development work carried out at Aston was in collaboration with the National Physics Laboratory. Three-dimensional calibration test phantoms were designed and fabricated as part of the project.

The phantoms being sold by Arden Photonics are fabricated in fused silica and can be used to measure sensitivity, distortion, spatial resolution, and the point spread function of a system.



### Phase mask fabrication and diffraction gratings

Femtosecond lasers can be used to directly inscribe phase masks in fused silica substrates, both on the surface and sub-surface.

This has some advantages over commercial masks in terms of cost and turn-around time. In addition, when the pattern is below the surface it becomes very robust.

To compensate for the size of the beam the masks generate second and third order Bragg gratings instead of a conventional first order Bragg gratings. This is not in itself a major drawback, but the effective laser induced "etch-depth" of the mask needs to be optimised with respect to the UV wavelength used for the Bragg grating inscription.

FBGs with reflectivity greater than 90% have been written in hydrogen loaded SMF28 with masks produced in this way.

Similar patterns can be inscribed on the end faces of fibre pigtailed – diffracting the light as it exits the fibre. Some of this work was carried out with funding for a short-term scientific mission from the COST Action TD1001: Novel and Reliable Optical Fibre Sensor Systems for Future Security and Safety Applications (OFSeSa).



### Femtosecond inscription in crystals for Mid-Infra-Red application

Interest in Mid Infra-Red (Mid-IR) photonics has exploded over the last decade. We have been working on experimental and numerical studies of femtosecond laser inscription and the characterisation of waveguiding structures in crystals for applications in this area.

Waveguides sculptured in bulk glass or crystal offer many advantages since such an approach allows the natural integration of multiple components within the same optical motherboard. Inscribed waveguide devices have been fabricated and characterised in  $\text{RbPb}_2\text{Cl}_5$  (RPC) and  $\beta\text{-BaB}_2\text{O}_4$  crystals.

This work has been performed in collaboration with Prof A. Okhrimchuk in the framework of the Leverhulme Professorship hosted by AIPT.

A.G. Okhrimchuk, S.G. Grechin, A.E. Kokh, V. Mezentsev, "Antisymmetric Distribution of Permanent Refractive Index Change in  $\beta\text{-BaB}_2\text{O}_4$  Crystal Under Exposure of Femtosecond Pulses", Progress on Ultrafast laser modifications of Materials, Cargèse, Corsica, France, 14-19 April 2013. Invited talk.

## Research area

# Fibre lasers

Lasers are engineering devices created at the interface of several research fields and technologies. This naturally makes them an interesting domain of interdisciplinary research and development. A great variety of lasers that cater to a range of applications in diverse areas of science and industry have been demonstrated already. Amongst them, fibre lasers form a booming field of research and technology. Employing advances in fibre-optic technology, fibre lasers present an alternative to existing solid state lasers, and sometimes even offer significant advantages over them in some applications.

Apart from their practical importance, fibre lasers represent a class of very interesting physical systems. Light propagating down the optical fibre is confined to the very small core of the fibre-optic waveguide. This increases the concentration of light energy to such an extent that it can interact with the fibre medium itself and change its optical properties. This change in the optical medium, in turn, affects the light propagation. Such a light matter interaction manifests itself in different forms – which have given rise to the field of nonlinear fibre optics. As optical fibres are inherently low loss, fibre lasers can be made to have large lengths, allowing the accumulation of the above mentioned nonlinear effects. The combination of such inherent nonlinear properties of an optical fibre and the light amplification (provided by gain fibres or through the Raman effect in a passive fibre) makes fibre lasers perfectly suited for studies of nonlinear processes. Fibre lasers

can have cavity lengths from a few centimetres to several hundred kilometres. For example, Aston University has developed the world's longest fibre laser, stretching to a length of 270 kilometres! Interestingly, such ultra-long lasers can be used both as a light source, and as a new and unique type of transmission medium. The AIPT has a well-established track record in many optical fibre related research areas. It is now in a leading position in novel optical fibre laser technology and applications, thanks to its recent research advances in the understanding of nonlinear effects, use of fibre based polarisation devices and incorporation of nano-materials in the fibre cavity.

## People

### Academic staff

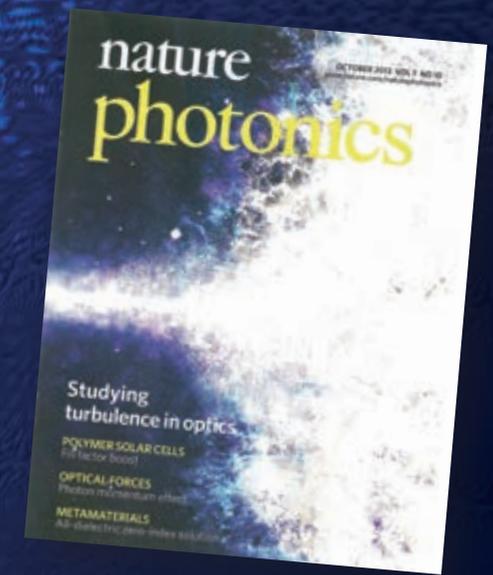
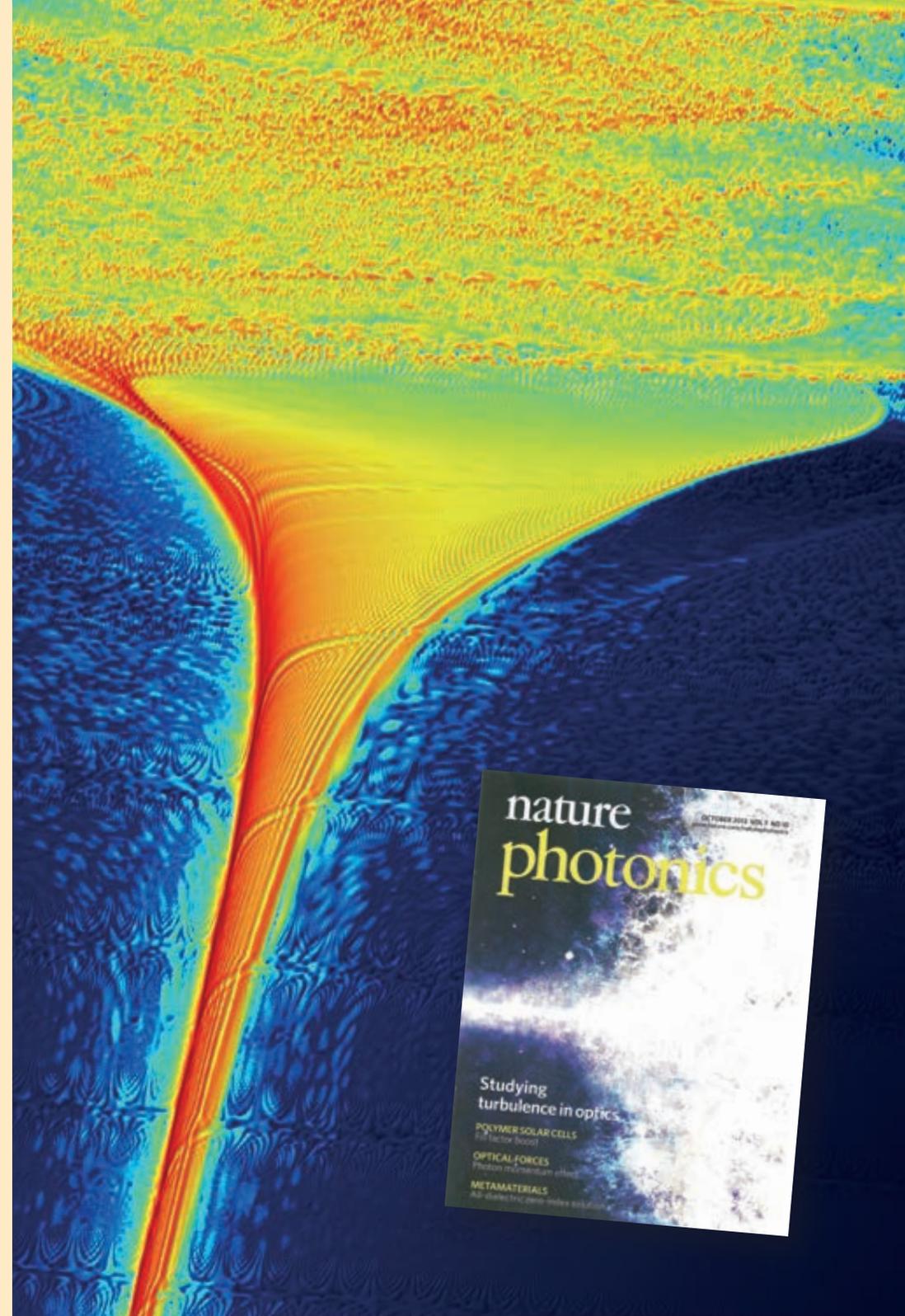
Prof. Sergei Turitsyn, Prof. Lin Zhang, Dr. Sonia Boscolo, Dr. Paul Harper, Dr. Alex Rozhin, Dr. Xuwen Shu, Dr. Elena Turitsyna, Dr. Kaiming Zhou.

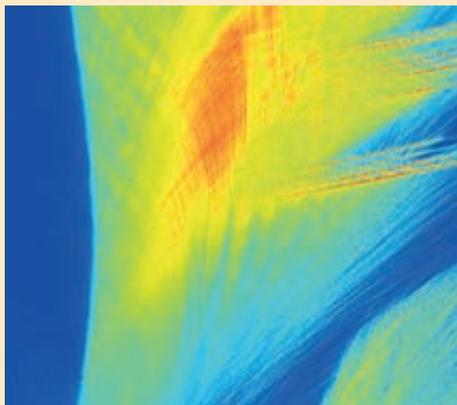
### Research fellows

Dr. Dmitry Churkin, Dr. Tatiana Habruseva, Dr. Jianfeng Li, Dr. Stanislav Kolpakov, Dr. Chengbo Mou, Dr. Sergei Sergeev, Dr. Atalla El-TaHER, Dr. Zuxing Zhang, Dr. Zhijun Yan

### Research Students

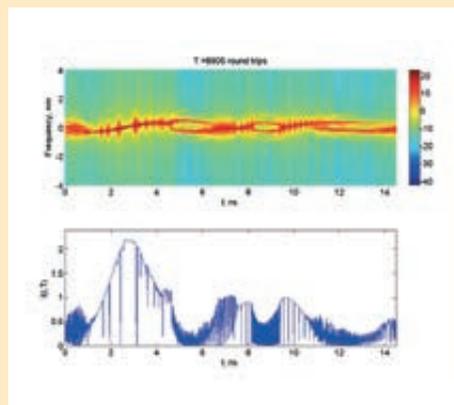
Mrs. Raz Arif, Mr. Srikanth Sugavanam, Mr. Nikita Tarasov,





### Real-time measurements of intensity spatio-temporal dynamics

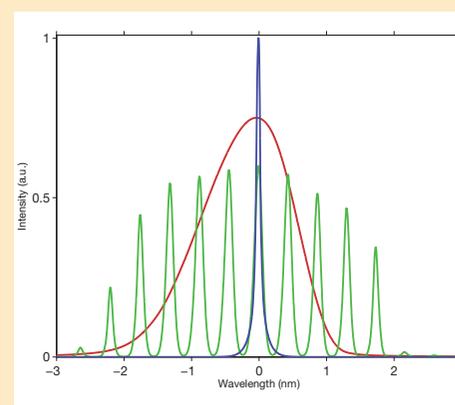
Laser dynamics are usually interpreted by measuring its output intensity as a function of time. In a laser, the light is trapped in the cavity, making round trips as it bounces back and forth between the mirrors. We developed in AIPT a real-time measurement technique which uses this internal periodicity of radiation in the laser cavity to reveal two-dimensional spatio-temporal intensity patterns (over fast time and slow evolution time) instead of usual one-dimensional intensity dynamics. In experiments carried out at AIPT, dark and grey solitons of picosecond-order temporal width were found in radiation emitted by different lasers. In addition, bright coherent structures were also revealed in the radiation previously thought to be completely stochastic. The developed technique allows for the precise characterization of laser dynamics on different scales and can potentially reveal mechanism of pulse formation and destruction, rogue wave formation and other interesting manifestations of nonlinear interactions in a laser cavity.



### Laminar-turbulent transition in a fibre laser

Studying transition to a highly disordered state of turbulence from a linearly stable coherent laminar state is conceptually and technically challenging and immensely important, e.g. all pipe and channel flows are of that type. In optics, understanding how systems lose coherence with increase of spatial size or excitation level is an open fundamental problem of practical importance. We identified, arguably, the simplest system where this classical problem can be studied: we learnt to operate a fibre laser in laminar and turbulent regimes. We showed that laminar phase is an analogue of a one-dimensional coherent condensate, and turbulence onset appears through a spatial loss of coherence. We discovered a new mechanism of laminar-turbulent transition in laser operation: condensate destruction by the clustering of dark/grey solutions.

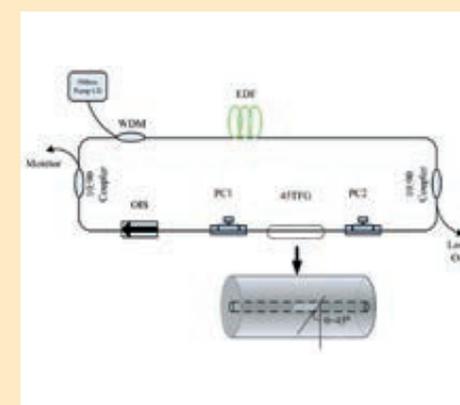
*E. G. Turitsyna, S. V. Smirnov, S. Sugavanam, N. Tarasov, X. Shu, S. A. Babin, E. V. Podivilov, D. V. Churkin, G. Falkovich & S. K. Turitsyn, "The laminar-turbulent transition in a fibre laser", Nature Photonics, 7, 783-786, (2013)*



### Femtosecond mode locked fibre lasers

Ultrashort pulse fibre lasers play an important role in the modern research and industrial applications, ranging from telecom and metrology to biological/chemical applications and machining. Typical pulse widths can range from anywhere between a few nanoseconds, to hundreds of femtoseconds. There are various ways by which ultrashort pulsing can be achieved, each with its own merits and limitations. At AIPT, we use 45-degree tilted fibre Bragg gratings (TFBGs) in our lasers to realize sub-picosecond pulses. The 45-degree TFBG is essentially an all-fiber polarizer operating on the 'pile of plates' principle. Being of an all-fiber nature, it has very low insertion losses – much less than bulk polarizers. Furthermore, TFBGs can withstand high powers and temperatures – a property that is very conducive towards high power laser applications where very few alternatives for mode-locking exist. Very recently, our group demonstrated a sub-100 femtosecond mode locked fiber laser based on this grating technology. Our all-fiber approach to laser design strives to meet the high demands of stability and repeatability placed by real-world applications.

*Z. Zhang, C. Mou, Z. Yan, K. Zhou, L. Zhang, and S. K. Turitsyn, Sub-100 fs mode-locked erbium-doped fiber laser using a 45-degree tilted fiber grating, Opt. Express 21, 28297-28303 (2013)*



### Spectral tailoring of random fibre lasers

The random distributed feedback fibre laser was first demonstrated at the AIPT in 2010. Instead of point reflectors as in conventional fibre lasers, random fibre lasers employ distributed Raman amplification to amplify Rayleigh backscattering events occurring along the length of the fiber. Remarkably, this generates the necessary feedback to sustain lasing. This unique characteristic gives the laser many interesting properties, making it an attractive proposition for real world applications. Spectral tailoring of the radiation of random fibre lasers is a highly desirable property, and is being actively studied presently at the AIPT. With the use of filtering elements, sub-nanometer line-widths can be routinely obtained in the random lasing configuration. Further, by the use of fibre based polarisation devices, multiwavelength generation in the system can also be obtained in a quite straightforward manner. Apart from the motivation to find real world applications, the random fiber laser provides a unique laboratory for the study stochastic nonlinear dynamics – a nascent area which holds a lot of potential.

*S. Sugavanam, N. Tarasov, X. Shu, and D. Churkin, "Narrow-band generation in random distributed feedback fibre laser," Opt. Express 21, 16466-16472 (2013)., Opt. Express 21, 16466 (2013)*

## Research area

# Biophotonics

AIPT has extended its research areas into the multi-disciplinary field of Biophotonics, particularly by exploiting optical fibre grating sensors and nano-materials. Optical fibre gratings can be configured to sense strain, bending, pressure, temperature and refractive index, which allows their use in a wide range of medical, food and environmental applications:

- ▶ We have used long period and Bragg grating bend sensors to construct a vest capable of monitoring the recruitment of various muscle groups to the breathing process.
- ▶ Long period grating sensors can also be used to monitor the blood pulsations associated with cardiac activity.
- ▶ Multiplexed Bragg grating sensors can be used to monitor temperature profiles and we were the first group to demonstrate this in-vivo.
- ▶ We were the first to demonstrate that fibre Bragg gratings can be used to detect the MHz frequency strains associated with medical ultrasound.
- ▶ We have shown that the combination of refractive index sensitivity with a smart fibre coating can permit label-free detection of specific biochemical species and DNA.
- ▶ Femtosecond laser micromachining and inscription technology developed in the group is being combined with grating based sensors to produce micro-fluidic lab-on-a-chip devices.
- ▶ Current funded projects:
  - ▶ EPSRC – Grating and Waveguide Plasmonic Sensors, Prof. DJ Webb, Dr. V Mezentsev, Dr. T Allsop, 2012-2015, £512k
  - ▶ TSB (33822-241174), Nutrition for Life CRD – Providing Safe and Healthy Foods, project title – “Distributed UV and Near Infra-red and Fluorescence

sensing system for real time monitoring of food quality and contamination and process control”, Prof. Lin Zhang, Dr. Kaiming Zhou, 2/2014-1/2016, Total fund £600,000 (£184,000 to AIPT).

### AIPT members working on Biophotonics projects

#### Academic Staff

- ▶ Prof. Lin Zhang
- ▶ Prof. David Webb
- ▶ Dr. Alex Rozhin

#### Research Fellows

- ▶ Dr. Kaiming Zhou
- ▶ Dr. Mykhaylo Dubov
- ▶ Dr. Tom Allsop
- ▶ Dr. Zhijun Yan
- ▶ Dr. Ranjeet Bhamber
- ▶ Dr. Sergey Kulinich

#### Research Students

Mr. Athanasios Manolis

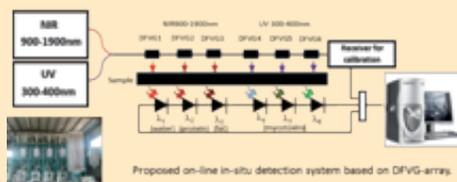
Mr. Zhongyuan Sun

#### International Collaboration

Optical fibre cardiorespiratory sensing—a commercialisation activity in collaboration with Prof. Ljupco Hadzievski, Vinca Institute, Serbia and DIASENS, also of Serbia.

Biofunctionalisation of Nanovaterials with Mr. Didier Alléar Diagenode Sa (Liege, Belgium).

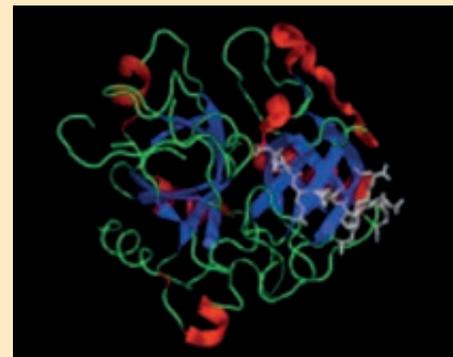




### Respiratory monitoring

Current technology for monitoring respiration usually involves the use of a spirometer – a tube held in the mouth, which monitors air flow using a small impeller. This approach is not appropriate for long term ambulatory monitoring, or use with uncooperative patients, such as children.

Engineers within AIPT have been developing monitoring systems based on arrays of optical fibre bend sensors that can monitor in real time the changes in the shape – and hence the volume – of the chest and abdomen. Two kinds of sensors have been investigated: long period gratings, which are directly sensitive to bending, and fibre Bragg gratings, which are easier to interrogate but which must be specially configured as bend sensors. The system itself takes the form of a close fitting vest that is comfortable to wear and of course requires no apparatus around the face of the patient. In addition to providing information on the total flow of air in and out of the lungs, the system can also monitor the recruitment of different muscle groups to the breathing process, which it is hoped will assist with the diagnosis of respiratory problems. The technology is patent protected and currently being commercialised with international partners.



### Plasmonic biosensors

Surface plasmon polaritons are waves involving the coupling of an electromagnetic field with free electrons in a thin metallic layer deposited on a dielectric. In our laboratories we generate these waves on the metallised surface of fibre or planar waveguides using fibre gratings inscribed within the waveguide to couple energy from the guided light. This process is extremely sensitive to the refractive index closely surrounding the metal film.

To sense specific biochemical species, it is necessary to have a coating on the device that binds to the target species resulting in a change in refractive index. We are collaborating with the University of Florence to develop aptamer based molecular recognition for these sensors. Aptamers take the form of oligonucleic acid or peptide molecules that will bind to a specific molecule or group of molecules. Unlike the more conventional antibody-antigen reaction often used for biosensing, aptamers can be assembled in vitro – it is not necessary that they already exist in nature – and so can be designed to target a huge range of species, from simple molecules up to large structures.

We have demonstrated this approach by detecting human thrombin, an enzyme key to the blood clotting process.



### FP7 Marie Curie Project

Dr. Alex Rozhin (Nanotechnology Research Group and AIPT) and Dr. Sergei Kulinich (Tokai University, Japan) have been awarded €380,000 M Curie IIF project on “Nanomaterial Photonic Sensors for Food Manufacturing”. The project is carried out in collaboration with the University of Lincoln (UK) and Diagenode Sa (Belgium). The ultimate goal of the project is to develop of new nanomaterials specifically applicable in novel macro-bacterial sensors for food manufacturing and processing industry.

The overall objective of this research is to develop the synthesis of ZnO, ZnS and PbS nanostructures with different sizes and morphologies via the laser ablation, then to modify and functionalize the surfaces nanostructures and finally to implement them as photonic sensors with bacteria-detecting properties, potentially for efficient and easy-to-use in food processing, weighing and packaging lines.

This ambitious research programme has a strong interdisciplinary nature combining materials engineering, surface science, bio-engineering, physics, chemistry and soft matter science. The project will have a positive impact on a longer shelf-life of ready food, monitoring of food manufacturing lines, and optimization of cleaning routine during food manufacturing and packaging.

### TSB project for food industry

Prof. Lin Zhang and Dr. Kaiming Zhou of AIPT have been awarded £184,000 to a £600,000 TSB project with three UK companies – Branscan, Arden Photonics and Warburtons Bakery – to develop a near Infra-Red (NIR) multi-point sensing system for process control in food and polymer processing industries. The currently available technology used in NIR spectroscopy is based on photodiode arrays, which are expensive, bulky and have slow response. This TSB project will develop multi-point (wavelength) spectroscopies for fast, low cost and portable operation by using a number of diffractive fibre volume gratings (DFVGs) as probes to detect the fluorescence and absorption lines associated with mycotoxins and the moisture level, protein and fat in NIR region in flour production line. AIPT has developed a range of devices and applications with DFVGs as the core technology, offering advantages:

- ▶ No mechanical moving part, all optical elements mounted on a substrate, decreasing noise from mechanical vibration.
- ▶ Flexible design for sensor position along the flour production line.
- ▶ Light streamed from one module to the next, giving flexibility for a number of monitoring of different absorption/fluorescence peaks.
- ▶ Using low cost light source.
- ▶ Using low cost photo-detectors.

# Nanomaterials Photonics

AIPT's Nanomaterials Photonics Group focuses on development of functional carbon nanomaterials with strong optical properties for ultra-short pulse lasers and sensor applications. We operate:

- ▶ Clean Room facilities for nanomaterials processing and functionalization
- ▶ Auto-drop platform for nanomaterials ink-jet printing
- ▶ Advanced optical spectroscopy laboratory for characterisation of nanomaterials optical properties from UV to mid IR spectral range
- ▶ Fibre laser laboratory for development of mode-locked fibre lasers

Our recent results include:

- ▶ First identification of the carbon nanotube (CNT) 'salting-out' effect in organic solvents.
- ▶ Development of polymethine-dye fluorescent probe for rapid recognition of CNTs.
- ▶ First experimental demonstration in laser physics of spiral attractors, achieved in fibre lasers mode-locked by CNT.
- ▶ High power generation of sub-ps pulses in Tm doped fibre laser with CNT mode locker.

Current funded projects:

- ▶ EU project TeLaSens (269271) FP7 Marie Currie International Research Staff exchange Scheme Project (IRSES) – Carbon Nanotubes Technologies in Pulsed Fibre Lasers for Telecom and Sensing Applications”, Dr. A. Rozhin, Dr. C Mou, Dr. M Dubov, Mrs. R Arif, 2011-2015, Total fund €270,000 (€130,000 to AIPT).
- ▶ NATO – Science for Peace and Security Project (SPS# 984189)- Novel Macromolecular Complexes for Rapid Detection of Hazardous Agents. Dr. A Rozhin, Dr. M Dubov, Mrs. R Arif, 2012-2014, Total fund €220,000 (€40,000 to AIPT).
- ▶ The British Council – Researcher Links 2013 project “New Advanced Materials for Photonics and Sensors”. Dr. A Rozhin, 2013-2014, Total fund £25,000
- ▶ EU project Marie Curie International Incoming Fellowship (FP7-PEOPLE-2012-IIF, Proposal number: 330516) “Nanomaterial Photonic Sensors for Food Manufacturing”, Dr. A Rozhin, Dr. S Kulinich, 2013-2015, Total fund €309,235

## AIPT members working on Nanomaterials Photonics projects

### Academic Staff

Dr. Alex Rozhin

### Research Fellows

Dr. Sergey Kulinich, Dr. Mykhaylo Dubov, Dr. Chengbo Mou

### Research Students

Mrs. Raz Arif, Mr. Athanasios Manolis

### International Collaboration

Advanced Fibre lasers –  
Dr. S Kobtsev, Novosibirsk State University (Russia)

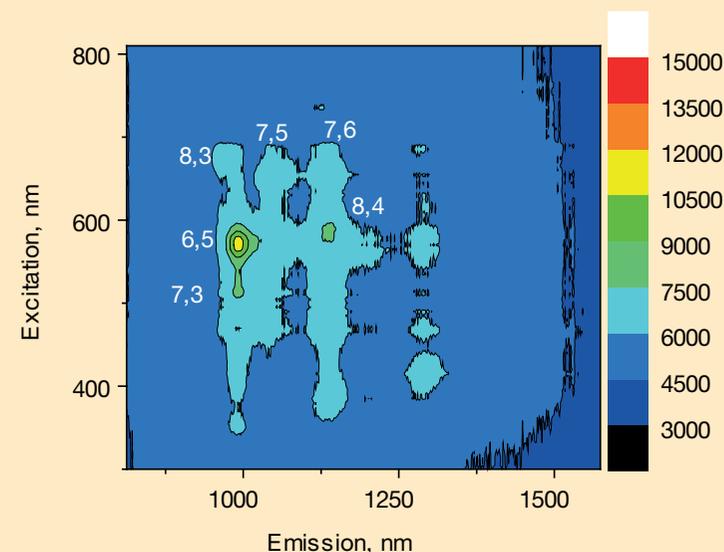
Novel Optical Fibre – Prof. E Dianov, Fibre Optic Research Centre (Moscow, Russia)

Spectroscopy of Carbon Nanomaterials – Dr. I Yanchuk, Institute for Semiconductors Physics (Kiev, Ukraine)

Biofunctionalisation of Nanomaterials – Mr. Didier Allear Diagenode Sa (Liege, Belgium)

Spectroscopy of Organic Molecules-  
Dr. A Verbitsky, Institutes of Physics (Kiev, Ukraine)

Fluorescence probes –  
Dr. M Shanduara, Institute of Organic Chemistry NAS Ukraine – (Kiev, Ukraine)



## Functionalisation of Carbon Nanomaterials

As grown nanomaterials typically have a wide distribution in size, surface and conductive properties. They also tend to form aggregates and show a relatively poor stability in liquid media. Nanomaterials photonics group is working toward development of stable dispersion of the prepared nanomaterials in aqueous and organic solvents via non-covalent approach, which typically does not affect their optical properties. We use different surfactants or polymers to create the non-covalent forces, including electrostatic interaction, hydrogen bonding and hydrophobic interaction. This stabilizes individual nanoparticles, at the same time inhibiting their agglomeration in liquids. Then, we sort the nanomaterials by their diameters, using density gradient centrifugation technique. The resulting dispersion is applicable for photonic nano-composites preparation or as a nano-ink for deposition on the optical parts with advanced auto-drop (Microdrop Technologies GmbH) ink-jet printing platform.

The following applications designed and developed with functionalise nanomaterials in our group:

- ▶ Polymer and microchannel saturable absorbers for mode-locked fibre laser generating between 1000 and 1900 nm.
- ▶ Functional carbon nanomaterials coatings for plasmonic gas sensors.

## NATO SPS project “Novel Macromolecular Complexes for Rapid Detection of Hazardous Agents”

This project addresses the problem of rapid portable sensors for the detection of dangerous environment pollutants. In the frame of the project we develop a sensor system for the spectroscopic detection of three major types of the pollutants:

- ▶ Ammonia, aliphatic primary and secondary amines.
- ▶ Heavy metals (mercury, lead, zinc, cadmium).
- ▶ Hydrogen sulphide and mercaptanes.
- ▶ Carbon nanotubes, which are toxic, and will be potential industrial pollutant in the near future.

The optical spectroscopy methods have been proved as sensitive tools for such detection. However the selectivity and sensitivity of such techniques require a further improvement. Here, we develop new detection method combining the chemical synthesis of sensor/probe molecules, development of optical spectroscopy techniques for their detection and finally fabrication the sensor device by using novel photonics micro-fabrication tools.

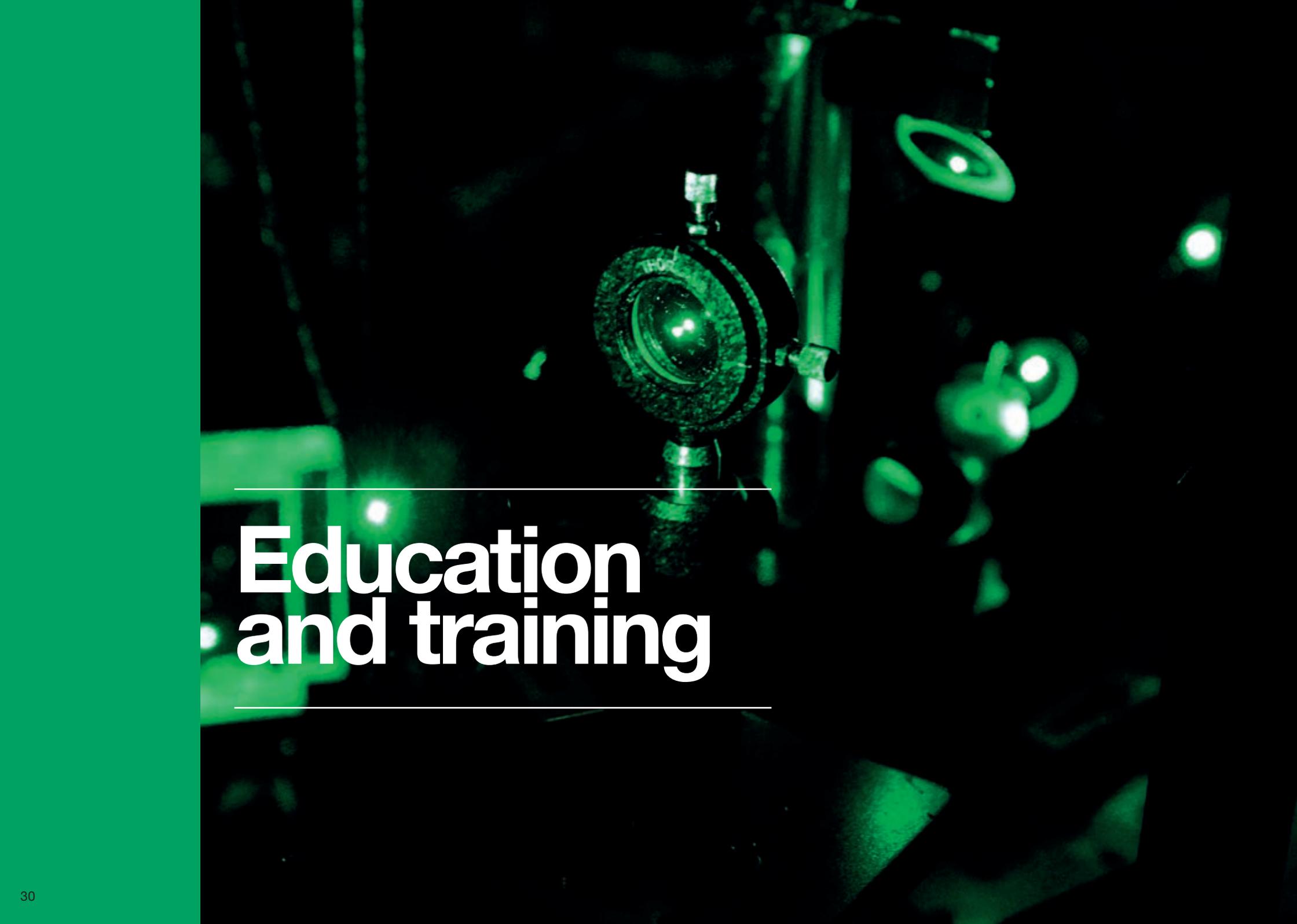
## FP7 IRSES project “Carbon Nanotubes Technologies in Pulsed Fibre Lasers for Telecom and Sensing Applications”

We work on development of CNT and Graphene composites for creation of novel fibre/waveguide lasers with emission in the broad spectral range covering telecom and sensor applications. Compact mode-locked fibre lasers will be key components for highly sensitive optical techniques in greenhouse gas monitoring, bio-medical sensing.

The overall research objectives for the TeLaSens project are:

- ▶ Optimization of Carbon NanoTube (CNT) saturable absorber device using theoretical modelling and experimental physical-chemistry methods.
- ▶ Design and development of new CNT based saturable absorber devices and comparison of them to the Semiconductor Saturable Absorption Mirrors (SESAMs).
- ▶ Design and development of new fibres for laser sources.
- ▶ Design and theoretical modelling of new laser cavities.
- ▶ Fabrication and testing of new ultra-short pulse lasers.
- ▶ Development of laser based sensor systems.

We have recently demonstrated both advanced saturable absorption devices made of CNT and graphene, Yt, Er and Tm doped mode-locked fibre lasers with sub-ps pulse generation regimes.



# Education and training

# Research Training

The AIPT provides a range of events and training opportunities throughout each year for students and staff members. In 2013, a diverse array of seminars given by the world leading experts in photonics took place as well as two sizable conferences organised by the AIPT students. We aim to establish within the Aston Postgraduate School a coherent educational program – Aston Postgraduate School in Photonics linking MAPNET Erasmus Mundus MSc courses and lectures for all postgraduate students.

# Student Opportunities and Events

The AIPT hosted its first student conference titled '*Photonics as an enabling technology – scientific perspectives, industrial applications*' at Aston University, from the 4th to the 6th of September 2013. This event was organized by three of its PhD students Miss. Ada Abang, Mr. Adenowo Gbadebo, and Mr. Srikanth Sugavanam, in co-ordination with PhD student Miss. Felicity McGrath of Imperial College, London. The event was supported by the AIPT, professional societies SPIE and OSA, and also by Aston University spin-off Astasense Limited. The aim of the conference was to highlight the powerful enabling role that photonics plays in today's technological arena, and the entrepreneurial opportunities that it presents.

The three day event was attended by over fifty doctoral students and post-doctoral researchers from universities all over the UK and companies in the photonics industry. The panel of speakers included both active researchers in the field, and also industry representatives. The talks were equally divided between discourses on state of the art, industry prospects and general guidance to aspiring scientists building a career towards full-time research. The session was formally opened by Prof. David Webb of Aston University, who highlighted the research activities carried out at the AIPT. Prof. John Dudley of the University of Franche-Comte, France, talked about the exciting field of nonlinear fibre optics, and how it is paving the way to revealing new physics. In a separate talk, he also shared his collective experience in the world of scientific research, and advised students on how to make the most of available resources and opportunities.

Along similar lines, Prof. Andrew Ellis talked about the trials and tribulations of research in a competitive field like telecommunications. A glimpse of state of the art in the area of infrared nanophotonics was given by Dr. Alfredo De

Rossi from Thales Research. Prof. Henry Kapteyn of the University of Colorado gave a very interesting talk on table-top X-ray lasers. For aspiring academics, Dr. Tatiana Habruseva gave a very informative presentation about funding opportunities available for early career researchers. The role of photonics in biomedicine was highlighted by Dr. Annamaria Cucinotta of the University of Parma, who talked about biomedical applications of microstructured optical fibres. From the viewpoint of industry, Dr. Graeme Malcolm, CEO of M-squared lasers emphasized the need for advances in photonics technology in application areas like energy and healthcare, while Dr. Loyd McKnight talked about the activities of the premier research institute Fraunhofer in the UK, which is known for its strong ties with industrial research and development.

Audience participation was encouraged, and to this end oral and poster presentation sessions were organized. The emphasis was on communication of ideas to a diverse scientific audience. Mr. Robert Woodward of Imperial College won the best oral presentation, and Mr. Samuel Bateman of the University of Bath won the award for the best poster. Conference proceedings also included an exhibition of research T&M equipment from leading companies, where the delegates directly interacted with industry representatives to find custom solutions for their projects. Social events of the conference included a dinner session for the delegates at the ICC Birmingham and a trip to Sir Isaac Newton's Woolsthorpe Manor near Grantham, Leicester.

**Ms. Abang**, president of the SPIE chapter of the AIPT – “The event was indeed a success as all the participants were really impressed with the level of planning and organisation in all aspects of the conference and were looking forward to coming around again for many of such events. We hope that we will be able to deliver a better conference in subsequent years to come by learning from the mistakes made and improving on the level of organisation carried out at our first conference”.

**Mr. Adenowo Gbadebo**, “Organising the eventing was very interesting and engaging, a lot of lessons were learnt. It was great to see our efforts come together at the end of it all to bring the idea of a student focused industrial conference to life. The positive feedback from all the attendees' exhibitors, speakers and students alike was absolutely encouraging. It makes organising another conference in the not too far future a good idea.”

**SPIE**  
Student Chapter  
Aston Institute of Photonic  
Technologies



# AIPT PhD Student Conference 2013



## Best oral presentation:

**Name: Ms. Jiangling Li**

**Title of presentation:** Polyacrylonitrile derived carbon fibres – Femtosecond laser patterning

**Abstract:** A preliminary study on the fabrication of carbon fibre micropatterns on Si substrate by using direct writing technique, femtosecond laser has been conducted. By varying processing parameters of femtosecond laser, various micropatterns with different shape and depth were achieved. The findings of this work evidenced that the simplicity and flexibility of femtosecond-laser technique, which shows a vast potential on the fabrication of carbon fibre micropatterns for MEMS applications.

## Runner-up:

**Name: Mr. Simon Fabbri**

**Title of presentation:** Electrical harmonics generation for highly efficient optical comb source

**Abstract:** We present a novel optical comb generation technique based on the use of a multi-harmonic electrical signal for driving the Mach-Zehnder modulator. The proposed scheme is highly power efficient and gives rise to square shaped combs of advanced flatness and side mode suppression ratio.

## Best poster presentation:

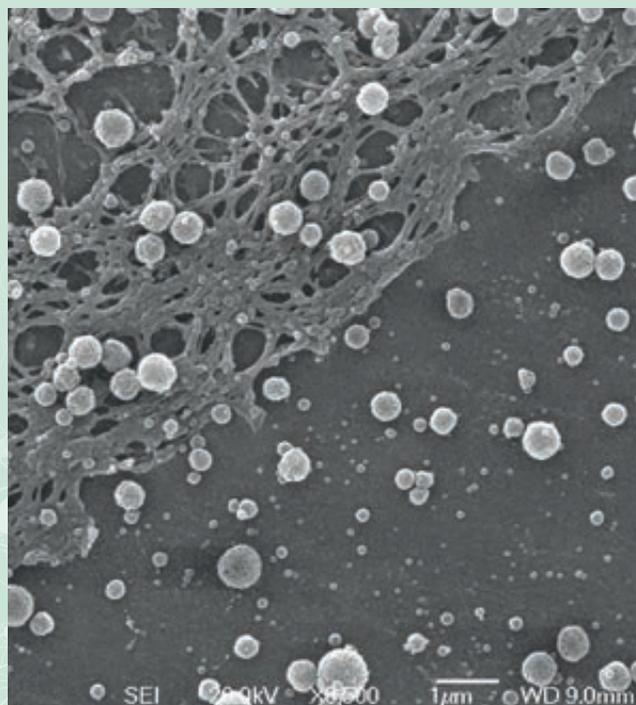
**Name: Ms. Raz Arif**

**Title of presentation:** Exfoliation of Graphene in Organic Solvent

**Abstract:** Graphene is a two dimension carbon allotrope with extreme mechanical strength, high electronic and thermal conductivities, and unique optical transparency in the broad spectral range, etc. All these properties can potentially lead to a number of exciting applications in polymer composites, plastic electronics, photonics, etc. Despite of recent progress in mechanical, thermal and chemical production of graphene, there is a huge need in simple and reliable graphene synthesis techniques.

Here we report a simple method of graphene production in the organic solvent N-Methyl-2-Pyrrolidone (NMP). We exfoliated pyrolytic graphite by using strong ultrasonication between 30 min and 6 hours in the pure NMP solution or in the NMP solution with the presence of PolyVinylPyrrolidone (PVP) polymer. Next, the solution subjected ultracentrifugation in order to achieve a mass separation of graphene in the colloidal solution. We study the resulting samples by using microscopic Raman spectroscopy with Ar<sup>+</sup> excitation laser at 514.5 nm. The analysis of intensity and frequencies of D, G and 2D peaks of Raman spectra at 1350, 1580 and 2700 cm<sup>-1</sup> respectively shows the presence of significant fraction of multi-layered graphene.

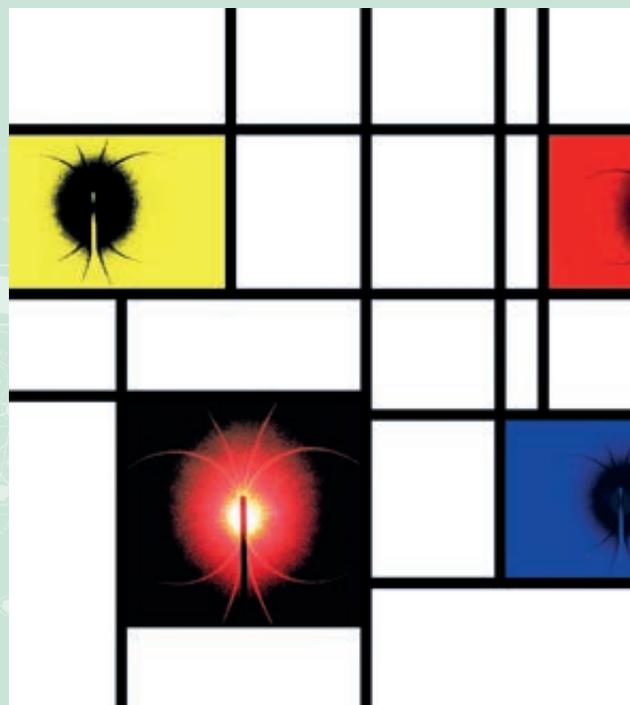
# AIPT Photo Competition 2013



## Winner for best photo:

**Name:** Ms. Jiangling Li

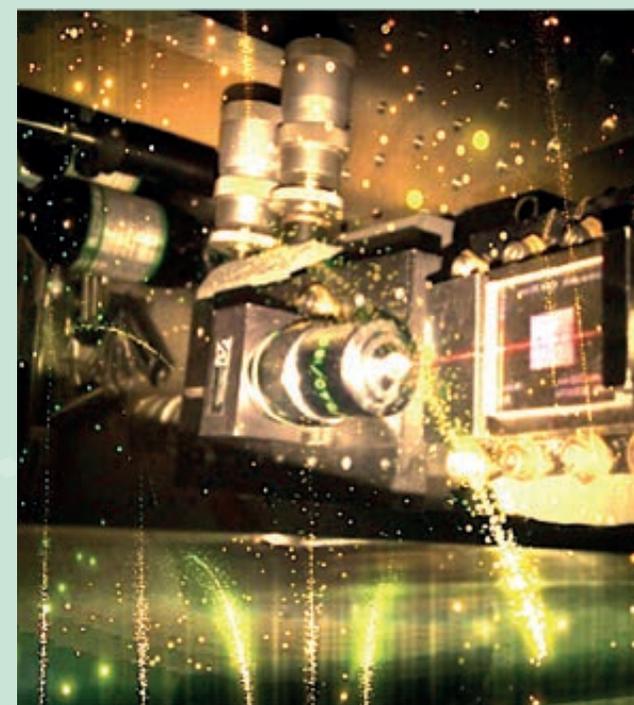
**Title:** Mini Meat Balls on Fused Spaghettis



## Runners-up:

**Name:** Prof. David Webb

**Title:** False colour images of laser light scattering from noise gratings recorded in poly(methyl methacrylate), in the style of Piet Mondrian



**Name:** Ms. Ada Abang

**Title:** Polymer fibre FBG Fabrication process

## AIPT Seminar Programme

Name	Affiliation	Title	Date of Event
Dr. Jize Yan	Dr. Jize Yan Centre for Smart Infrastructure and Construction, University of Cambridge, UK	Nanophotonics of optical fibres	November, 2013
Prof. Claudio Conti	Department of Physics, University Sapienza, Rome, Italy	Experiments on various random lasers	November, 2013
Dr. Vitaly Mikhailov	OFS Labs, Somerset, New-Jersey,USA	In-line high speed polarimeter and it's application in 100G+transmission system	October, 2013
Dr. Alexander Turchin	Institute of Physics, National Academy of Sciences, Kiev, Ukraine	Single-shot scattering interferometry – a tool for permittivity 3D reconstruction	October, 2013
Prof. Robin Kaiser	University of Nice Sophia Antipolis, Nice, France	A cold-atom random laser	October, 2013
Prof. Dan Marom	Applied Physics Department, Hebrew University, Jerusalem, Israel	Switching and manipulating spectrally dispersed light in current and future telecom scenarios	September, 2013
Mr. Michael Roelens	Finisar Corporation, Australia	Introduction and tutorial on the operation of the Wavelength Selective Switch	September, 2013
Prof. Tingyan Wang	Laboratory of specialty fiber optics and optical access networks, Shanghai University, China	Special optical fiber sensors	August, 2013
Prof. Michael Sumetsky	OFS Laboratories, USA	Surface nanoscale Axial Photonics (SNAP)	July, 2013
Prof. Alexander Marchenko	Institute of Physics, National Academy of Sciences, Kiev, Ukraine	Scanning tunneling microscopy of ultrathin organic films: fundamental aspects and application	July, 2013
Prof. Andrea Fratalocchi	King Abdullah University of Science and Technology (KAUST) , Thuwal, , Saudi Arabia	A brief lecture on complexity-driven Photonics: from chaotic energy harvesting to many-body solitons and light condensation effects	July, 2013
Prof. Dmitry Turaev	Imperial College London, UK	Fermi acceleration in time-dependent billiards	June, 2013
Prof. Sahar Al-Malaika	Chemical Engineering and Applied Chemistry, SEAS, Aston University, UK	Overview of the Research Activity of the Polymer Processing and Performance Research Unit	June, 2013
Prof. Alexander Rubenchik	Lawrence Livermore National Lab ,Livermore ,USA	The laser material processing. Beyond welding and cutting	June, 2013
Dr. Alfredo de Rossi	Thales Research and Technology Group, France	Nonlinear photonic crystal waveguides and all-optical signal processing	May, 2013
Dr. Xin Yang	Optoelectronics Research Centre, University of Southampton, UK	Pulse-Shaping assisted nonlinear optical signal generation in fibers	April, 2013
Prof. John Arkwright	CSIRO Materials Science and Engineering, Lindfield, Sydney, Australia	From Cables to Colons – A journey for fibre Bragg grating technology into the "Dark continent" of the human digestive track	April, 2013
Prof. Kestutis Staliunas	Universitat Politecnica de Catalunya, Barselona	Faraday patterns in optical fibers	March, 2013
Dr. Arkadi Chipouline	Institute of Applied Physics, Friedrich Schiller University Jena, Germany	Qualitative models in nanophotonics: scientific and educational aspects	February,2013
Dr. Kamal Hammani,	University of Burgundy, Dijon (France)	Rogue waves and extremes statistics in fibered optical systems	December 2013

# Student Research Areas and Projects

## PhD Students

Name	AIPT Supervisor	Thesis topic / Research Area
Ms. Ada Abang	Prof. David Webb	Development of polymer fibre sensors
Mr. Adedotum Adebayo	Prof. Lin Zhang	Novel Grating Structure in Fibre and their Application
Mrs. Raz Arif	Dr. Alex Rozhin	Optical properties of nanomaterials and their photonic applications
Mr. Simon Fabbri	Prof. Andrew Ellis	Optical Communication
Mr. Adenowo Gbadebo	Prof. Sergei Turitsyn	Fibre Bragg grating fabrication
Mr. Alexey Ivanenko	Prof. Sergei Turitsyn	Ultra-Long Mode-Locked Er-Doped Fibre Lasers
Mr. Huseyin Karakuzu	Dr. Sonia Boscolo	Nonlinear Optics, Lasers, femtosecond laser Inscription, pulse shaping
Mr. Son Thai Le	Prof. Sergei Turitsyn	Digital Signal Processing Techniques for High-speed CO-OFDM Transmissions
Mr. Graham Lee	Dr. Kate Sugden	Femtosecond Laser Micromachining and Inscription of Novel Planar and Fibre Devices
Mr. Athanasios Manolis	Dr. Alex Rozhin	Nano Photonics sensors for food and environmental monitoring
Mr. Neil Murray	Dr. Paul Harper	Optical Regeneration of phase noise degraded signals
Mr. Ehikioya Odobe	Prof. Lin Zhang	Femtosecond Laser Technology
Mr. Janarthanan Rasakanthan	Dr. Kate Sugden	Advances in Characterisation, Calibration and Data Processing Speed of Optical Coherence Tomography Systems
Mr. Pawel Rosa	Dr. Paul Harper	Ultra-long Raman Laser based amplifiers for high speed optical telecommunication
Ms. Maria Sorokina	Prof. Sergei Turitsyn	Shannon capacity, fibre-optic communication, all-optical regeneration
Mr. Srikanth Sugavanam	Prof. Sergei Turitsyn	Fibre lasers
Mr. Zhongyuan Sun	Prof. Lin Zhang	Optical Fibre gating sensing
Mr. Mingming Tan	Dr. Paul Harper	High speed long haul optical communication using Raman amplification
Mr. Nikita Tarasov	Prof. Sergei Turitsyn	Random, Raman, Mode-locked Lasers
Mr. Changle Wang	Prof. Lin Zhang	Fibre gratings, especially gratings in multicore fibres Dynamic polarization control using liquid crystal
Mr. Xianchuan Wang	Prof. Lin Zhang	Distributed Optical Fibre Sensing Techniques and Systems

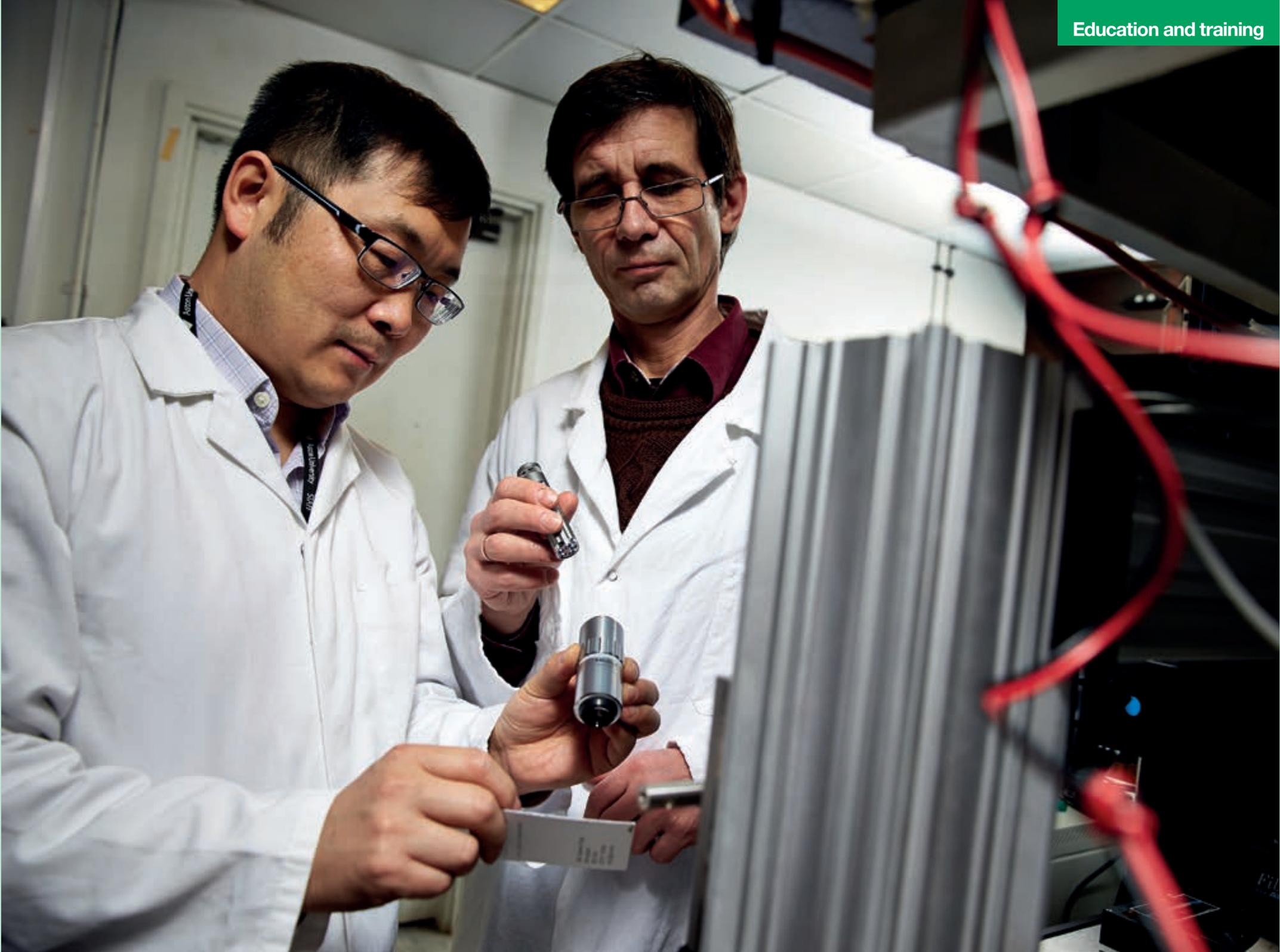
## Doctoral Thesis 2013

- ▶ High Performance Numerical Modeling of Ultra-short Laser Pulse Propagation Based on Multithreaded Parallel Hardware, by Mandana Baregheh
- ▶ Ultra-Long Mode-Locked Er-Doped Fibre Lasers, by Alexey Ivanenko
- ▶ Advanced Tilted Fiber Grating and Their Applications, by Zhijun Yan
- ▶ Advanced Photonic Microstructures, Devices and Applications by Femtosecond Laser Inscription technology, by Charalambos Koutsides

## Masters Students

Each year the AIPT hosts a number of masters students projects with an optics theme. These projects allow students to tackle relevant modern day problems and to pursue cutting edge research.

Name	AIPT Supervisor	Thesis/Project Title
Wajahat Ali	Prof. Andrew Ellis	Digital Signal Processing for All Optical Fast-OFDM
Mayowa Ajayeoba	Dr. Elena Turitsyna	Study and Numerical Modeling of Long Period Gratings
Nnamdi Aneze	Prof. David Webb	Fabrication and Characterisation of Polymer Optical Fibre
Swati Bhargava	Dr. Paul Harper	Digital Signal Processing in Optical Communications
Albert Chukwuma,	Prof. Andrew Ellis	All Optical Modulation Stripping
Vladimir Gordienko	Prof. Keith Blow	Optical Parametric Amplifiers for Multi-Channel High Bit Rate Systems
Chidinma Iloh	Prof. Andrew Ellis	Few Mode Fibre Design
Martha Kasembo	Prof. Keith Blow	Turbulence Limited Free Space Optical Links
Kondiwani Kazembe	Dr. Sonia Boscolo	Nonlinear Pulse Shaping in Mode-Locked Fibre Lasers
Thomas Kwashie	Prof. Andrew Ellis	Electronic Polarisation Demultiplexing
Renatus Mgetta	Dr. Sonia Boscolo	Impact of Fourth-Order Dispersion on the Evolution of Parabolic Optical Pulses
Aysha Riasat	Dr. Sonia Boscolo	Impact of Saturable Absorption on the Energy Evolution in Laser Cavities
Getinet Woyessa	Prof. Lin Zhang	Optical Fibre Laser Sensing System and Signal Wireless Transmission





# Community

# Industrial collaboration

## Links to Business – Photonics Case Study Special

### Aston University helps businesses grow with photonics expertise

AIPT is one of the largest groups in photonics research in the UK. The group has a world-recognised level of achievement in non-linear photonics, high-speed optical transmission and processing, in fibre optic components and in fibre optic sensors.

AIPT has a wide range of device and system-level topics at the leading edge of technology, recently expanding its activities in a number of key areas including femtosecond pulsed laser techniques, medical sensing devices, and planar integrated optical circuits.

A distinguishing feature of the Institute's research profile is the way in which significant industrial and collaborative projects provide the context for fundamental research, usually of an interdisciplinary nature. It maintains active and fertile collaborations with industrial companies and academic institutions throughout the world.

Aston University has secured funding from the European Regional Development Fund (ERDF) to deliver technical support to SMEs in the West Midlands so that they understand the advantages and potential opportunities of embracing a range of photonics technologies and expertise in their business.

AIPT have recently delivered this technical support to Arden Photonics, one of the few photonics companies within the West Midlands, designing and manufacturing high quality components and instrumentation for the measurement of a wide range of properties of optical fibres and lasers. The company was putting a new instrument into the market,

but did not have enough data to compare it to a major competitor. In collaboration with the ERDF team, Arden Photonics tested and characterised the instrument and obtained the first hand data which proved that their product was better than their competitor. Arden Photonics have now gone on to cement their relationship with AIPT through a project funded by the Technology Strategy Board.

Kimal, a West Midlands based SME who develop catheters and associated kits for a range of medical requirements, worked with AIPT to add functionality and increase added value of their catheters. During the collaboration, the ERDF team were able to successfully micro-machine the surface of a catheter making both holes and writing shapes. An investigation was also undertaken into state-of-the-art plastic fibres, and Kimal are now addressing commercial availability of suitable plastic fibres with the AIPT team through an EU programme known as TRIPOD.



## Optical Fibre Technology Enables Safer Approach for Gas Data Ltd

Gas Data Ltd designs and manufactures an extensive range of portable and fixed gas-analysis instrumentation solutions. These are used in diverse applications world-wide, including waste disposal, bioenergy, air-quality, food storage, security and odour monitoring.

Gas Data Ltd has embarked on a Knowledge Transfer Partnership (KTP) with academics from the AIPT in the School of Engineering and Applied Science to help develop and implement state-of-the-art sustainable gas monitoring solutions.

The aim of this KTP project is to develop a range of gas monitoring solutions, utilising optical fibre technologies, for difficult-to-detect gases. Current technologies have proven successful in certain markets such as landfill and early biogas, but as renewable energy markets grow, Gas Data Ltd recognise that the company's future depends on developing more sophisticated products that deliver greater accuracy and have higher tolerance to contamination, as well as the ability to operate in hostile environments.

Aston's School of Engineering and Applied Science has a long track record of successful collaborations with companies both large and small, and AIPT is one of the largest photonics research groups in the UK, possessing a world-recognised record of achievement in this area.

This partnership with the AIPT will lead to the development of optical fibre based devices for detecting gases such as hydrogen, carbon dioxide and hydrogen sulphide. As early adopters of optical fibre technologies in this

field, Gas Data Ltd will gain a clear competitive advantage across Europe.

The application of optical fibre to sensors will open opportunities to reduce susceptibility to contamination by mixed gases, offer greater accuracy and sensitivity, and be well suited to challenging environments. Furthermore, it will enable Gas Data Ltd to simplify systems and therefore reduce overall costs.

Matthew Humphreys, Managing Director of Gas Data Ltd said of the project: "The immediate impact will be the introduction of optical fibre technologies into the company. This change in Gas Data's technical capability will increase its competitive advantage in the current market and enable the launch of unique products into emerging markets. Collaboration with the AIPT, an acknowledged centre of excellence for research in optical systems, will enable Gas Data to become a leader in innovative detection technologies."

For the academic team at Aston, the KTP project will provide a unique opportunity to translate their research to industry as well as enhance their existing research in this area. Prof. David Webb, Deputy Director of the AIPT, said of the project: "The relationship with Gas Data will enable future collaboration on more advanced sensing concepts which offer opportunities that cannot be addressed by current sensing technology."

## Aston Helps Improve Food Safety

In an exciting new £600,000 project funded by the Technology Strategy Board, Aston University has teamed up with Branscan Ltd, Arden Photonics Ltd and Warburtons Bakery, to use innovative photonic technology to develop a sensing solution for characterising and inspecting food products.

Near Infra-Red (NIR) spectroscopy is used to determine the physical properties and quality of powdered food products such as flour. This project will look at using photonic technology to develop an innovative combination sensing solution to monitor quality and quantity at multiple points in the quality control process of powdered food products to make it more efficient.

The technology, which has been developed by the AIPT, will be low cost, robust and occupy relatively small space, allowing many points of detection during the procession. This will revolutionise the quality control process, as unlike existing technologies, it will allow for the process to be continuously monitored and in real time, rather than waiting for discrete samples to be analysed post production. The provision of real-time in-process data about food quality and safety for food processors will help to meet consumer demands for traceability, safety and high quality in food.

AIPT, based in the School of Engineering and Applied Science at Aston University, is an internationally recognised research centre specialising in fibre optics, high-

speed optical communications and nonlinear photonic technologies. Branscan has over 20 years' global experience in quality control technology for flour milling, baking and other food industries. Arden Photonics, design and manufacture equipment for optical fibre test and inspection, optical metrology and beam profiling. Warburtons are the largest bakers in the UK.

The project will use Branscan's knowledge of the market and application of NIR technology, Arden Photonics' expertise in signal processing and instrumentation, Aston's expertise in sensor technology and Warburtons operational experience to produce a high tech method of monitoring food to ensure food safety.

Prof. Lin Zhang of Electronic Engineering from AIPT and academic lead said: 'This project has the potential to produce a range of benefits to the food industry. Applying photonic technology to help control the process of the powdered food products closely will mean we can manage the quality of grain used; reduce possible waste; increase job security in these businesses, and as a result improve long term business growth. We are looking forward to working with Branscan, Arden and Warburtons to put our research into practice.'

## Advanced Measurement Tools from Optimec Ltd.

Optimec Ltd (Optimec) has 34 years of experience in the design and manufacture of soft contact lens measuring instruments, and has an understanding of customer and operator requirements and a strong presence in the market. The manufacturing process for contact lenses has become increasingly precise and accurate through the use of higher performance lathes and moulds. It is essential that Optimec is able to offer measuring instruments capable of the same degree of precision, which current technology is unable to deliver.

In order to overcome this problem, the company has entered into a two and a half year KTP with Dr. Kate Sugden and Dr. Thomas Drew from Aston University's School of Engineering and Applied Science and School of Life and Health Sciences, to develop a new generation of innovative soft contact lens measuring instruments, utilising novel techniques to match improved accuracy of lens manufacturing processes.

Optimec is seeking to develop its knowledge of new and emerging optical measurement technologies, to evaluate their potential application to the measurement of hydrated soft contact lenses whilst immersed in saline solution. The introduction into Optimec's instruments of advanced metrology is a novel approach to satisfying the market's demand for improved instrumentation. This is strategically essential for Optimec to maintain and improve its market position through the introduction of a unique product, which will form the platform for a full range of lens measuring instruments that will measure soft contact lenses and also enable expansion into new markets such as intraocular lenses.

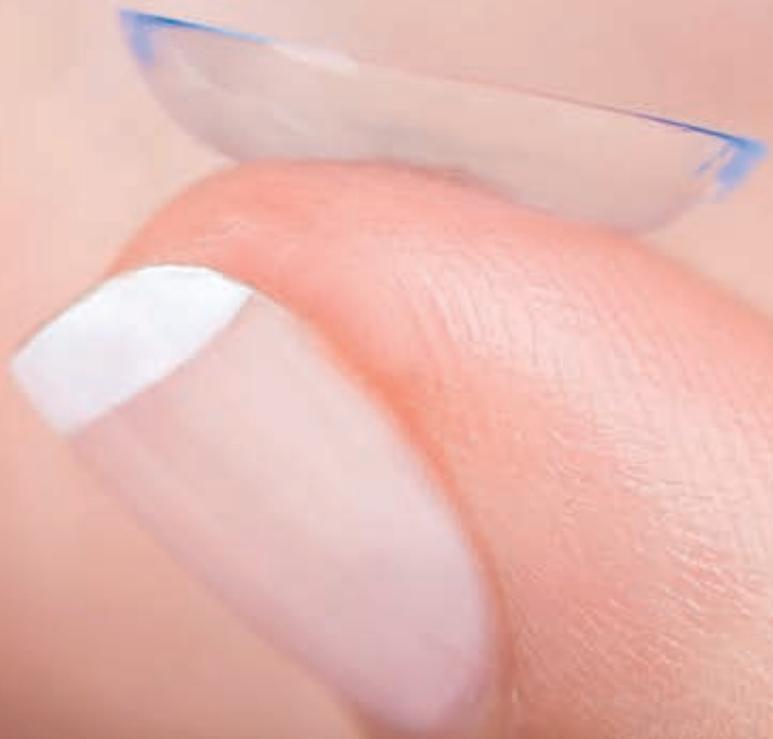
The development of interference methods will not only minimise operator dependent variation, but offer improved resolution and

accuracy. This enables the de-skilling of these measurements and opens opportunities to address the difficulties of measuring modern non symmetrical lenses such as toric and varifocal. It is also possible to introduce the capability of full 3D mapping, lens ray tracing, simulation, performance assessment capabilities and very advanced metrology compared to current metrology systems.

For Aston University, the work will contribute to the research output of both the Schools of Engineering and Applied Sciences and Life and Health Sciences in areas of Biomedical Engineering, Vision Sciences, Electronics and Optics. The project builds on prior research, and within the limits of commercial confidentiality, will provide material for publications in international journals such as Optics Express (ranked 5th of 76 for impact), IEEE sensors, Applied Optics, and at the major conferences in the field.

Dr. Thomas Drew also said: "This is a great opportunity for the multi-disciplinary Biomedical Engineering Group to work closely with a business to develop commercially exploitable technology based on cutting edge research."

Dr. Kate Sugden commented: "Student projects are an expected spin off the technology developed in this project. The partners anticipate that the successful project will identify other areas of joint research and knowledge transfer, leading to further opportunities for co-operation in funded programmes. In addition, it will offer opportunities for associated projects at both postgraduate and undergraduate levels, and for student placements."



# Outreach activities

## Engaging with local schools

Members of AIPT, Dr Kate Sugden and Dr Elena Turitsyna participated in Aston University Masterclass Programme that offers a great opportunity for students to enrich their sixth form studies by providing stimulating workshops from Aston University academics in a university setting. Activities provided by AIPT staff members included a lecture on Information Theory, a Masterclass on programming Lego Mindstorms Robots with C programming language and a workshop on building an amplifier. These sessions enabled students to discover more about the subjects taught in Electronic Engineering programmes, also enhance their knowledge in electronics, programming, and sensing and telecommunication technologies.

Dr Elena Turitsyna ran a series of workshops on “Mathematics of Google” at the annual Further Maths conference organized for West Midlands’ schools by King Edward VI Camp Hill School for Girls. The schools that took part in the mentioned activities:

- ▶ Banbury College, Banbury
- ▶ Bishop Milner Catholic College, Dudley
- ▶ King Edward VI Aston, Birmingham
- ▶ King Edward VI Camp Hill Boys/ Girls, Birmingham
- ▶ Adams College, Newport
- ▶ Aston University Engineering Academy, Birmingham
- ▶ John Henry Newman Catholic College, Birmingham
- ▶ Sidney Stringer Academy, Coventry

## Residential Courses in Engineering in AIPT funded by The Smallpeice Trust

The AIPT hosted 28 sixth form students on a High Speed Communications course funded by the Smallpeice Trust. The course took place from 8th to 10th July, 2013 at Aston University. The benefits of high speed communications are becoming increasingly recognised and valued, they are essential for delivering healthcare, industrial development, transport, financial and other services that help every country flourish and develop economically and socially. From enabling schools on opposite sides of the world to learn together in real time, to giving a surgeon in a remote hospital the chance to be assisted by a specialist in a large city; the applications are endless.

This course provided students with the perfect opportunity to work alongside experienced professionals as they learn about the astonishing world of electrons, photons and waves and how these drive our high speed communications.

Through classroom and laboratory sessions, students developed their knowledge of the components and systems that make up our global communications network.

## Outreach Training Programme

The AIPT student chapter of the International Society for Optics and Photonics (SPIE) has been awarded \$3,000 by SPIE for outreach activities, which will be used to purchase optics kits for use in schools

The AIPT SPIE student chapter applied for the Education Outreach Grant and was awarded \$3000. This fund was used to purchase the Photonics Explorer kit manufactured by the Photonics Explorer Team, B-Phot, Department of Applied Physics and Photonics, Vrije Universiteit Brussel (VUB), Brussel, Belgium. School teachers around the West Midlands of United Kingdom, where the AIPT SPIE student chapter is located, were invited to partake in a two-hour training event and they were given the Photonics explorer kit for free. The training was carried out by Amrita Prasad, CEO – EYEST (Excite Youth for Engineering Science and Technology).

The training was carried out for ten teachers from eight different schools in the West Midlands of the UK. The schools that took part in the training event are listed below.

- ▶ Landau Fort Academy, Tamworth, Staffordshire
- ▶ Grace Academy, Coventry
- ▶ Aston Engineering Academy, Birmingham
- ▶ King Edward High School, Birmingham
- ▶ Springwell Community College, Derbyshire
- ▶ Holy Trinity School, Birmingham
- ▶ Cockshut Hill School, Birmingham
- ▶ Holy Head School, Birmingham







# Publications list 2013

## Journal Articles

- ▶ A. Abang and D. J. Webb, "Influence of mounting on the hysteresis of polymer fiber Bragg grating strain sensors," *Opt. Lett.*, vol. 38, no. 9, pp. 1376–1378, 2013.
- ▶ A. Adebayo, Z. Yan, K. Zhou, L. Zhang, H. Fu, and D. Robinson, "Power Tapping Function in Near Infra-Red Region Based on 45 Tilted Fiber Gratings," *Opt. Photonics J.*, vol. 03, no. 02, pp. 158–162, 2013.
- ▶ N. Akhmediev, J. M. Dudley, D. R. Solli, and S. K. Turitsyn, "Recent progress in investigating optical rogue waves," *J. Opt.*, vol. 15, no. 6, p. 060201, 2013.
- ▶ T. Allsop, R. Neal, M. Dvorak, K. Kalli, A. Rozhin, and D. J. Webb, "Physical characteristics of localized surface plasmons resulting from nano-scale structured multi-layer thin films deposited on D-shaped optical fiber," *Opt. Express*, vol. 21, no. 16, pp. 18765–18776, 2013.
- ▶ A. Bednyakova, O. A. Gorbunov, M. O. Politko, S. I. Kablukov, S. V. Smirnov, D. V. Churkin, M. P. Fedoruk, and S. A. Babin, "Generation dynamics of the narrowband Yb-doped fiber laser," *Opt. Express*, vol. 21, no. 7, pp. 8177–8182, 2013.
- ▶ R. Davoyan, S. K. Turitsyn, and Y. S. Kivshar, "Self-similar parabolic plasmonic beams," *Opt. Lett.*, vol. 38, no. 4, pp. 428–30, 2013.
- ▶ A. D. Ellis, N. Mac Suibhne, F. C. Gunning, S. Sygletos "Expressions for the nonlinear transmission performance of multi-mode optical fiber," *Opt. Express*, vol. 21, no. 19, pp. 22834–22846, 2013.
- ▶ S. J. Fabbri, C. O'Riordan, S. Sygletos, and A. D. Ellis, "Active stabilisation of single drive dual-parallel Mach-Zehnder modulator for single sideband signal generation," *Electron. Lett.*, vol. 49, no. 2, pp. 135–136, 2013.
- ▶ K. Hammani, S. Boscolo, and C. Finot, "Pulse transition to solitons in normally dispersive fibre amplifiers," *J. Opt.*, vol. 15, no. 2, p. 025202, 2013.
- ▶ G. Jacobsen, T. Xu, S. Popov, and S. Sergeyev, "Study of EEPN mitigation using modified RF pilot and Viterbi-Viterbi based phase noise compensation," *Opt. Express*, vol. 21, no. 10, pp. 12351–12362, 2013.
- ▶ H. Karakuzu, M. Dubov, and Sonia Boscolo, "Control of the properties of micro-structured waveguides in lithium niobate crystal," *Opt. Express*, vol. 21, no. 14, pp. 17122–17130, 2013.
- ▶ N. A. Koliada, B. N. Nyushkov, A. V. Ivanenko, S. M. Kobtsev, P. Harper, S. K. Turitsyn, V. I. Denisov, and V. S. Pivtsov, "Generation of dissipative solitons in an actively mode-locked ultralong fiber laser," *Quantum Electron.*, vol. 43, no. 2, pp. 95–98, 2013.
- ▶ J. Li, H. Luo, Y. Liu, L. Zhang, and S. D. Jackson, "Modeling and Optimization of Cascaded Erbium and Holmium Doped Fluoride Fiber Lasers," *IEEE J. Sel. Top. Quantum Electron.*, vol. 20, no. 5, pp. 1–14, Sep. 2014.
- ▶ P. Li, Z. Yan, K. Zhou, L. Zhang, and J. Leng, "Monitoring static shape memory polymers using a fiber Bragg grating as a vector-bending sensor," *Opt. Eng.*, vol. 52, no. 1, p. 014401, 2013.
- ▶ P. Li, Z. Yan, L. Zhang, Y. Liu, J. Leng, and K. T. Lau, "Monitoring of deployment process of shape memory polymers for morphing structures with embedded fibre Bragg grating sensors," *J. Intell. Mater. Syst. Struct.*, 2013.
- ▶ F. Marques, L. B. Bilro, N. J. Alberto, D. J. Webb, and R. N. Nogueira, "Inscription of narrow bandwidth Bragg gratings in polymer optical fibers," *J. Opt.*, vol. 15, no. 7, p. 075404, 2013.
- ▶ F. Marques, L. B. Bilro, N. J. Alberto, D. J. Webb, and R. N. Nogueira, "Narrow bandwidth Bragg gratings imprinted in polymer optical fibers for different spectral windows," *Opt. Commun.*, vol. 307, pp. 57–61, 2013
- ▶ F. Marques, L. Bilro, L. Kahn, R. A. Oliveira, D. J. Webb, and R. N. Nogueira, "Acousto-Optic Effect in Microstructured Polymer Fiber Bragg Gratings: Simulation and Experimental Overview," *J. Light. Technol.*, vol. 31, no. 10, pp. 1551–1558, 2013.
- ▶ C. Mou, S. V. Sergeyev, A. G. Rozhin, and S.K. Turitsyn "Bound state vector solitons with locked and precessing states of polarization," *Opt. Express*, vol. 21, pp. 26868–26875, 2013.
- ▶ C. Mou, K. Zhou, Z. Yan, H. Fu, and L. Zhang, "Liquid level sensor based on an excessively tilted fibre grating," *Opt. Commun.*, vol. 305, pp. 271–275, 2013.
- ▶ N. J. Murray, N. J. Doran, O. A. Olubodun, and P. Harper, "Performance enhancement of asymmetric filtered 40 Gb/s carrier suppressed return to zero-differential phase shift keying receiver in a 50 GHz grid," *IET Optoelectron.*, vol. 7, no. 1, pp. 14–19, 2013.
- ▶ G. Okhrimchuk, S. G. Grechin, A. E. Kokh, and V. Mezentsev, "Antisymmetric Distribution of Permanent Refractive Index Change in  $\beta$ -BaB<sub>2</sub>O<sub>4</sub> Crystal Under Exposure of Femtosecond Pulses," *MATEC Web Conf.*, vol. 8, p. 02003, 2013.
- ▶ S. L. I. Olsson, B. Corcoran, C. Lundström, E. Tipsuwannakul, S. Sygletos, A. D. Ellis, Z. Tong, M. Karlsson, and P. A. Andrekson, "Injection locking-based pump recovery for phase-sensitive amplified links," *Opt. Express*, vol. 21, no. 12, pp. 14512–14529, 2013.
- ▶ J. E. Prilepsky, S. A. Derevyanko, and S. K. Turitsyn, "Nonlinear spectral management: Linearization of the lossless fiber channel," *Opt. Lett.* 38, pp. 4232–4235, 2013.
- ▶ M. A. Preciado, X. Shu, K. Sugden "Proposal and design of phase-modulated fiber gratings in transmission for pulse shaping," *Opt. Lett.*, vol. 38, no. 1, pp. 70–72, 2013.
- ▶ D. D. Saez-Rodriguez, K. Nielsen, H. K. Rasmussen, O. Bang, D. J. Webb, "Highly photosensitive polymethyl methacrylate microstructured polymer optical fiber with doped core," *Opt. Lett.*, vol. 38, no. 19, pp. 3769–3772, 2013.
- ▶ M. D. Petrović, A. Daničić, V. Atanasoski, S. Radosavljević, V. Prodanović, N. Miljković, J. Petrović, D. Petrović, B. Bojović, L. Hadžievski, T. Allsop, G. Lloyd, and D. J. Webb, "Fibre-grating sensors for the measurement of physiological pulsations," *Phys. Scr.*, vol. T157, p. 014022, 2013.
- ▶ M. N. Petrovich, F. Poletti, J. P. Wooller, A. M. Heidt, N. K. Baddela, Z. Li, D. R. Gray, R. Slavik, F. Parmigiani, N. V. Wheeler, J. R. Hayes, E. Numkam, L. Grüner-Nielsen, B. Pálsdóttir, R. Phelan, B. Kelly, J. O'Carroll, M. Becker, N. MacSuibhne, J. Zhao, F. C. G. Gunning, A. D. Ellis, P. Petropoulos, S. U. Alam, and D. J. Richardson, "Demonstration of amplified data transmission at 2  $\mu$ m in a low-loss wide bandwidth hollow core photonic bandgap fiber," *Opt. Express*, vol. 21, no. 23, p. 28559, 2013.
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## Book sections

- ▶ D. Rafique and A. D. Ellis, "Scaling the Benefits of Digital Nonlinear Compensation in High Bit-Rate Optical Meshed Networks," in "Current Developments in Optical Fiber Technology," 2013
- ▶ S.K. Turitsyn, S.A. Babin, E.G. Turitsyna, G. E. Falkovich, E.V. Podivilov, D.V. Churkin, "Optical Wave Turbulence," in "Advances in a Wave Turbulence", World Scientific Series on Nonlinear Science Series A: Volume 83 Victor Shrira (Keele University, UK) edited by: Sergey Nazarenko (University of Warwick, UK), pp. 113–163, 2013.

## Patent activity of AIPT members

- ▶ N. J. Doran, O.Olubodun, D.Govan, "Signal Recovery System", US Patent 20,130,045,016, 2013
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- ▶ M. Sumetsky, "Microbubble optical resonator," US patent 8,515,227,2013
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## Invited Talks & Presentations

- ▶ S. Boscolo, S. V. Sergeyev, C. Mou, C. Finot, and S. K. Turitsyn, "Nonlinear pulse shaping and soliton dynamics in mode-locked fibre lasers," Conference: Physics and Mathematics of Nonlinear Phenomena 2013 (PMNP 2013), Gallipoli (Lecce), Italy, June 22–29, 2013.
- ▶ S. Boscolo, "Recent progress on optical pulse shaping and waveform generation in fibre-based systems," First International Workshop on Spatio-Temporal Complexity in Optical Fibers, Como, Italy, 16–18 September, 2013.
- ▶ D. Churkin, "Laminar-turbulent transition in fibre laser", Advanced Workshop on Nonlinear Photonics, Disorder and Wave Turbulence, Trieste, Italy, July 14–19, 2013.
- ▶ A.D. Ellis, M. Sorokina, S. Sygletos, S.K. Turitsyn, "Capacity in Nonlinear Fiber Transmission Systems", ACP2014.
- ▶ A. D. Ellis, S. Sygletos, "Phase sensitive regeneration based on SOAs", OFC 2013, paper OW4C1.
- ▶ A. D. Ellis, N.J.Doran, "Are few mode fibres a solution to the capacity crunch?", Proc ICTON 2013, paper Tu.C2.1.
- ▶ A. D. Ellis, "The MODE-GAP project", IEEE Photonics Conference (IPC), Paper 299445
- ▶ A. D. Ellis, M. A. Sorokina, S. Sygletos, S. K. Turitsyn, "Capacity limits in nonlinear fiber transmission", in proc. Asia Communications and Photonics, Paper AW4F.1
- ▶ A. D. Ellis, N. Mac Suibhne, "Nonlinear effects in few mode fibres", in proc. EXAT International Symposium on extremely advanced transmission technology 2013, paper IV.2
- ▶ A. D. Ellis as an IEEE Distinguished lecturer gave a series of invited presentations "Ultra High Capacity Optical Transmission Systems", as an IEEE Distinguished lecturer: 15th January 2013, Dublin Joint Institution; 14th March 2013, IEEE photonic society Orlando Chapter; 15th March 2013, IEEE Photonics Society Ottawa Chapter Symposium Jointly with NRC / OPC / OPRA; 15th March 2013, Montreal; 22nd March 2013, UCSB; 22nd May 2013 University College Cork IEEE Student Branch.
- ▶ W. Forysiak "Progress in InP-based Photonic Components and Sub-systems for Digital Coherent Systems at 100Gbit/s and Beyond", Optical Communication (ECOC 2013), 39th European Conference and Exhibition, London Sept 22-26, 2013, Mo.3.C.2
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- ▶ A. Rozhin "Novel Macromolecular Complexes for Rapid Detection of Hazardous Agents", NATO workshop on Defence Against Chemical, Biological, Radiological and Nuclear Agents in Brussels, Belgium, 22-24 October, 2013.
- ▶ S. Sergeyev, S. K. Turitsyn, and Ch. Mou, "Slowly evolving vector solitons in mode locked fibre lasers", XXXIII Dynamics Days Europe, Madrid, Spain, June 3–7 2013.
- ▶ S. V. Sergeyev, S. Boscolo, C. Mou, C. Finot, and S. K. Turitsyn, "Nonlinear pulse shaping and polarization dynamics in mode-locked fibre lasers," 15th Anniversary International Conference on Transparent Optical Networks (ICTON 2013), Cartagena, Spain, June 23-27, 2013
- ▶ M. Sorokina, S. Sygletos, S.K. Turitsyn, "Design of nonlinear regenerative systems with high capacity, 15th International Conference on Transparent Optical Networks (ICTON 2013), Cartagena, Spain,

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- ▶ M. Sumetsky, "SNAP: Fabrication of Ultra-low-loss Miniature Photonic Circuits with Sub-angstrom Precision," Invited Paper, Conference on Lasers and Electro-Optics (CLEO) 2013.
- ▶ M. Sumetsky, "SNAP coupled microresonator delay line with record large delay time and low loss," Invited Paper, International Conference on Transparent Optical Networks (ICTON), Cartagena, 2013.
- ▶ M. Sumetsky, "Quantum mechanics" of light at the surface of an optical fiber," Invited paper, International Conference on Materials for Advanced Technologies, Singapore, 2013.
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- ▶ S. K. Turitsyn Advanced Workshop on Nonlinear Photonics, Disordered Media and Turbulence, Trieste, Italy, July 15–19, 2013.
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