UNIVERSITY OF BATH

PHYSICS at BATH

Department of Physics **End of Year Report** 2022

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A year of transformation.

The year 2022 marked an important transition for us. We have left our traditional home in the 3 West building and we relocated to 8 West. There were challenges: emerging from Covid restrictions, building works, temporary relocation for colleagues. Many of us felt deep concern for our community. But we are back together, once again. We are now looking forward to making the best of 8 West and we formulated a vision for our common future. Inevitably, there are things left behind: our arguably emblematic Physics Square, our offices and many big phones with large buttons. But our relocation has brought us all under the same roof and we have new teaching labs that can inspire our students and staff alike. Despite the challenges throughout this year, our colleagues have achieved much. Some of these achievements are included in this report. I know that the record does not capture all the richness of 2022. But this is a start.

Prof Ventsislav Valev
Head of Department

Today is a great day for science!

Our Vision for Physics in Bath

The year is 2028, the national Research Excellence Framework results are just in and we have hit all our targets. For outputs, impact and environment, we are in the top 10 UK physics departments. Our grant income has steadily increased over the years. An ever-larger proportion of our research income now comes from sources other than the Research Councils. We consistently score very high in student satisfaction surveys and we comfortably recruit strong undergraduate students to meet our targets. We are committed to delivering exceptional courses. We are recognised as a leading department of physics education and research, capable of coordinating large initiatives, such as centres for doctoral training. Our reach is global. We lead numerous partnerships with nearby universities within the South West. Our leaders are focussed on strategy, implementation and above all, on delivering results.

Building upon our culture is the priority

To meet our strategic growth targets, we have increased our productivity by creating a vibrant community. All staff feel valued, with clear roles and career paths. Our staff enjoy each other's company. We have a (re)generator room – our staff often have energizing discussions there to generate great ideas. It is also a place to drink coffee, relax and revitalise. Our staff have the opportunity to have lunch together and many of them do. When they have a problem or need support, there is always someone they can talk to. We collectively celebrate our successes and our events are inclusive. All staff feel empowered to bring their distinctive contributions to develop and deliver the vision. Diversity brings different perspectives and viewpoints that help us to increase our impact and reach. Our community includes the undergraduate and postgraduate students and there are Department events dedicated to each learning stage. We have created a community record – a department yearly report that staff can bring home at the end of the calendar year. There, one can read about our activities, our research and teaching successes, our new department members, etc. The report also goes to our extended community, including partners and alumni of the department. A library of all previous reports is available in our meeting room.

Research funding is diversified

Over recent years, our funding has diversified. The majority of our research income is now from sources other than the Research Councils, such as: business and industry, Innovate UK, the Royal Society, the Leverhulme Trust, West of England Combined Authority, the Wellcome Trust, the Royal Academy of Engineering, the British Embassies, Research England, Bath and North East Somerset Council, DSTL, DASA, etc. We regularly exchange visiting postdoctoral researchers and PhD students with partners abroad. Our increased research power softens the vagaries of Government research funding. Within our grant portfolio, our academics are leading large research programs. Growing resilience to failure has been the key. We support each other in overcoming rejections and we take failure as scientists – it is data! It is never personal. Our increased research power means that rejections have a short-term effect on morale and grant applications are swiftly redeveloped into new proposals.

Our environment is refurbished

From the west car park, the physics building is immediately recognisable and inviting. We are now working in a completely refreshed environment and we are all together, in the same building. Once inside, there is an immediate impression that this is a place of learning. The corridors and meeting room walls are lined up with items that celebrate our successes: prizes, prominent research papers, cover arts and prototypes are all present. Display items also demonstrate the career possibilities that Physics offers (we have a section on the wall with alumni photographs), as well as spin-out successes and prominent collaborative work. Office doors are personalized with laser cut doorplates that highlight our achievements. The meeting room is a place of inspiration. Visitors are impressed with the attention to detail and want to work in a place like our building.

Our labs are inspiring and world-leading

Inspiration takes different forms. Walking into some of our labs feels like being on a glamorous science fiction movie set (with lasers, robots, space vacuum, quantum computers). Others are places of contemplation – this is where the first hollow core fibre was made, the first Hall probe microscope built, etc. Our safety measures and signage tell everyone that our labs are special places and that we care for people. The labs host unique and cutting edge equipment operated by scores of students, postdoctoral researchers, and expert technical staff. Our researchers also have access to world-leading shared facilities (including observational satellites and high performance computing machines). In the words of Nicolaas Bloembergen (Physics Nobel 1981): *"When you use new technology, new things are bound to happen."* Following this recipe for scientific discoveries, our unique equipment and our access to world-leading facilities routinely produce high-impact research results.

We create impressive narratives

For most of our exciting research, there are outreach activities, with narratives and props to explain the science to visitors. A public engagement professional is in charge of lab tours and of organising meetings with academics (both theorists and experimentalists). Some of our visitors have been fund managers, industry partners, editors, higher management, and we regularly host visits from our alumni. Many are very impressed and the visits have changed the perceptions of key partners. As a result, our academics are much more confident about submitting ambitious grant applications and manuscripts. Consequently, our success rates have increased.

Our leadership is shared and empowering

Leadership and management are distributed throughout the department through effective delegation processes. A senior department manager ensures that our administrative processes run smoothly. A Deputy Head of Department complements the Head of Department's expertise. The Head of Department draws expertise from training, feedback, mentorship, experience. The Head of Department focusses on strategy and on meeting the key performance indicator targets for the department. Throughout the department, delegation improves our staff's leadership and management skills. The process benefits their research teams and their teaching. It also prepares them for taking on larger responsibilities within the department. Our staff look forward to their Career Conversations, which are recognised as useful to achieve their career goals. Teamwork and volunteering within the Department are a valued integral part of the career conversations and promotion processes. Department meetings tell stories of colleagues who are leading initiatives of strategic importance for our community.

We concentrate on guided learning

In our undergraduate programmes, our focus is on the effective guidance of learning. This shows in our student satisfaction survey results. We are committed to delivering exceptional courses. We have star teachers and teaching awards reflect that fact. Our teaching labs are inviting playgrounds where even parents visiting on open days want to start a physics degree. We have attracted a large number of overseas students. All researchers are enthusiastically participating in the learning process. Our learning spaces are stimulating environments. Our courses are continuously refreshed and remain fit for the future. All the overheads of preparing new courses and new assessments has freed time for research. At the end of each year, we offer student prizes to our best students to reward their efforts, to build their confidence and to strengthen their CVs as they launch their professional lives. The number of our PhD students has increased. Our PhD students benefit from visits to internationally leading research institutions abroad and, in turn, we host PhD student visits from these institutions.

We focus on key media

The media seek out our expertise and our work is often reported in key media including those that publish university rankings, such as The Guardian, The Times, The Daily Telegraph, Financial Times.

We collaborate strongly with the university press office. Numerous activities regularly appear on the university website news sections.

Prizes and awards have accured our credibility

Our Physics website demonstrates our partnerships and global reach. Many of our staff have received prestigious awards from the Institute of Physics and other learned societies, according to their career stage. Most of our staff have been elected Fellows of the Institute of Physics and many have been elected Fellows of other learned societies. The accrued prestige for our department lends credibility to our grant applications and to our manuscript submissions. As a result, our application success rates have increased. We now spend less writing grant applications and more time doing the science that increases our credibility even more.

Sponsorship levels in the department

At the entrance of the building, we gratefully display a list of our sponsors, who have helped to make this vision a reality. Sponsorships include:

- Undergraduate student placements at companies
- Prizes for PhD students
- Sponsorships for our Student Societies
- Company involvement via doctoral training centre bids
- Sponsorship for research workshops with key national and international partners
- Individual pieces of research equipment that can be share between academics in the department
- Teaching labs kit funded externally, e.g. by alumni or by innovation in teaching programmes (e.g. in the maker lab or telescope)
- Sponsorship for producing a software version of the maker lab, with emphasise on robotics and programming hardware.
- Sponsorship for commissioning inspirational art work for the department
- Company funded PhD studentships
- Sponsorship for named personal or research Chairs, e.g. RAEng research chair
- Named laboratory
- Named research team or centre

Staff in our department

Academic and Research staff

Dr Julieta Arancio, Ms Mathilda Avirett-Mackenzie, Dr Jack Binysh, Mr Ross Challinor, Dr Stavros Drakopoulos, Dr Stephen Hamer, Dr Kerrianne Harrington, Ms Nuria Jordana-Mitjans, Dr Ranjeet Kumar, Mr Martin Leonhardt, Dr Menglong Li, Dr Kunjalata Majhi, Mr Cameron McGarry, Mr Danila Puzyrev, Dr Stephen Wells, Dr Harry Wood, Prof. Paul Coleman, Prof. John Davies, Dr Emilija Petronijevic

Dr Euan Allen

Dr Steven Andrews

Prof. Kamal Asadi

Prof. Simon Bending

Prof. David Bird

Prof. Tim Birks

Dr Philippe Blondel

Dr Yarden Brody

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Dr Simon Crampin

Dr Enrico Da Como

Dr Sara Dale

Dr Steven Davies

Dr Alex Davis

Dr Andriy Gorbach

Dr Sergey Gordeev

Dr Adelina Ilie

Dr Richard James

Prof. Jonathan Knight

Dr Frances Laughton

Dr Gary Mathlin

Dr Peter Mosley

Dr Marcin Mucha-Kruczynski

Prof. Carole Mundell

Dr Alessandro Narduzzo


Prof. Alain Nogaret


Dr Josh Nunn


Dr Kristina Rusimova


Prof. Philip Salmon


Dr Patricia Schady

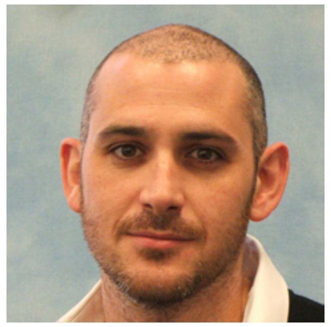

Dr Vicky Scowcroft


Prof. Dmitry Skryabin


Dr Peter Sloan


Dr Paul Snow


Dr Anton Souslov


Dr James Stone


Dr Kei Takashina


Dr Jun Toshikawa


Dr David Tsang


Prof. Ventsislav Valev


Dr Hendrik Van Eerten

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Dr Carolin Villforth


Prof. William Wadsworth


Prof. Alison Walker


Prof. Daniel Wolverson


Prof. Stijn Wuyts


Dr Anita Zeidler

Technical staff and Professional Services

Katherine Bright, Charlotte Checkley, Joshua English, Eleni Galanti, Jake Masters, Joseph Mills, Robin Mocock, Ash Moore, Julia Pearce, Edyta Pope, Kate Remington


Clare Cambridge


Dr Daniel Lou-Hing


Dr Charlotte Parry


Steven Renshaw


Dr Christopher Shearwood


Dr Stephen Wedge


Isabel Wells


Dr Jenny Williams

Highlights of 2022

New Staff

A new academic – Dr Habib Rostami – has joined the department, from November 2022. Earlier in the year, Julia Pearce, Kate Remington and Edyta Pope joined the Professional Services team and Joshua English the Technical team.

Research Fellowships

Dr Euan Allen was awarded a five-year personal Fellowship from the Royal Academy of Engineering. The fellowship is focused on developing and demonstrating novel optical sensors that utilise aspects of quantum physics to improve their performance. Moreover, Dr Alex Davis was awarded a five-year personal Fellowship from EPSRC. His research programme aims to develop novel fibre-based sources of "squeezed vacuum" (an exotic form of light) for applications in quantum communications and computing. Dr Sara Dale has been awarded an extension of her Royal Society University Fellowship entitled "Suping up 2D materials", which brought further funding to the group and also new state of the art facilities with a cryogenic free superconducting magnet for quantum transport experiments at low temperature.

Research Grants

- Prof Bending was awarded a grant from EPSRC to explore the interplay between the magnetic domain structure and supercurrents in unique ferromagnetic iron-based superconductors with potential applications in Magnetic Resonance Imaging (MRI), fusion reactors or magnetic levitation.
- Dr Blondel was awarded an EC Horizons grant for 5 years, as part of a Norway-led international consortium, to investigate climate change in the Arctic using in particular underwater acoustics.
- Dr Mosley had a BT-funded project (with Co-Is Dr Rusimova and Prof Knight) to investigate the use of hollow-core fibre within future mobile networks and a project funded by the US Air Force Office of Scientific Research, to develop optical cavities towards high-performance single-photon sources and low-loss switching for photonic quantum technologies.
- Dr Souslov has also secured funding from the US Air Force Office of Scientific Research to study topologically-protected modes in multicore optical fibre.
- Prof Valev was awarded funding from the Leverhulme Trust to investigate the optical properties of an emergent class of hybrid nanomaterials, composed of organic molecules and inorganic nanoparticles.
- Dr Dale received extra funding from the Royal Society for her work on phase engineering 2D materials with ionic liquids. Prof Valev was awarded extra funding from the Royal Society for his international collaboration project on tackling environmental science challenges using Raman spectroscopy.
- Dr Gorbach received funding from the Royal Society, for his collaboration with the Massachusetts Institute of Technology, on nonlinear photonics with 2D materials.
- Dr Toshikawa obtained observing time on Keck, the world's largest optical telescope, to study spectroscopically the formation of galaxy clusters in the early Universe. The time frames were allocated under an ongoing STFC-funded research project led by Prof Wuyts.
- Dr Schady is among the first batch of astronomers worldwide to have been awarded observer time on the flagship NASA/European Space Agency mission "James Webb Space Telescope", and observations based on her proposal are currently being taken. The Bath astrophysics group was successful with a joint STFC consolidated grant bid, which has resulted in post-docs awarded to Dr Schady, Dr Van Eerten and Dr Tsang, on topics ranging from James Webb observations to massive stellar explosions. A Nature publication on gamma-ray bursts from colliding neutron stars co-authored by Dr Van Eerten was accepted for publication in September.
- Prof Asadi received financial support towards the estate costs of establishing his research lab, from the Garfield-Weston Foundation.
- Prof Alain Nogaret co-lead the modelling part of the GW4 community on epilepsy 2022/23.
- Prof Salmon and Dr Zeidler were awarded neutron beam time at ISIS and the Institute Laue-Langevin for four Bath-led experiments on the structure of amorphous materials in collaborations with Corning Inc. of the USA and the University of São Paulo, Brazil.
- Dr Ilie received an Impact Acceleration Account grant for extending her patented glucose-monitoring technology for co-monitoring of other substances, and Alumni funding for research in quantum nanomaterials.

Research Prizes

Prof Valev led the experimental work that was awarded the Horizon 2022 Prize from the Faraday Division of the Royal Society of Chemistry "For the discovery of chiroptical harmonic scattering, theoretically predicted in 1979 and demonstrated experimentally 40 years later". He shared this prize with Dr Kristina Rusimova. Prof Valev was also elected Fellow of Optica (the Optical Society) "For pioneering contributions to nonlinear nanophotonics and new chiroptical effects". Dr Lukas Ohnoutek was awarded the Department of Physics PhD Prize for his thesis "Chiral optical effects in harmonic scattering". Doctoral student Leah Murphy was awarded a Best Poster Prize at the Institute of Physics's (IoP) Photon 2022 Conference in Nottingham. Doctoral student Will Luckin was awarded a Best Poster Prize at the 2022 annual meeting of the IoP Theory of Condensed Matter Group in Warwick. Hesameddin Mohammadi won the Best Student Talk prize at the 16th International Conference on the Physics of Non-Crystalline Solids, in Canterbury. Esther Giron-Lange won Best Poster Prize for her contribution at the 2022 UK Neutron & Muon Science and User Meeting held at Warwick University. Dr Jack Binysh was awarded the Alexei Likhtman Poster Prize at the 6th Edwards Symposium – Soft Matter for the 21st Century in Cambridge, UK in September 2022. Ben Olohan, Duncan Neill and Tabijah Wasawo were awarded the first, second and third place, respectively, in the Best Poster Competition at the Eureka 2022 Conference in Bath. Dr Charlotte Avery, Jack Binysh and Dr Julian Stirling were awarded Joint First Place in the Highlight series of Best Research Talks 2022, in the Department of Physics, in Bath.

Ceryx Medical

Spin off companies

Prof Nogaret is co-founder in the spin off company Ceryx Medical that holds several patents on neural networks and pacemakers. The company has attracted an investment fund of £3.9 million in March 2022. The company has also received the IoP Business Start-Up Award 2022 "for developing a unique bioelectronic technology that could change the way diseases such as heart failure are treated by reinstating natural communication between the heart and lungs". Moreover, Dr Ilie is co-founder and CSO of Transdermal Diagnostics, a spin off company focusing on glucose monitoring with patents awarded in the USA and Japan and pending in other territories, and £1.1 million in funding received from venture capital and Innovate UK. The company was a finalist in the international Emerging Technologies Competition 2021 run by the Royal Society of Chemistry.

Conferences

Dr Da Como, Dr Dale, Prof Bending, Dr Mucha-Kruczynski and Dr Souslov organized the "Condensed Matter and Quantum Materials 2022 conference CMQM-2022" on our Claverton Down campus. The event gathered more than 150 scientists from around the world working on quantum materials. The conference has been sponsored by several IoP research groups and received support from industry sponsors. Prof Wolverson organized the "International Conference on Semiconductors and Related Materials 2022". This event gathered international speakers and attendees from around the world and staying on campus at Bath. Prof Skryabin co-organized the 11th biennial conference supported by several IoP research groups "Photon 2022" (Nottingham, 30 August to 2 September).

Dr Mucha-Kruczynski co-organized the annual meeting of the IoP's Theory of Condensed Matter Group (Warwick, 16 June 2022). Dr Anita Zeidler co-organized the meeting on Understanding the Structure of Liquids: Celebrating John Enderby's Scientific Legacy held at the University of Bristol (5-6 September 2022), supported by several IoP research groups. Dr Blondel gave the keynote speech at the International Conference on Underwater Acoustics ICUA-2022 at Southampton in June 2022. Dr Souslov co-organized the annual UK Metamaterials Network Annual Conference 2022 in Dorking, UK.

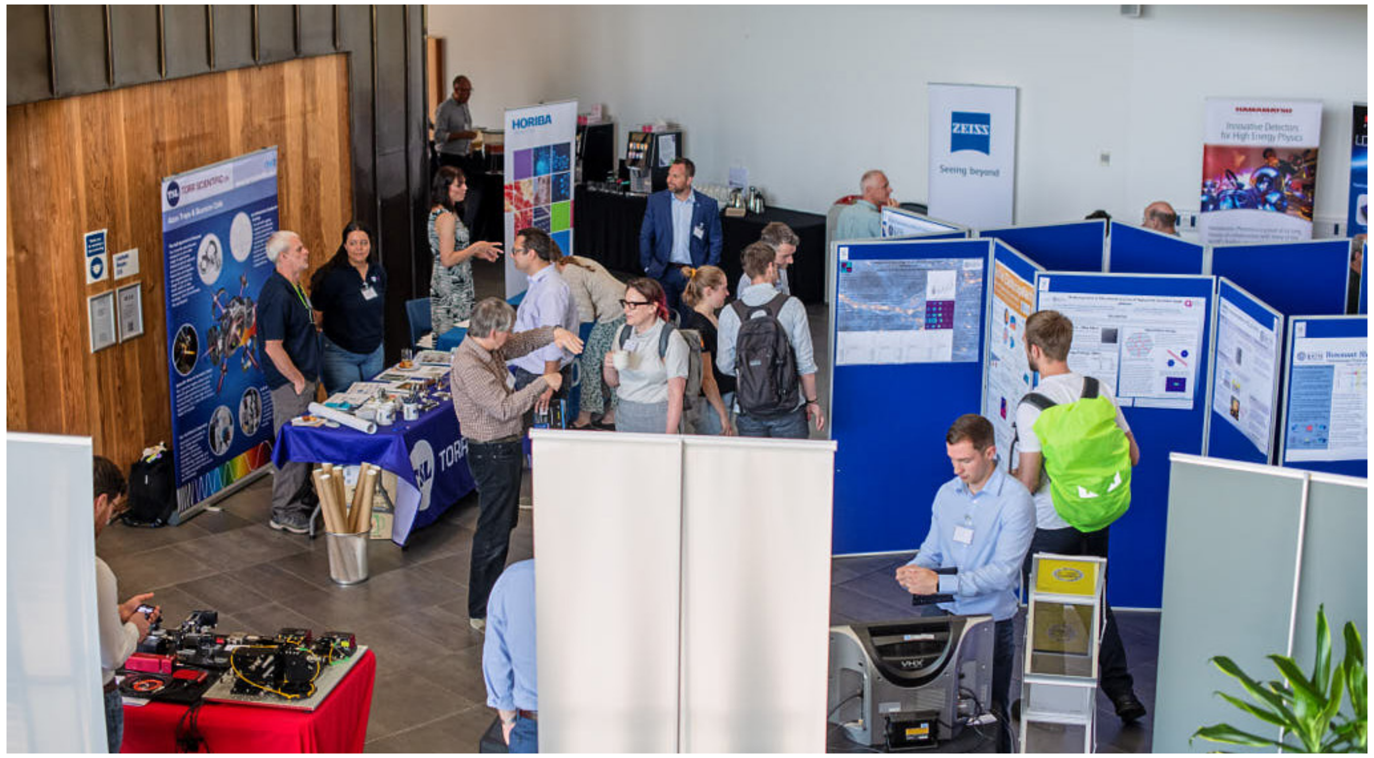
New undergraduate degree program

Thanks to a large effort of the whole department, we have started a new undergraduate degree programme on Physics with Theoretical Physics. This degree provides a broad understanding of physics with less emphasis on experimental laboratories and a stronger focus on theoretical, mathematical and computational aspects. Students learn about the deep connections between mathematics and theoretical physics and develop their scientific computing and theoretical modelling skills to understand and solve complex physical problems. During the course, students discover the fundamental theoretical physics describing the intertwining of space, time, matter and energy. They develop and apply theoretical models, learn about active matter and general relativity, investigate nonlinear physics and quantum optics. As well as gaining a deep knowledge and understanding of physics, students on this degree graduate with strong experimental, mathematical and computational expertise. They also gain powerful problem-solving, analytical and critical thinking skills, preparing them for a career in physics and beyond.

Outreach

Dr Blondel has been working with 'We The Curious' at Bristol, as part of their Wellcome-funded programme. Prof Wuyts talked about peering into the deep Universe with the James Webb Space Telescope, in the Bath Abbey together with Dr Osborne in association with the touring exhibition Museum of the Moon by artist Luke Jerram, and in engagement with schools (Exeter Mathematics School), SU Space Society and SU Physoc. He further shared his experience during the GW4 career panels event on 'Being an International Academic'. Prof Walker was featured in an interview article that appeared in Physics World, discussing energy efficient housing and her contribution in the field of photovoltaics and the recent energy crisis. Prof Bending's talk at the 7th International Conference on Superconductivity and Magnetism is available on Youtube and relates to a recent Physical Review Letters paper from his work. Prof Valev has given the Sixth Annual Regional STEM Lecture to over 900 students from 40 schools and colleges across the Tees Valley. He also led a team of postgraduates on 5 science workshops at primary schools in Bath. Professor Mundell gave the world's largest astronomy lesson to celebrate the Queen's Platinum Jubilee in collaboration with the British High Commission, India, the Bulandshar Government and Las Cumbres Observatory/University of Cardiff. She was also an invited panelist for the United Nations Development Programme, China, event 'Leading the Way – Empowering Women and Girls in Science and Innovation' where she and her fellow panelists spoke to a global audience of 200,000 people. Prof Salmon gave a public lecture at the Bath Royal Literary and Scientific Institute to celebrate 2022 at the United Nation's International Year of Glass. Dr Zeidler and Prof Salmon performed outreach activities at a local school. Dr Blondel actively participated in the series of events organized by the University's Institute for Policy Research 'Our oceans: A deep dive' throughout 2021 – 2022, giving a talk about his own research and chairing other panels.

Department of Physics holds second Eureka research conference



The conference celebrated recent scientific achievements in the areas of Photonics, Astrophysics, Nanoscience and Theory.

Researchers from the Department of Physics held their second Eureka conference on 15 June 2022, aimed at celebrating recent scientific achievements in the areas of Photonics, Astrophysics, Nanoscience and Theory. The conference was organised by Dr Kristina Rusimova, on behalf of the Department of Physics Research and Knowledge Exchange Committee (DRKEC).

During the one-day event, the Heads of Research Groups summarized the latest academic successes, including an impressive number of publications in top peer-reviewed journals. Noted were also the awards of several prestigious fellowships, scientific prizes and research grants within the Department. The establishment of key collaborations with industrial partners and of spin outs was highlighted.

Associate Dean for Research Prof Tim Rogers said: *"Listening to the impressive research highlights from the Department of Physics with talks covering everything from quantum optics to gamma ray bursts was great fun and one of those occasions where I am struck by how fortunate I am to have the job that I do. This conference is an excellent initiative and something that could well work for other departments."*

The Pro Vice Chancellor for Research Prof Sarah Hainsworth, who gave the opening talk at the conference said: *"I hope that the challenge that I gave at the front of the day will feed through to people's work going forwards."*

The Vice Chancellor Prof Ian White, said: *"Congratulations on the day and best wishes for the future of the event."*

The programme of the conference consisted of two oral sessions, followed by a poster session. Prof Richard Penty from the University of Cambridge gave the opening scientific talk, followed by talks from Prof Stijn Wuyts, Dr Enrico Da Como, Prof Jonathan Knight and Dr Marcin Mucha-Kruczynski.

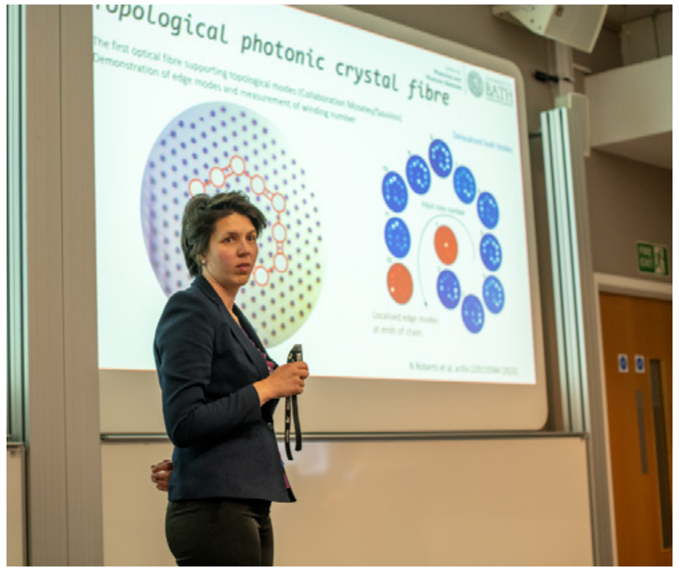
The afternoon session saw focussed research presentations by Dr Anita Zeidler, Bethan Easeman, Prof Alain Nogaret, Dr Euan Allen, Will Luckin and Dr Philippe Blondel, on topics as diverse as missing metals in star formation, (optical) neuromorphics, Lifshitz transition, ordering in silica glass and climate change.

At the end of the poster session, the Department awarded several prizes:

- Three colleagues shared the Joint First Place in the Highlight series of Best Research Talks 2022: Dr Charlotte Avery, Dr Jack Binysh and Dr Julian Stirling. This prize was awarded by the DRKEC.
- Three Best Poster Awards were also announced, for Ben Olohan (1st place), Duncan Neill (2nd place) and Tabija Wasawo (3rd place). The jury for the best poster awards consisted of Prof Ruth Oulton (University of Bristol), Prof Euan Hendy (University of Exeter), Prof Oliver A Williams (University of Cardiff) and Prof Tim Harries (University of Exeter).

The organisers are especially grateful to Charlotte Parry, Ben Olohan, Kunjalata Majhi and Dr Robin Jones for their help, which allowed the event to run smoothly.

The conference was sponsored by 10 industrial companies, including Toptica and Amplitude.



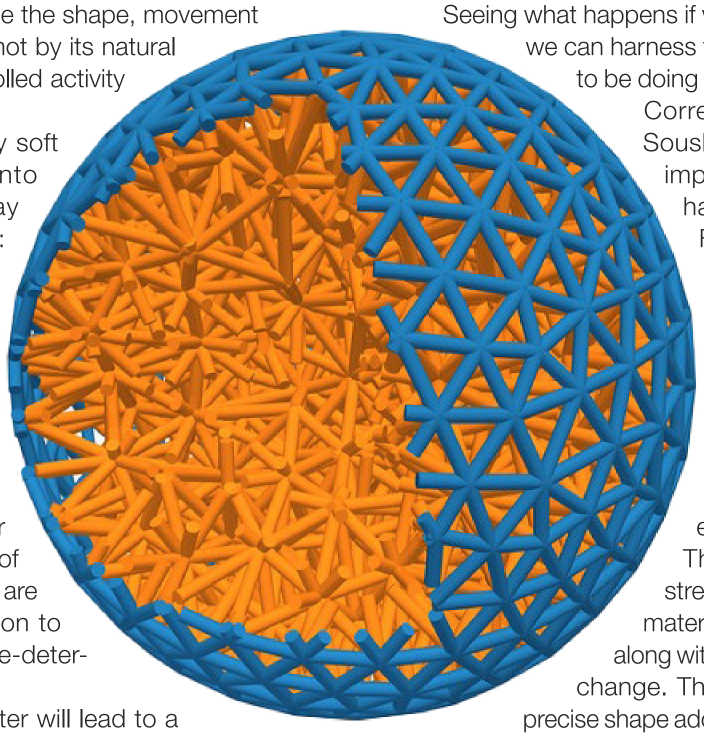
The next generation of robots will be shape-shifters

by Vittoria D'Alessio

Physicists have discovered a new way to coat soft robots in materials that allow them to move and function in a more purposeful way. The research, led by the University of Bath, is described in Science Advances.

Authors of the study believe their breakthrough modelling on 'active matter' could mark a turning point in the design of robots. With further development of the concept, it may be possible to determine the shape, movement and behaviour of a soft solid not by its natural elasticity but by human-controlled activity on its surface.

The surface of an ordinary soft material always shrinks into a sphere. Think of the way water beads into droplets: the beading occurs because the surface of liquids and other soft material naturally contracts into the smallest surface area possible – i.e. a sphere. But active matter can be designed to work against this tendency. An example of this in action would be a rubber ball that's wrapped in a layer of nano-robots, where the robots are programmed to work in unison to distort the ball into a new, pre-determined shape (say, a star).



It is hoped that active matter will lead to a new generation of machines whose function will come from the bottom up. So, instead of being governed by a central controller (the way today's robotic arms are controlled in factories), these new machines would be made from many individual active units that cooperate to determine the machine's movement and function. This is akin to the workings of our own biological tissues, such as the fibres in heart muscle.

Using this idea, scientists could design soft machines with arms made of flexible materials powered by robots embedded in their surface. They could also tailor the size and shape of drug delivery capsules, by coating the surface of nanoparticles in a responsive, active material. This in turn could have a dramatic effect on how a drug interacts with cells in the body.

Work on active matter challenges the assumption that the energetic cost of the surface of a liquid or soft solid must always be positive, because a certain amount of energy is always necessary to create a surface.

Dr Jack Binysh, study first author, said: "Active matter makes us look at the familiar rules of nature – rules like the fact that surface tension has to be positive – in a new light. Seeing what happens if we break these rules, and how we can harness the results, is an exciting place to be doing research."

Corresponding author Dr Anton Souslov added: "This study is an important proof of concept and has many useful implications. For instance, future technology could produce soft robots that are far squishier and better at picking up and manipulating delicate materials."

For the study, the researchers developed theory and simulations that described a 3D soft solid whose surface experiences active stresses. They found that these active stresses expand the surface of the material, pulling the solid underneath along with it, and causing a global shape change. The researchers found that the precise shape adopted by the solid could then be tailored by altering the elastic properties of the material. In the next phase of this work – which has already begun – the researchers will apply this general principle to design specific robots, such as soft arms or self-swimming materials. They will also look at collective behaviour – for example, what happens when you have many active solids, all packed together.

This work was a collaboration between the Universities of Bath and Birmingham. It was funded by the Engineering and Physical Sciences Research Council (EPSRC) through New Investigator Award no. EP/T000961/1.

Scan QR to read the research paper

Image "Active matter": Wrapping an elastic ball (orange) in a layer of tiny robots (blue) allows researchers to program shape and behaviour. **Image credit:** Jack Binysh

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Scan QR to read the full article

Can a new technique for capturing 'hot' electrons make solar cells more efficient?

by Vittoria D'Alessio

A new way of extracting quantitative information from state-of-the-art single molecule experiments has been developed by physicists at the University of Bath.

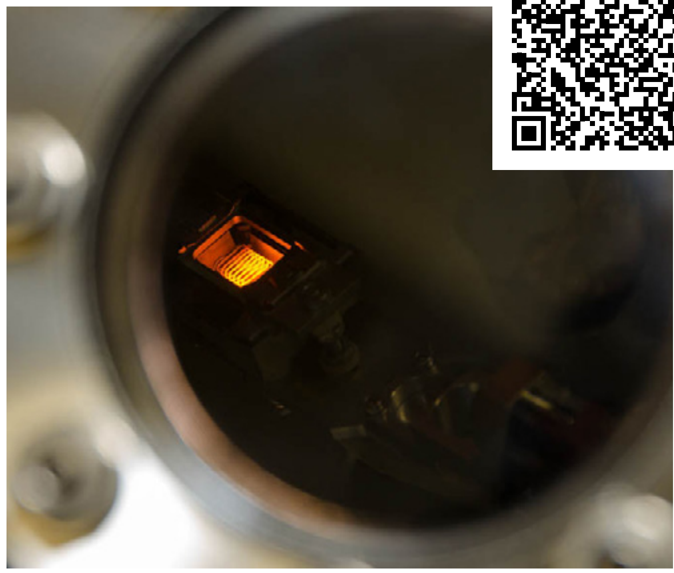
Using this quantitative information, the researchers will be able to probe the ultra-fast physics of 'hot' electrons on surfaces – the same physics that governs and limits the efficacy of silicon-based solar cells.

Solar cells work by converting light into electrons, whose energy can be collected and harvested. A hot solar cell is a novel type of cell that converts sunlight to electricity more efficiently than conventional solar cells. However, the efficiency of this process is limited by the creation of energetic, or 'hot', electrons that are extremely short lived and lose most of their energy to their surrounding within the first few femtoseconds of their creation (1 femtosecond equals 1/1,000,000,000,000,000 of a second).

The ultra-short lifetime of hot electrons and the corresponding short distance they can travel mean probing and influencing the properties of hot electrons is experimentally challenging. To date, there have been a few techniques capable of circumventing these challenges, but none has proven capable of spatial resolution – meaning, they can't tell us about the crucial connection between a material's atomic structure and the dynamics of hot electrons within that material.

The researchers from Bath's Department of Physics studied hot electrons using a scanning tunnelling microscope (STM). This device is designed to image individual atoms and molecules. By injecting a small electrical current (a beam of hot electrons) into a single target molecule, the device can also manipulate a target – moving it, rotating it, breaking a chemical bond or making a new chemical bond.

Atomic manipulation is the ultimate limit of nanoscience and single molecule chemistry. These are the areas of physics that use matter on an atomic or molecular scale to study the electrical, optical, thermal and mechanical properties of materials. To date, atomic manipulation has been used to develop (among other things) molecular machines (where, for instance, a molecule rotates when a current of electrons is applied) and single molecule light emitters (the smallest possible organic light emitting diodes).



The Bath scientists, however, have turned traditional experiments on their head. Instead of using a beam of electrons to measure and control what the target molecule does, they have used the molecules to measure what the electrons themselves are doing.

"We have used single-molecule reactions as a probe for the fate of the hot electrons in the first few femtoseconds of their lifetime – before they lose their energy to their surroundings," explained Dr Kristina Rusimova from the Department of Physics, who led the research. This work opens a new route for quantitatively and accurately measuring hot electron processes and controlling them. In time, it is hoped that it will feed into the new field of hot solar cells, where the aim is to capture the energy of an electron created in a photovoltaic cell before it has lost energy to its surroundings within the tiny first few femtoseconds of its existence.

Dr Peter Sloan, the Bath Physics researcher who designed the experiment and constructed the model this research was based on, said: *"New understanding of the processes that underpin the fate of elementary charges is among the most important contributions to nanoscience. Molecular nanoprobe experiments open new, previously unexplored ways to look at the behaviour of hot charge carriers at their relevant atomic length scales."*

Dr Rusimova added: *"Through state-of-the-art, rigorous and extensive experiment, we have identified the physical mechanism responsible not only for the charge transport across a silicon surface but also for the final manipulation step, where a molecule excited by an electron is ejected from the silicon surface, but crucially only after the hot electron has already lost its excess thermal energy. For the first time, we've linked the energy dependence of this manipulation step to the underlying surface electronic band structure."*

Intriguingly, this is also a starting point for designing other more complex materials where it should be possible to control the hot electron transport through, for example, creating defects to deliberately alter the energy landscape of the material, or regulating the material temperature.

The research was funded by the Engineering and Physical Sciences Research Council (EPSRC).

Black holes don't always power gamma-ray bursts, new research shows

by Vittoria D'Alessio

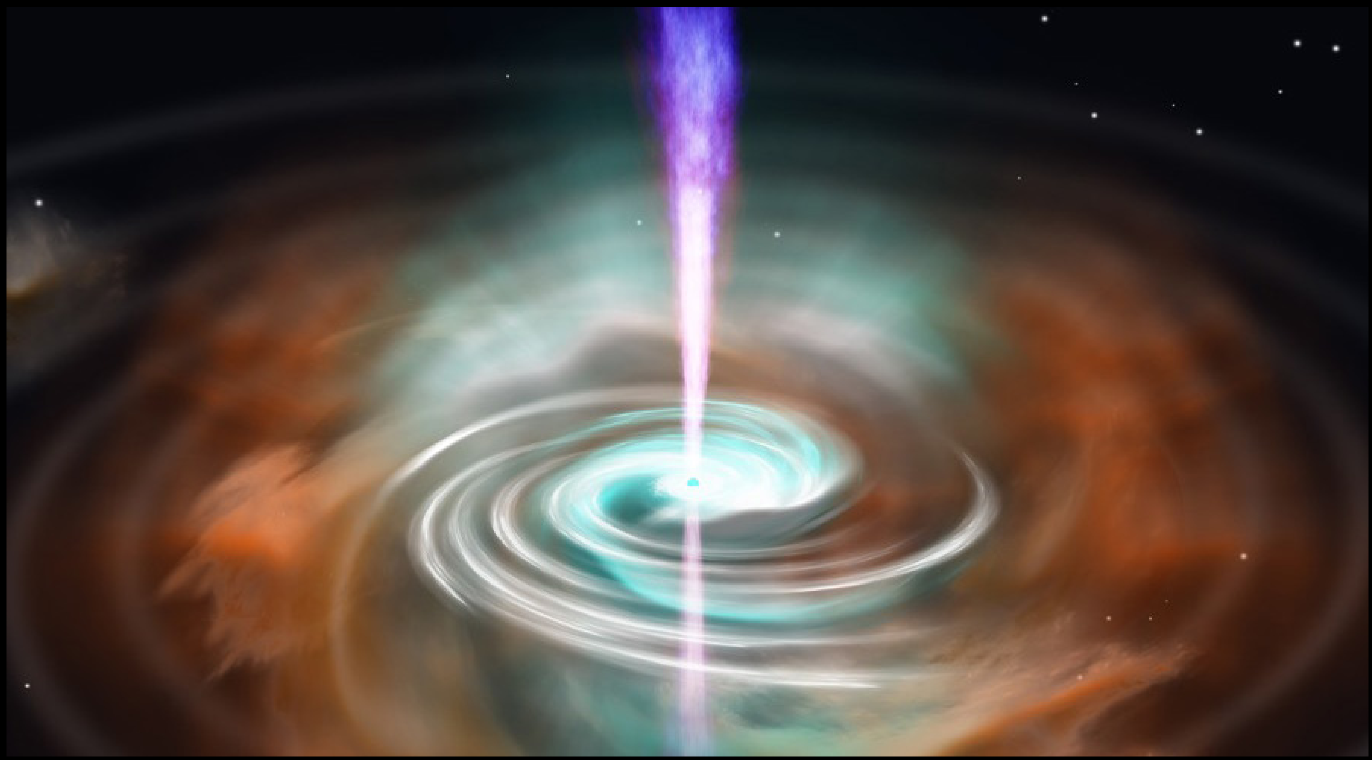


Image: An artist's impression of a gamma-ray burst powered by a neutron star. Credit: Nuria Jordana-Mitjans

Space scientists may need to rethink how GRBs are formed after research shows supramassive stars sometimes trigger these huge extragalactic bursts of energy.

Gamma-ray bursts (GRBs) have been detected by satellites orbiting Earth as luminous flashes of the most energetic gamma-ray radiation lasting milliseconds to hundreds of seconds. These catastrophic blasts occur in distant galaxies, billions of light years from Earth.

A sub-type of GRB known as a short-duration GRB starts life when two neutron stars collide. These ultra-dense stars have the mass of our Sun compressed down to half the size of a city like London, and in the final moments of their life, just before triggering a GRB, they generate ripples in space-time – known to astronomers as gravitational waves.

Until now, space scientists have largely agreed that the 'engine' powering such energetic and short-lived bursts must always come from a newly formed black hole (a region of space-time where gravity is so strong that nothing, not even light, can escape from it). However, new research by an international team of astrophysicists, led by Dr Nuria Jordana-Mitjans at the University of Bath, is challenging this scientific orthodoxy.

According to the study's findings, some short-duration GRBs are triggered by the birth of a supramassive star (otherwise known as a neutron star remnant) not a black hole.

Dr Jordana-Mitjans said: "Such findings are important as they confirm that newborn neutron stars can power some short-duration GRBs and the bright emissions across the electromagnetic spectrum that have been detected accompanying them. This discovery may offer a new way to locate neutron star mergers, and thus gravitational waves emitters, when we're searching the skies for signals."

Competing Theories

Much is known about short-duration GRBs. They start life when two neutron stars, which have been spiralling ever closer, constantly accelerating, finally crash. And from the crash site, a jetted explosion releases the gamma-ray radiation that makes a GRB, followed by a longer-lived afterglow. A day later, the radioactive material that was expelled in all directions during the explosion produces what researchers call a kilonova.

However, precisely what remains after two neutron stars collide – the 'product' of the crash – and consequently the power source that gives a GRB its extraordinary energy, has long been a matter of debate. Scientists may now be closer to resolving this debate, thanks to the findings of the Bath-led study.

Space scientists are split between two theories. The first theory has it that neutron stars merge to briefly form an extremely massive neutron star, only for this star to then collapse into a black hole in a fraction of a second. The second argues that the two neutron stars would result in a less heavy neutron star with a higher life expectancy.

So the question that has been needling astrophysicists for decades is this: are short-duration GRBs powered by a black hole or by the birth of a long-lived neutron star?

To date, most astrophysicists have supported the black hole theory, agreeing that to produce a GRB, it is necessary for the massive neutron star to collapse almost instantly.

Disappearing Afterglow

What initially puzzled the researchers was that the optical light from the afterglow that followed GRB 180618A disappeared after just 35 minutes. Further analysis showed that the material responsible for such a brief emission was expanding close to the speed of light due to some source of continuous energy that was pushing it from behind.

What was more surprising was that this emission had the imprint of a newborn, rapidly spinning and highly magnetised neutron star, called a millisecond magnetar. The team found that the magnetar after GRB 180618A was reheating the leftover material of the crash as it was slowing down.

In GRB 180618A, the magnetar-powered optical emission was one-thousand times brighter than what was expected from a classical kilonova.

Electromagnetic Signals

Astrophysicists learn about neutron star collisions by measuring the electromagnetic signals of the resultant GRBs. The signal originating from a black hole would be expected to differ from that coming from a neutron star remnant.

The electromagnetic signal from the GRB explored for this study (named GRB 180618A) made it clear to Dr Jordana-Mitjans and her collaborators that a neutron star remnant rather than a black hole must have given rise to this burst.

Elaborating, Dr Jordana-Mitjans said: "For the first time, our observations highlight multiple signals from a surviving neutron star that lived for at least one day after the death of the original neutron star binary."

Professor Carole Mundell, study co-author and professor of Extragalactic Astronomy at Bath, where she holds the Hiroko Sherwin Chair in Extragalactic Astronomy, said: "We were excited to catch the very early optical light from this short gamma-ray burst – something that is still largely impossible to do without using a robotic telescope. But when we analysed our exquisite data, we were surprised to find we couldn't explain it with the standard fast-collapse black hole model of GRBs.

"Our discovery opens new hope for upcoming sky surveys with telescopes such as the Rubin Observatory LSST with which we may find signals from hundreds of thousands of such long-lived neutron stars, before they collapse to become black holes."

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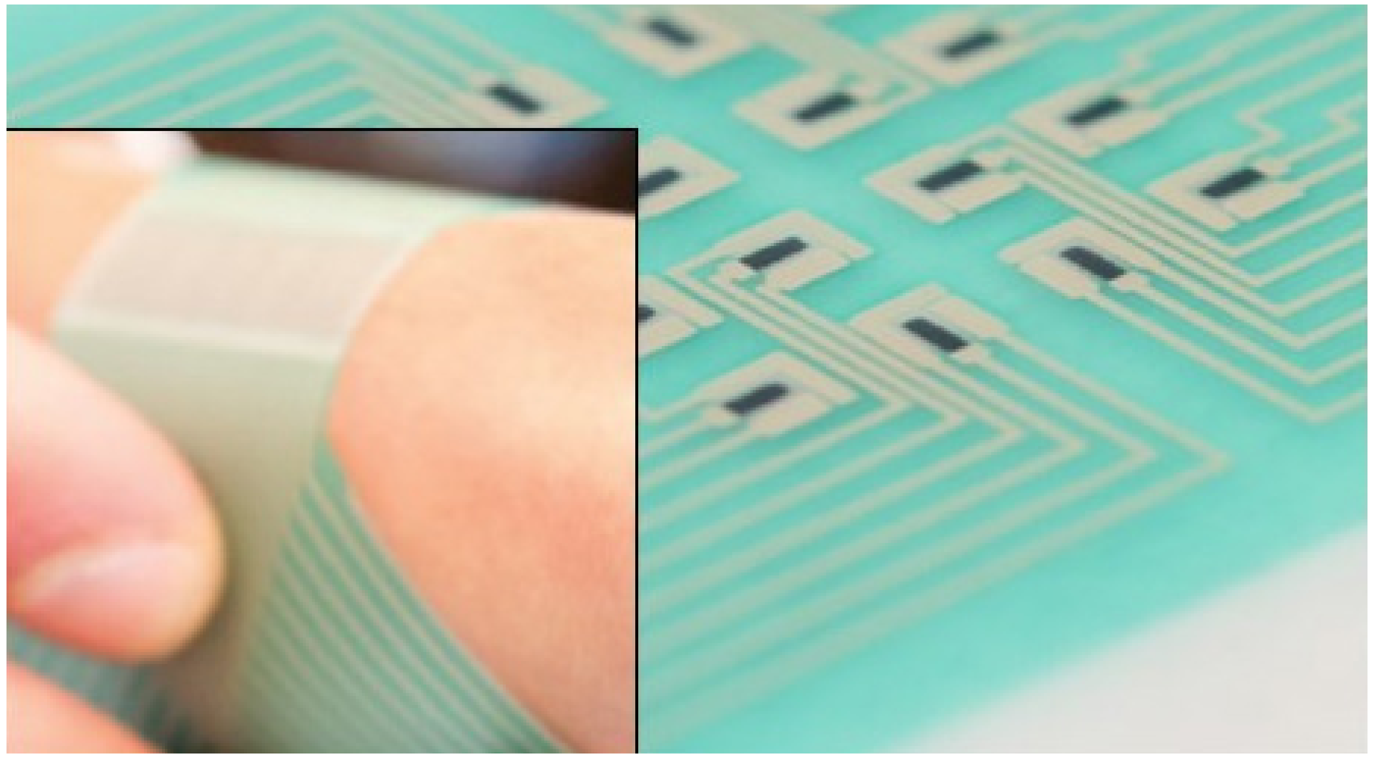
£1.1M funding for the world's first needle-free continuous glucose monitor

by Vittoria D'Alessio



Transdermal Diagnostics receives £800,000 in seed funding and a £300,000 grant from Innovate UK.

Transdermal Diagnostics, a University of Bath spinout company developing technology to monitor glucose levels non-invasively, has received £800,000 in seed funding and a £300,000 grant from Innovate UK.

The researchers have invented a wearable patch that allows people with diabetes to painlessly monitor their blood glucose levels. The £1.1M will advance the team's cutting-edge technology towards commercialisation.

The technology promises to enable people living with diabetes to significantly slow down, or even prevent, the progression of the disease by monitoring blood glucose levels around the clock in a completely painless manner.

The patch will sample glucose through the skin and will eliminate the need for the poorly tolerated finger-prick blood test. Readings will be transmitted wirelessly to a mobile phone.

In March this year, the researchers – led by by Dr Adelina Ilie, Dr Luca Lipani, and Professor Richard Guy from the Departments of Physics and Life Sciences at the University of Bath – established the spinout company that will continue to develop the patch.

Funding

Following the award of a prestigious Innovate UK grant of £300K at its inception, Transdermal Diagnostics has closed a pre-seed investment round of nearly £800,000.

The funding round was led by QUBIS, which specialises in innovation focused spin-out companies, and includes Pioneer Group, Immetric, Bristol Private Equity Club and Science Angel Syndicate.

Dr Ilie, chief scientific officer and director at Transdermal Diagnostics, said: *"Our wearable, affordable patch will appeal particularly to people living with Type-2 diabetes and those considered to be pre-diabetic. It has great market potential because no such technology currently exists on the market."*

She added: *"Developing the patch needed a truly interdisciplinary approach, and it was only made possible by the latest advances across multiple fields, such as advanced nanomaterials, nano- and bio-technology, and machine learning-driven data analysis. Scalable methods able to deliver a device like ours on a flexible platform were also essential."*

Dr Lipani, CEO and director of the company, said: *"Our technology equips users with the knowledge to manage and make informed decisions about their health, and we're delighted to have achieved the milestones of spinning-out the company and acquiring the investment needed to move the technology forward.*

"We have a great team and I'm confident we will be able to make a tremendous impact on chronic disease management, particularly for those individuals living with diabetes desperate to get rid of those painful finger-pricks for blood sugar monitoring."

Company director Professor Richard Guy said: *"The spin-out of Transdermal Diagnostics provides the impetus to develop a revolutionary, affordable and needle-free glucose monitoring technology to inhibit or even arrest the progression of diabetes, enabling those living with the disease to safely and effectively manage and control their blood sugar levels."*

Patented Technology

The patented patch technology – first reported in Nature Nanotechnology in 2018 – uses a unique multiplex architecture to sample, via preferential pathways, the fluid that nurtures the living cells of the skin. This fluid contains glucose at a level that is very similar to that found in the blood. The approach enables the amount of glucose sampled to be detected and quantified non-invasively, without puncturing the skin, thereby avoiding any need for a blood sample.

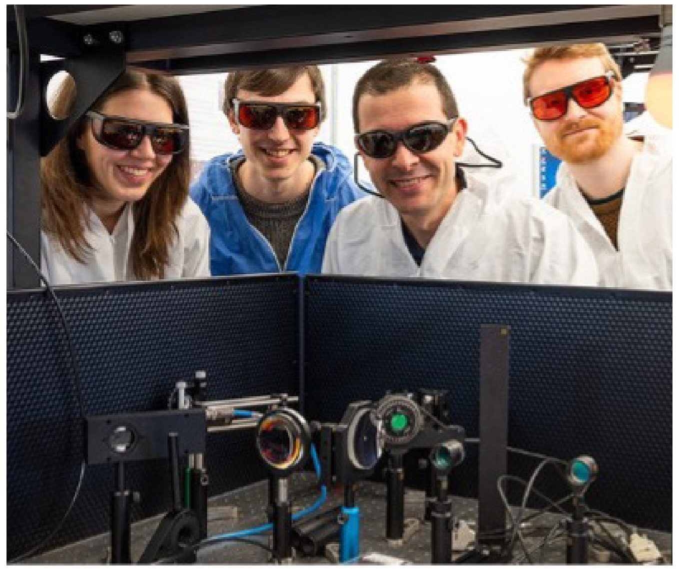
The process of spinning out the new company was catalysed by the research team's involvement in the Innovate UK Innovation to Commercialisation of University Research (ICURe) Discovery programme delivered by North by North West partners.

ICURe allowed the company's founders to determine market validity and the commercial potential of their glucose-monitoring technology. As a result, Transdermal Diagnostics was awarded an Innovate UK grant of £300K. The company has also received valuable input via the SETsquared Scale-Up Programme.

Transdermal's path through the ICURe programme was supported by business advisor and now company non-executive director, Dr Ben Miles, who is the CEO and founder of Spin Up Science.

Drs Jenni Rogers and Phil Brown of the University's Research & Innovation Services, supported the creation of Transdermal Diagnostics. Dr Rogers said: *"We're delighted to see Transdermal Diagnostics spin out from the university. The technology has great potential to benefit people with diabetes, in particular, and we look forward to seeing its commercial realisation."*

Researchers awarded Faraday Division Horizon Prize



by Vicky Just

A team of scientists including Chemistry and Physics researchers from Bath has won the Royal Society of Chemistry's 2022 Faraday Division Horizon Prize.

A team of scientists from the UK, Belgium and Germany has won the Royal Society of Chemistry's Faraday Division Horizon Prize for the discovery of chiroptical harmonic scattering, theoretically predicted in 1979 and demonstrated experimentally 40 years later.

When light of a certain colour (frequency f) shines on many materials, they can produce colour-shifted harmonics (frequencies 2f, 3f, 4f, etc.). In 1979, David Andrews, a postdoctoral scientist developed a theory predicting that on illuminating a chiral molecule with circularly polarised light, the intensity of light scattered at such harmonics would depend on the chirality of the scatterers – an effect known as chiroptical hyper Rayleigh scattering (CHRS).

However, for four decades, experimental evidence for such an effect remained elusive.

In 2019, a team at the University of Bath finally reported the first experimental observation of CHRS. Key to this success were the use of highly sensitive equipment and the choice of materials. The team made use of meta-molecules – silver nanohelices much smaller than the wavelength of light, fabricated in the group of Peer Fischer in Germany. Upon illumination with circularly polarized light, it was observed that the intensity of light scattered at the second harmonic (2f) depended on the chirality of the helices.

The Team's work provides a straightforward,user-friendly technique for an in-depth characterisation of the light-matter interaction in chiral materials.

This type of interaction is crucial for numerous emerging nanotechnologies – including nanorobotics, where the chirality of nanorobots can be used to monitor their functions.

The team at Bath, from the Departments of Chemistry and Physics, included: Dr David Carbery, Joel Collins, David Hooper, Robin Jones, Lukas Ohnoutek, Ben Olohan, Dr Dan Pantos, Dr Fabienne Pradaux-Caggiano, Dora Rasadean, Dr Kristina Rusimova and Professor Ventsislav Valev.

Dr Kristina Rusimova (Physics) said: "*Many molecules that are essential to life (e.g. DNA, amino acids) exhibit a handedness called chirality. This chirality can completely change their properties and thus knowing their exact chirality is absolutely vital.*

"This work constitutes the first demonstration of a simple and elegant method of detecting the chirality of both artificial nanostructures and molecules. Not only that, but the effect is 100,000 times more sensitive than its linear counterparts."

Professor Valev led the experimental work on the project. He said: *"The importance of chirality in biological processes is often compared to the invention of a standardised screw for the industrial revolution.*

"As human-made nanotechnology is progressing, it too requires chirality, for things to fit both together and with the existing biomachinery. It is at this interface, between organic and inorganic chiral technology, that I believe our technology will be most impactful; it could help characterize and guide chirality transfer between organics and inorganics."

Professor David Andrews, from the University of East Anglia, said: "It is a real honour, and especially rewarding, to win this prize and be connected with these pioneering experimental studies, vindicating theory from so long ago."

Historic buildings could be protected from rising energy bills by solar panels

by Vicky Just

New study by the CDT in New and Sustainable Photovoltaics shows installing solar panels on Bath Abbey could save 10 tonnes of carbon dioxide annually.

Installing solar panels could help historic buildings beat the rising costs of energy, according to a new study by a team of UK researchers led by the University of Bath.

- Feasibility study estimates installing solar panels on Bath Abbey could save around 10 tonnes of carbon dioxide per year – the weight of an African elephant or equivalent to an average car driving almost twice the circumference of the Earth.
- Solar panels could produce enough electricity to cover 35% of the Abbey's usage.
- Study demonstrates that using solar panels could significantly reduce the carbon footprint of key heritage buildings that are difficult to insulate.

Researchers from the Centre for Doctoral Training in New and Sustainable Photovoltaics – a consortium of seven universities led by the University of Bath that trains doctoral students in different aspects of solar energy technology – looked at the dimensions, tilt and orientation of the Abbey roof, along with historic weather data, and shading of the roof from spires, to model the best configuration for 164 photovoltaic (PV) panels and estimated the amount of electricity that could be generated in a normal year.

They found that the set up could produce around 45 Mega-Watt hours per year, which accounts for roughly 35% of the Abbey's annual usage. The equivalent amount of carbon dioxide saved, versus buying the electricity from the National Grid, would be around 10 tonnes per year, significantly reducing the carbon footprint of the building.

A cost-benefit analysis showed that the system could pay for itself in 13 years and provide a profit of £139,000 over a lifespan of 25 years. It would also future-proof the Abbey from rising costs of energy bills. The findings show that despite a large initial outlay, the system would be financially feasible for the historic grade I listed building.

They have published their findings in the journal Energy Science & Engineering.

Matthew Smiles, PhD researcher at the University of Liverpool who is first author on the study, said: *"It's very difficult to insulate historic Grade I listed buildings like Bath Abbey, so installing solar panels is a good way to reduce the carbon footprint of these buildings.*

"Most of the Abbey's electricity is used during the day, when the solar panels would be generating energy from sunlight, making it an ideal building to implement them.

"With increasing energy prices, installing solar panels could result in large cost savings."

In the model, the panels were sited such that they couldn't be seen from the street, only from a distance from the Bath Skyline, so would have minimal visual impact on the historic building.

Professor Alison Walker, Director of the Centre for Doctoral Training in New and Sustainable Photovoltaics at the University of Bath's Department of Physics, has collaborated with Bath Abbey for several years on the project.

She said: *"This paper is an amazing collaboration between the PhD students and the Bath Abbey Footprint Project who first invited us to look into solar for the Abbey and arranged for the students to visit the Abbey roof to see how solar could work.*

"It's great for the students, whose research projects are all on solar power, to see a practical application of the training they have done in universities across the UK".

PhD student Adam Urwick, who performed the abbey modelling, module design and shadings analysis from the University of Sheffield, said: "The proposed installation would generate 45MWh and save about 10 tonnes of CO_2 emissions in its first year of generation. This is equivalent to the emissions of an average vehicle driving 80,000km - almost twice the circumference of the Earth.

"Not only does it make financial sense, but the installation of solar panels on Bath Abbey could inspire reinvigoration of solar PV deployment in the UK which has stagnated over the past 5 years."

The research was performed as part of a feasibility study for the Abbey's Footprint programme, as part of the Church of England's campaign, Shrinking the Footprint, which aims to reduce the carbon footprint of its historic buildings.

The Bath Abbey Footprint programme has already reduced its carbon footprint by using the geothermal hot springs of the local area to provide underfloor heating and installing LED light bulbs to illuminate the interior.

Although environmental and planning rules must also be considered carefully, installing solar panels is another potential way the Abbey could reduce its footprint further.

Nathan Ward, Footprint Project Director at Bath Abbey, said: *"It's been fantastic working with the University of Bath and the other universities on this project. The students and staff have shown a high level of commitment, knowledge and enthusiasm and have provided us with well-considered and invaluable research that we would like to use practically in the future.*

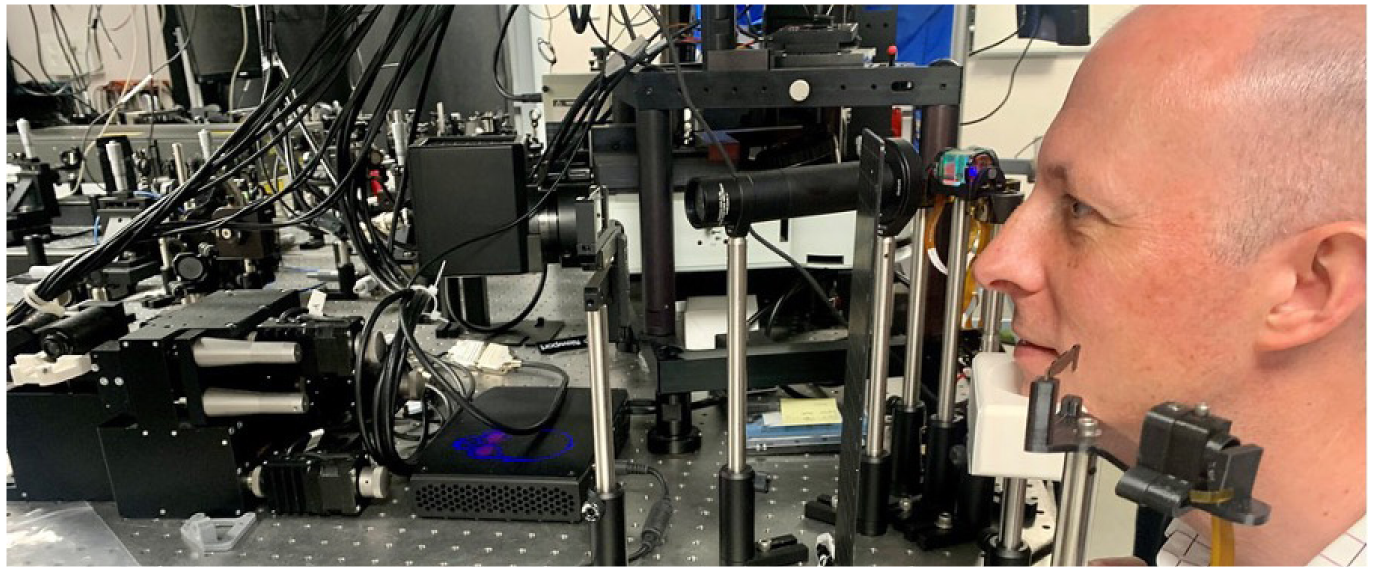
"The research will help us greatly in exploring the use of solar panels on the Bath Abbey roof. The Abbey is highly committed in the outstanding care of both our built and natural environment and to reduce our carbon footprint.

"This has been achieved in part thanks to our Footprint project which saw the installation of new LED lighting and eco-friendly underfloor heating that uses energy from Bath's natural hot water, but the use of solar panels would enable us to reduce our carbon footprint further."

The Centre for Doctoral Training in New and Sustainable Photovoltaics is a consortium of seven universities and 12 industrial partners led by the University of Bath and funded by the Engineering and Physical Sciences Research Council (EPSRC). The universities include: The Universities of Bath, Cambridge, Liverpool, Loughborough, Oxford, Sheffield and Southampton.

Bath researchers attend joint optics workshop at Tel Aviv University

by Vittoria D'Alessio



Researchers from the Centre for Photonics and Photonic Materials at Bath attend a workshop hosted by the Tel Aviv University Center for Light-Matter Interaction

Researchers from the Centre for Photonics and Photonic Materials at the University of Bath have attended a workshop hosted by the Tel Aviv University Center for Light-Matter Interaction, aimed at fostering new collaborations, and developing existing ones, between the two institutions.

The four-day trip saw researchers attend talks covering a range of photonic and metamaterial systems, followed by visits to various laboratories across the Tel Aviv Campus. The visit is the second of its kind, with the previous 2016 event leading to several joint papers and grant applications in soliton photonics, quantum and chiral optics.

Professor Ventsislav Valev, lead organiser from the University of Bath of this year's trip, said, *"This was a great opportunity to see some fantastic science and generate new ideas between our diverse and active research centres. We are extremely grateful to our hosts at Tel-Aviv University, who organised the local programme and provided many opportunities for fruitful discussions. I am confident that the visit will lead to tangible research outputs between the two universities."*

Professor Ady Arie, who led the organisation from Tel Aviv University, said: *"We were delighted to host our colleagues from the University of Bath. The visit provided exposure to the current research in topics of joint interest and will further strengthen the successful collaboration between researchers from the two institutes."*

The workshop covered a broad range of topics on the science of light, including solitons, microstructured fibre, advanced non-linear optics, optical computing, and optical chiral materials. Contributions from the University of Bath included talks from Dmitry Skryabin, Euan Allen, Peter Mosely, Kristina Rusimova, and Ventsislav Valev. Contributions from Tel Aviv University included Itai Epstein, Tal Carmon, Haim Suchowski, Ady Arie, Boris Malomed, Gil Markovich, Tal Ellenbogen, Sharly Fleischer, and Pavel Ginzburg. The day also saw attendance from Karen Shurkin, head of UK Science & Innovation Network Israel at the British Embassy.

It is anticipated that this trip will result in even more research collaborations forming between the two centres, with a further follow-up return visit to Bath within the next two or three years.

The workshop was sponsored by the Academic Study Group on Israel and the Middle East and by the Tel Aviv University Center for Light-Matter Interaction.

Laser scientists from Bath and Bulgaria strengthen ties in Sofia

by Vittoria D'Alessio

A series of workshops on photonic and laser systems in Sofia strengthen collaborations between scientists from the UK and Bulgaria.

A workshop on photonic and laser systems has taken place in Sofia, the capital of Bulgaria. The objective was to foster existing collaborations and develop new ones between scientists from the UK and Bulgaria.

Representing the UK were physicists from the Centre for Photonics and Phonic Materials (CPPM) at the University of Bath, while the Bulgarian participants hailed from University of Sofia and the Bulgarian Academy of Sciences. The workshop was organised by the UK Embassy to Bulgaria. During the four-day trip, the researchers also visited four laboratories in Sofia.

Dr Rob Dixon, Her Majesty's ambassador to Bulgaria, said: *"It is great to see this fantastic UK-Bulgarian cooperation in laser science and technology. Nearly 50% of all Bulgarian science projects under the Horizon 2020 programme had a UK partner. It is important to preserve this partnership."*

Professor Ventsislav Valev, who led the Bath team, said: *"This was a wonderful opportunity to see exciting new science being developed with state-of-the-art laser systems in the Bulgarian institutions. We discovered many areas of overlapping scientific interests between Bath and our Bulgarian colleagues.*

"Our discussions have opened a plethora of collaboration possibilities. We are extremely grateful to our hosts in Sofia, and especially to Dr Emilia Pecheva from the UK Embassy for the flawless organisation of the entire event. Doubtlessly, there will be impactful scientific outcomes from this visit."

Professor Hassan Chamati from the Institute of Solid State Physics in Sofia gave the opening talk at the event. He said: *"It was a great pleasure to host our colleagues from the CPPM in Bath. We are grateful for the interest in our work and, in turn, we were delighted to learn about work in the UK. The visit provided an excellent foundation for establishing further research collaborations in the area of laser science."*

The topics at the workshop covered a broad range of research topics, including optical fibres, quantum photonics, quantum computing, chirality, nonlinear optics, ultrafast laser processing, laser-matter interactions, new laser sources for technological applications, and nuclear magnetic resonance.

Contributions from the University of Bath included talks from Professor Jonathan Knight, Dr Peter Mosley, Dr Joshua Nunn and Professor Ventsislav Valev. Contributions from Sofia included Professor Todor Petrov, Professor Lyubomir Stoichev, Professor Lubomir Kovachev, Professor Nikolay Nedyalkov, Professor Ivan Buchvarov and Professor Pavletta Shestakova.

Professor Valev added: *"I felt deeply moved by our visit to the Faculty of Physics at Sofia University. Over 25 years ago, as a wide-eyed schoolboy and would-be physicist, I visited this faculty for inspiration. Seeing my enthusiasm, my girlfriend at the time (wife now) took a photograph of me in front of the entrance.*

"Returning now, as a professor of physics and future head of department on a visit organised by the UK Embassy was a humbling experience and something of a personal pilgrimage. I am especially grateful to my colleagues for offering to recreate the photograph."

It is anticipated that this trip will result in research collaborations forming between the CPPM and scientists in Sofia, with a further follow up visit in the next two or three years.

The workshop was sponsored by the UK Science and Innovation Network in Bulgaria.

Enhanced pacemaker developer Ceryx Medical wins prestigious Institute of Physics award

by Tony Roddam

University of Bath spin-out hailed for revolutionary development to provide world's first curative therapy for heart failure.

Bioelectronic company Ceryx Medical, a spin-out from the Universities of Bath and Bristol, has won the 2022 Business Start-up Award from the UK's Institute of Physics, which praised the company's revolutionary bioelectronic devices.

Ceryx was formed in 2016 as a joint venture exploiting the neuronal technology patented by the University of Bath and the know-how in cardiac neuromodulation at the University of Bristol. This innovative research created microchip technology for medical devices that restores the natural synchronization of biological rhythms, including a neuronal cardiac pacemaker which has the potential to provide the world's first curative therapy for heart failure.

"These bioelectronic devices help restore the lost physiological functions within the body. This approach allows revolutionary therapies with no side effects to be employed," The Institute of Physics - the professional body and learned society for physics in the UK and Ireland - said in its award citation.

Unlike conventional pacemakers which apply metronomic stimulation, the neuronal pacemaker produces minute adjustments to heartbeat intervals to resynchronize the cardiac and respiratory rhythms. This has the effect of saving the heart energy, reverting the debilitating symptoms of heart failure by giving the heart the opportunity to repair itself.

"We are delighted to have been recognised nationally for our development work on solving a truly global problem. An estimated 30 million people suffer from heart failure and, once the cycle of heart failure is established, current therapies can do little to prevent disease progression. We believe we can change that," said Dr Stuart Plant, Ceryx Chief Executive Officer.

"Even on optimal medical therapy, mortality rates five years from diagnosis are 50%, which is considerably higher than most forms of cancer. Caring for these patients accounts for around 2 percent of healthcare budgets, around £100 billion every year," Plant said.

Alain Nogaret, co-founder of Ceryx, and Professor at the University of Bath's Department of Physics, said: *"I am delighted to see Ceryx technology recognised by the Institute of Physics. Ceryx is an example of how research in nonlinear science can be translated to medical device applications for the greater benefit of society."*

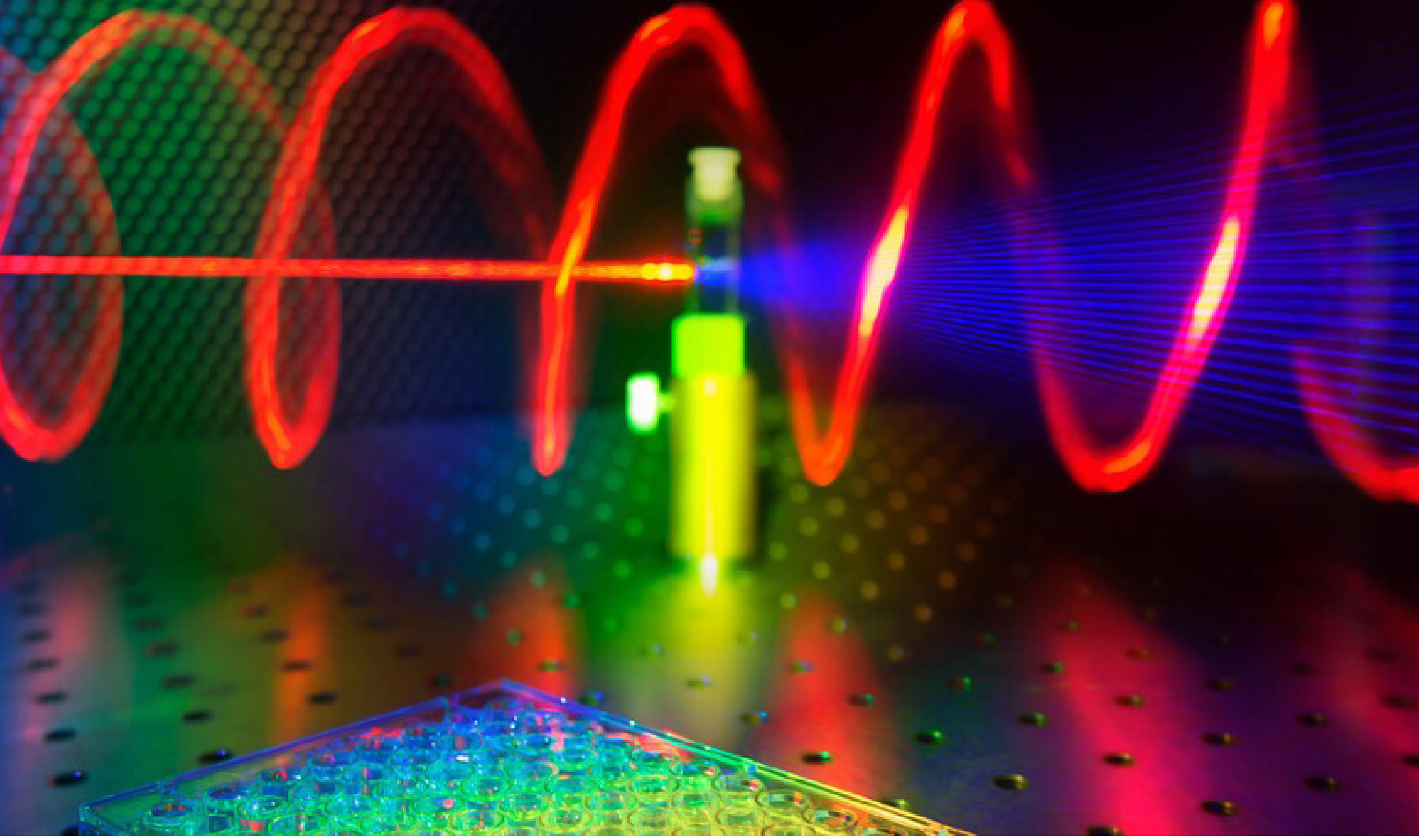
Jonathan Knight, Vice-President (Enterprise) at the University of Bath, said the university was proud to have played its part in helping Ceryx grow.

"The University of Bath works with businesses, researchers, and students to enable new ideas, innovation, and growth – Ceryx is just one of the many success stories in our Enterprise and Entrepreneurship community – and this recognition by the Institute of Physics is well deserved," Knight said.

The technology developed by Ceryx continuously monitors the patient's cardiorespiratory system, processing this information and generating precisely timed impulses which optimise the beating of the heart. By restoring the natural modulation of the heart, it has the potential to restore cardiac performance, boost physical performance, relieve stress on the heart and even reverse cardiac remodelling indicative of heart failure, all of which goes towards saving patients' lives and improving their quality of life.

Dr Plant added: *"One complaint we hear from heart patients fitted with a conventional pacemaker is that their heart feels disconnected from their emotions – one patient said she was disconcerted when seeing her new grandchildren to find her heart did not match the joy she knew she was experiencing. We would like to remedy that."*

Ceryx plans to launch its first human studies for the enhanced pacemaker in early 2023.



Keeping up with the first law of robotics: A new photonic effect for accelerated drug discovery

by Vittoria D'Alessio

Physicists at the University of Bath and University of Michigan demonstrate a new photonic effect in semiconducting nanohelices.

A new photonic effect in semiconducting helical particles with nanoscale dimensions has been discovered by an international team of scientists led by researchers at the University of Bath. The observed effect has the potential to accelerate the discovery and development of life-saving medicines and photonic technologies.

In his Robot series, science-fiction writer Isaac Asimov imagined a future where robots grew into trustworthy companions for humans. These robots were guided by the laws of robotics, the first of which states that 'a robot may not injure a human being or, through inaction, allow a human being to come to harm'.

Thanks to the new photonic discovery, robots may get a chance to prevent humans from coming to harm in a very meaningful way – by greatly speeding up the development of important drugs, such as new antibiotics.

Currently, the World Health Organisation regards antibiotic resistance (the growing ineffectiveness of drugs currently on the market) as one of the top 10 threats to humanity. Moreover, globalisation coupled with human encroachment into wildlife habitats increases the risk of new infectious diseases emerging. It is widely recognised that the cost of discovering and development new drugs for these and other conditions using today's technology is unsustainable. The need for pharmaceutical research to be accelerated has never been more pressing and it would benefit hugely from the help of artificial intelligence (AI).

Bath Physics professor Ventsislav Valev, who headed the research, said: *"Although we are a long way still from Asimov's positronic robot brains, our latest finding does have the potential to link AI algorithms that analyse chemical reactions and robotic arms that prepare chemical mixtures – a process known as high-throughput screening."*

Meeting the needs of robotised chemistry

High-throughput screening (HTS) is an experimental method that uses robots to discover new drugs. Some labs have adopted it already, to help them analyse vast libraries of molecules. In the future, however, discovering new drugs could happen entirely through HTS. Using this method, robots simultaneously operate a large number of syringes, preparing thousands of chemical mixtures that are then robotically analysed. The results are fed back to AI algorithms, which then determine what mixtures to prepare next, and so on until a useful drug is discovered.

The analytical step is key, since without it, the robots cannot know what they have prepared.

HTS happens on microplates (or tablets) that are about the size of a chocolate bar. Each tablet contains wells into which the chemical mixtures are poured. The more wells found on a tablet, the more chemicals can be analysed in one hit. But though a modern tablet can host thousands of wells, the size of the table does not change.

"To meet the requirements of the emerging robotised chemistry, wells are getting really tiny – too small for current analytical methods," said Professor Valev. "So, fundamentally new methods are needed to analyse would-be drugs.

"Currently, most new drugs that are entering the market and the majority of old drugs are chiral (their chemical formula lacks mirror symmetry). Therefore it is especially important to be able to measure chirality in tiny volumes of less than 1 mm3 which is about the size of a cube with sides of the thickness of a credit card."

The effect discovered by the researchers allows chirality to be measured in volumes that are 10,000 times smaller than 1 mm3.

"We have used a very exciting new material developed by our colleagues at the University of Michigan in the US, led by Professor Nicholas Kotov," explained Professor Valev. "It's a biomimetic structure (i.e. one that simulates biological phenomena) that chemically assembles into semiconducting helices, at the nanoscale, similarly to the way proteins assemble."

Professor Kotov said: "Being illuminated with red light, the small semiconductor helices generate new light that is blue and twisted. The blue light is also emitted in a specific direction, which makes it easy to collect and analyse. The trifecta of unusual optical effects drastically reduce the noise that other nanoscale molecules and particles in biological fluids may cause."

Professor Valev added: *"This means that by carefully measuring the blue light, we can ascertain the direction of twist (or chirality) of the structures we're studying."*

The twist of the nanohelices can change dramatically depending on the kind of biomolecules that were present when these helixes formed, providing a wealth of information about the biological samples.

"Our results open the way for measuring chirality in volumes potentially 10-million times smaller than 1 mm3. Although the structures that we measured so far are much larger than typical pharmaceuticals, we have proven that the physical effect is real, so in principle, applications to molecules and especially drugs are now only a question of technological development. Our next step is to seek funding for this development," said Professor Valev.

PhD student Lukas Ohnoutek, also involved in the research, said: "In nanotechnology, one of the big challenges is to be able to see the properties of tiny things. Nowadays, this is easy for stationary objects but it's still hard for an object that freely floats in a liquid.

"It has been extremely gratifying to reduce our volume of study so successfully – we now focus light to a spot that would be invisible to most people's eyes. And within that volume, we can determine the direction of twist of helices that are much smaller still."

The research is published in the journal Nature Photonics. It was funded by The Royal Society, the Science and Technology Facilities Council (STFC) and the Engineering and Physical Science Research Council (EPSRC).

Image: Upon illuminating chiral semiconductor nanoparticles with circularly polarised light (in red), third harmonic Mie scattering light streams out (in blue). **Credit:** Ventsislav Valev, Kylian Valev and Lukas Ohnoutek

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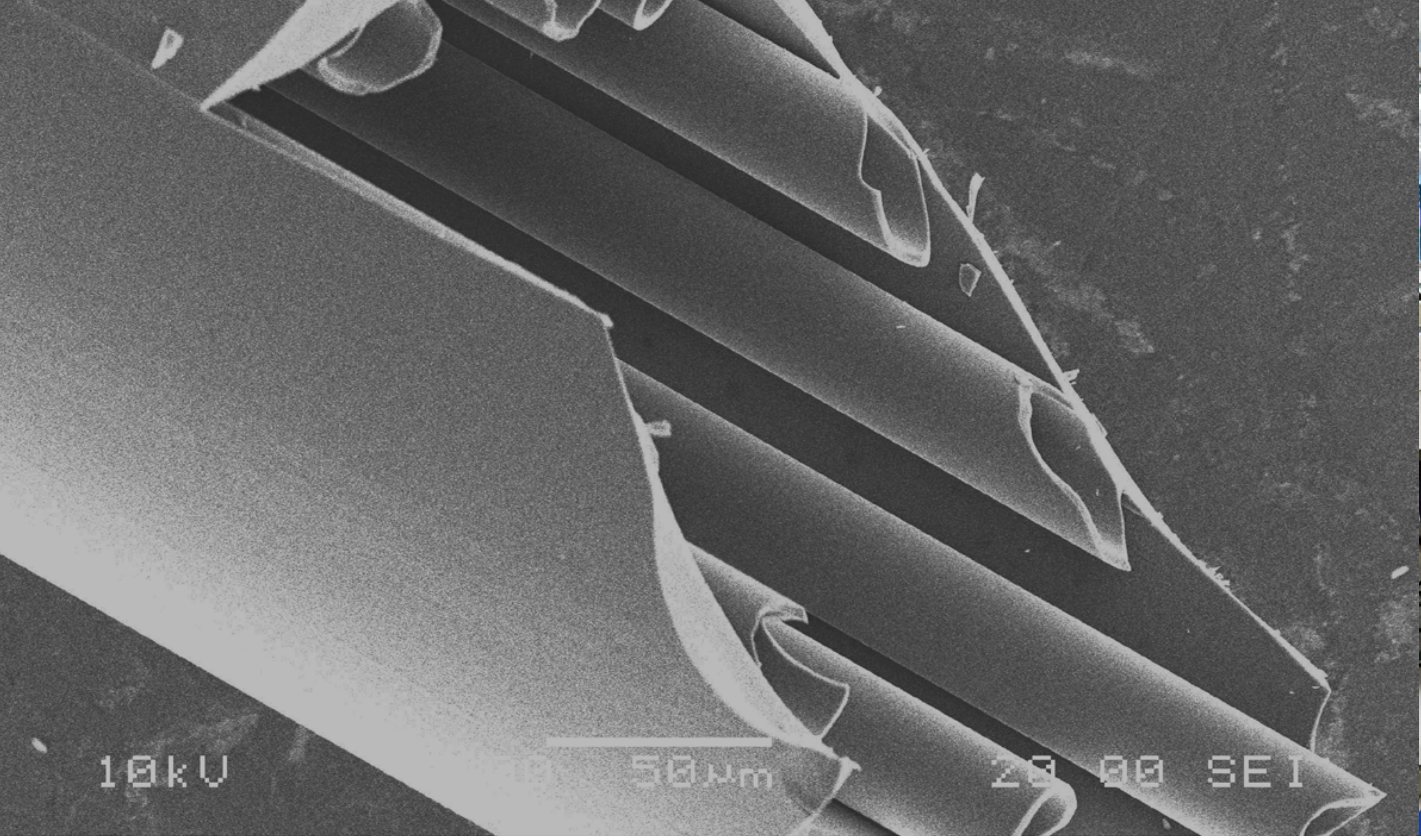

Blue light boost for hollow optical fibres

The University of Bath's Centre for Photonics and Photonic Materials (CPPM) is working with BT's global research and development centre to boost the use of hollow-core optical fibre.

Researchers from BT will use the Centre's optical fibre fabrication facility and photonics lab to develop a better understanding of potential applications of hollow-core optical fibres.

"This work provides an exciting challenge at the forefront of photonics," said Dr Daniel Gilks, Senior Researcher, Breakthrough Hardware Prototyping and Amelia Lees, Network Physics at BT.

"This collaboration will be a part of ongoing work within BT's Strategy and Research department to build a meaningful strategic relationship between BT and the University of Bath.

"This is an exciting opportunity to work alongside researchers from BT to develop new hollow-core fibre and understand the impact that it might have in enhancing the performance of future communication networks. We're looking forward to getting stuck into the project, fabricating fibre and commissioning a rubidium filling rig," said Dr Peter Mosley, senior lecturer from the Department of Physics at the University of Bath, will lead the project.

"We hope that this initial project will develop into an ongoing relationship between BT and the CPPM, enabling our expertise in specialty fibre to be brought to bear on a variety of challenges in communications," he said.

New teaching labs opened in Department of Physics

The Department of Physics has completed the installation of brand new purpose designed undergraduate teaching laboratories. Find out more.

Earlier this year the Department of Physics started work on the installation of brand new undergraduate teaching spaces in East Building. We are excited to announce that these are now open and ready for use.

Located in East Building, the new physics laboratories are more than 700m2 of purpose designed space for undergraduate teaching. They bring together experimental activities and projects in all years, as well as theoretical, computational and industry-led projects in the final year.

The large and airy laboratories provide a fitting home for our high quality equipment, including for low-temperature physics, astrophysics, photonics, quantum and electronic physics, and nanophysics.

Professor Ventsislav Valev, Head of Department said *"We have always been proud of the excellent practical provision in our physics courses. This new investment provides a fantastic environment for students where their practical, computational and project skills will develop during their time in Bath. I'm especially grateful to Professor William Wadsworth, who led the relocation of our teaching laboratories."*

Seeing stars in Bath with the Bath Physics Observatory

Astronomy is one of the few sciences where the data (star-light) can be seen by all. Yet, there is a disconnect between a typical undergraduate lecture and, for example, where a planet may be in the sky and how to observe it. With the advent of moderate cost, high-quality "back-garden" astronomy, and standard computers powerful enough to produce original research, we have shown that it is possible to build a small observatory capable of authentic astrophysical research for a modest budget.

In 2018 Drs Peter Sloan, Vicky Scowcroft, Steve Davies and Gary Mathlin formed a group with this goal. Since then, we have gone from a Raspberry Pi camera and home-owned telescope, to a permanent roll-top observatory with two fully automated telescope systems capable of undergraduate use and astronomical science. This has been funded by the Alumni Fund at Bath, the Faculty of Science and the Royal Astronomical Society. So far, the observatory and its telescopes have been used by six MPhys students and four BSc students doing final year projects, as well 10 Year 2 students undertaking an innovative Extended Physics Project in the main year 2 lab unit and one year 2 student project on an RAS funded summer project. These projects have focused on planetary transits, variable stars and planning for high-resolution planetary imaging. We have recently bought a high-resolution spectrometer with the aim of measuring radial velocities of binary star systems, the rotation of galaxies and the temperature variation of pulsating stars. To briefly expand on one topic, to understand how the Universe is evolving, we must first build a map. But how far away are the stars? All we have is a measure of their brightness. They could be bright and far away or nearby and dim. How would you know? It turns out a particular family of stars pulsate, resulting in their brightness changing over time. The timescale of these brightness changes is driven primarily by the star's size, which in turn is related to the intrinsic brightness of the star. By comparing the brightness of the star measured at the Observatory with that predicted from the pulsation period, we can infer the distance of the star. This is the same technique that sailors used to infer distances to lighthouses, where 'standard candles' of known brightness were used to help them navigate the coastline in the days before GPS.

One of the big open questions in astronomy today is 'how fast is the Universe expanding?'. To answer this question, we must have very accurate and precise distances not only to the most distant objects, but also to those nearby. The stars that provide the key to answering this question are very nearby; so close that they appear too bright to observe with large telescopes. However, they are ideal targets for small telescopes such as the ones at the BPO. The work carried out by the undergraduate students in labs and projects can (and will) directly contribute to this research, providing data that is not obtainable at professional observatories.

We are building up expertise and teaching material so that the observatory can be used to a high level by a wider cross-section of students. We hope it inspires and helps educate many students to come.

Image centre : M51 - the Whirlpool Galaxy taken from the BPO

Tutorial activities by Dr Gary Mathlin

Since the founding of the department, tutorials have been a key part of our teaching program. They combine academic and pastoral aspects, where discussions bring together themes from across several units. Students also receive feedback on draft lab reports and advice on their academic progression, which can include CVs and career development.

In September 2001, I was given a 1st year tutor group of students who came through clearing (our students came with typical grades BCC at the time). I thought the aim of the game was to produce the graduates with the best degree classification and failed to realise that tutorials were not a competitive sport, so I worked the group really hard through years one and two. As a result, three of the group went on to land excellent graduate jobs or further study, mainly as a result of placements.

One student went to the Royal Navy nuclear submarine division on placement and after graduating joined the officer training core and became a submarine commander.

The second one went to the avalanche research centre in Davos, and, as a result of the people she met there, moved to Leeds to do a PhD in wind shear on mountainous landscapes and then post-doc in the USA. She is now a member of a faculty in a US college.

The third student went on placement to a finance institution in London. After graduating, he joined the company as an options and futures trader and earned very large sums of money.

The last student in the group struggled and took several repeat years . He joined his father's undertaking business when he graduated but, after a year, landed a job in the off-shore oil and gas industry where he rose quickly to become head of exploration of the West Africa and Scandinavia division of the firm.

Nowadays, students come with grades A*AA but the lessons learnt still apply. The work I did with that group laid the foundation of the way I run tutorials today.

Each student takes a regular turn in standing at the white board summarising topics/parts of topics from the current units while the rest of the group ask questions to uncover all the sticking points and misconceptions.

Additionally, each student presents a draft of each lab report which the rest of the group peer reviews, pointing out things that don't make sense, as well as any contradictions, structure problems and so on.

I use this with all my Physics groups. I do it in such a way that the students take ownership of the process and, after a few weeks, start dividing up the topics and scheduling the peer reviews themselves.

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