Spring 2017, Number 10

Department of Physics Newsletter

UNIVERSITY OF OXFORD

FROM OXFORD TO MARS

The enigma of methane on Mars

PAVING THE WAY TO A NEW GENERATION OF LIGHT SOURCES
Plasma acceleration

POWERED BY A STAR
Astronomy off the grid

THE IMPACT OF OUR RESEARCH
A new collaborative initiative with Industry

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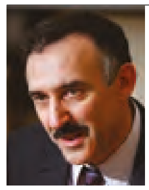
PAVING THE WAY TO A NEW GENERATION OF LIGHT SOURCES



Professor Andrei Seryi, Director of the John Adams Institute (JAI)

One of the most spectacular phenomena, as we often hear from schoolchildren visiting our Physics Department, is a meteor shower – a wide glowing trail left by tiny grains of matter on the night sky. Even more amazing (rare but still possible in Oxfordshire) are Aurorae Borealis, the result of interaction of 'solar wind' – the accelerated subatomic elementary particles – with the Earth's atmosphere.

Cosmic rays – elementary particles of tiny masses, which enter the Earth's atmosphere with the energy of a cricket ball – are much more difficult to observe with a naked eye and even their acceleration mechanism still remains a mystery. Yet we are often asked by schoolchildren; can we create such cosmic rays in the laboratory, and if so, why would we want to do this and how would we use such scientific tools?

Following Freeman Dyson, who refuted the idea of concept-driven scientific revolution and instead argued that creation of scientific tools drives progress, we are well armed to answer these questions. We can point schoolchildren to the many tens of thousands of accelerators used in science and industry. We can describe how physicists and engineers can, in fact, compete with nature. Even though the elementary particle energies achieved in accelerators are less than a millionth of those of the most energetic space particles, we can accelerate billions and billions of particles simultaneously. Moreover, we have found ways to focus the particle flux and compress it to a tiny size. For instance, one of the most ambitious modern accelerators – the Large Hadron Collider (LHC) at CERN – accelerates proton beams to an energy equivalent to that of a Boeing 747 at take-off, and this energy is concentrated within a 'point' less than a human hair in diameter.

PAVING THE WAY FOR NEW ACCELERATORS

Discoveries such as those enabled by accelerated beams can shake our imagination and amaze us, both with the ability of modern physics to predict them, and with their ever-reaching consequences. The Higgs Boson (predicted back in 1964 and revealed in 2012 by an instrument, the LHC, whose construction began in 1998) is of profound importance for understanding the mechanism that creates masses of all subatomic particles. Discoveries that, we hope, are still to come at the LHC, are perhaps those true 'unknown unknowns' (in contrast to the predicted, thus 'known unknown' Higgs) that will take us beyond the Standard Model of particle physics and promise to be even more fascinating.

Excited by the recent progress, we should also be vigilant about the next steps. The time it takes to design and build any new accelerator or collider, and the fact that their sizes and costs tend to increase, slowing down progress in recent decades, indicates that a technological revolution is required to make further progress. Back in 1940 Enrico Fermi dreamed about a giant accelerator on a stable orbit that circled the Earth. We now need to be much more responsible and ensure that every technological advance is explored and exploited before we can propose to funding agencies a collider even two or three times larger than the LHC.

Thinking about the next technological revolution in accelerators, we can recall that some plasma physicists have recently argued that the above-mentioned ultra-high-energy cosmic rays are, in fact, the result of plasma acceleration happening far away in our Galaxy. These same processes may drive the technology to create the next breakthrough here on Earth. And even though we do not directly study cosmic rays at the John Adams Institute (JAI) for accelerator science, we are looking into this technology as a possible workhorse for next generation colliders and various other accelerators.

Conventional accelerators operate on the principle of particle acceleration in resonators, these are metal containers of a certain shape that have a limited ability to withstand strong electromagnetic fields due to possible electric breakdowns and destruction of the resonator walls. However, the wave produced in plasma, a material which is already 'broken-down', can create an accelerating gradient a thousand times larger, which would allow us to reduce the size of the accelerators.

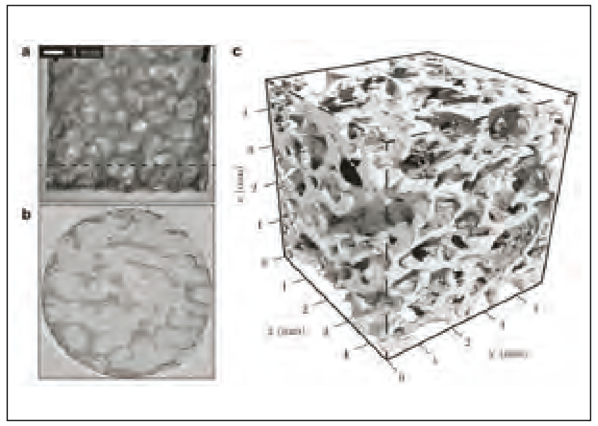
PLASMA-BASED COLLIDERS: FROM CONCEPT TO REALITY

We are often asked the question: 'when will plasma acceleration-based colliders become a reality?' The answer is, certainly not tomorrow: the research and development roadmaps toward plasma acceleration colliders created by US and European communities extend to around 2035.

With colliders in mind, here at the JAI we are strongly focused on plasma acceleration applications that have a more immediate use for society and industry: compact light sources. Our eventual goal is the creation of a compact, coherent x-ray source – a Free Electron Laser (FEL) – similar in functionality to the operating Linac Coherent Light Source (LCLS) at the Stanford Linear Accelerator Centre (SLAC) or the European XFEL being commisioned at the German Electron Synchrotron Centre (DESY, Hamburg) – but about a hundred times smaller, thanks to advantages in plasma acceleration.

Figure 1 (opposite below): Concept of an incoherent x-ray source based on laser-plasma accelerator.

Figure 2 (opposite above): Tomographic reconstruction of trabecular bone sample:
a) a raw image of the bone sample recorded on the x-ray camera;
b) 2D reconstruction of a one-pixel high horizontal slice of the sample at the position indicated in a);
c) stacking together 1,300 such slices generates a 3D voxel map of the bone sample. An isosurface marking the detailed structure of the bone surface is constructed and rendered using a ray-tracing method.



IMAGES IN FIG. 2 COURTESY PROF ZULFIKAR NAJMUDING (IMPERIAL COLLEGE AND JAI), J. COLE ET AL, SCI REP. 2015 AUG 18;5:13244. DOI: 10.1038/SREP13244.

Building an FEL based on plasma acceleration requires solving a number of challenges. For instance, if we scale up all the phase space dimensions, the beam accelerated by plasma looks like a sheet of A4 paper – very thin (in size) and wide (in angular and energy spread). Our dream beam, however, would have the same volume but would be round, like a hazelnut. Creating a beam with proper phase space suitable for FEL is a task we are currently working on. Another challenge we have is the limitation imposed by high power solid-state lasers needed for plasma excitation which, unfortunately, have low repetition rates (just a few Hz), and very low 'wall-plug' efficiency. The multi-pulse plasma acceleration technology developed by our team and led by Prof Simon Hooker (JAI/Oxford) could use high-repetition-rate fibre lasers to overcome this difficulty.

While the plasma acceleration FEL is being actively developed, a compact incoherent light source based on plasma acceleration (see Fig. 1) is already possible and can actually be quite bright. In fact, it is comparable in peak brightness with the third generation synchrotron light sources. The x-rays produced by such sources have already been used in trials conducted in consultation with medical experts. For example, the team led by Prof Zulfikar Najmudin of JAI/Imperial College London (ICL), is studying microscopic bone damage caused by osteoporosis – see Fig. 2.

A BOLD NEW APPROACH TO TRAINING ACCELERATOR SCIENTISTS

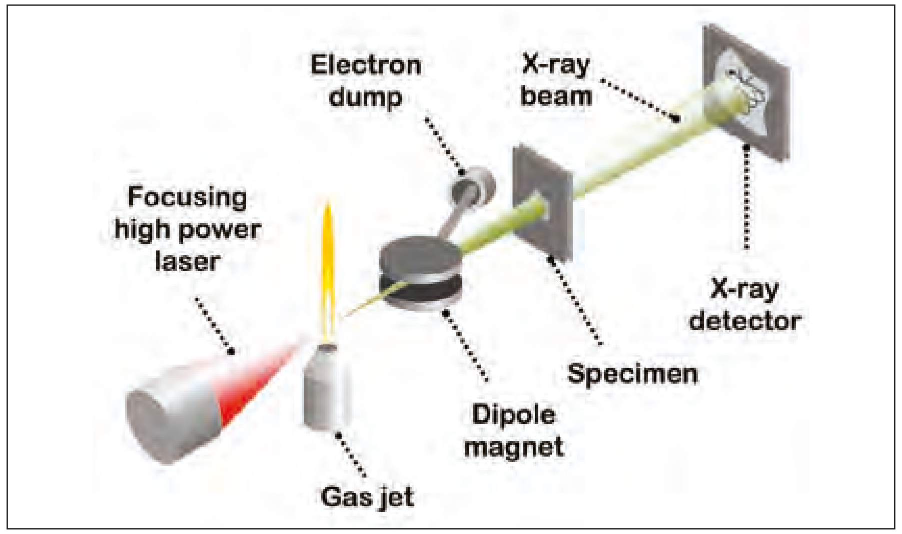
Work on novel technologies such as plasma acceleration FEL and light sources requires a new approach to graduate training. The graduate course offered to JAI students is coordinated by Prof Emmanuel Tsesmelis (CERN/JAI) and combines classic accelerator theory with plasma and laser physics, as well as real life experiences such as lectures given to students via video from the heart of the LHC-CERN control room.

The JAI graduate training is world renowned with its trademark being the students' design project. In this project, all first-year JAI graduate students work as a team for two months to design an innovative accelerator, ensuring that all the major systems (optics, magnets, accelerator systems) are self-consistent. The projects vary each year, with recent projects ranging from a plasma accelerator for proton therapy to the electron-positron option of the Future Circular Collider.

The JAI students' design project utilises a proven and effective hands-on approach. It allows students to master and put into practice the theoretical concepts and methods they have learnt during the previous terms' lectures.

The JAI's graduate training approach has been successfully applied in 2016 at the US Particle Accelerator School (USPAS) where Prof Andrei Seryi (JAI/Oxford) and Dr Aakash Sahai (JAI/ICL) taught a one-week class on 'Unifying physics of accelerators, lasers and plasma'. Here the design project had to be completed in just one week, so detailed simulations were replaced by estimations of the parameters of the key systems.

The results of this JAI-led USPAS class exceeded our expectations; the students were able to develop a novel design of an x-ray source based on a compact storage ring of an electron beam with on-orbit and on-energy injection by a laser plasma acceleration system. Based on their successful design, the team of students were invited to present their concept at the prestigious North American Particle Accelerator Conference (NAPAC 2016) where the USPAS leadership praised their achievement.



Following the research and training principles outlined above, the JAI is determined to bring its basic research to industrial, medical and societal applications in the near future. We hope that our research will help to design compact sources of synchrotron radiation that are based on synergy between lasers and new accelerators. We believe that these sources will be able to revolutionise the world of accelerator physics and its applications, as has happened with the invention of visible-light lasers, which spurred science and industry in the 20th century. In particular, the development of very compact sources of x-ray pulses, the first likely application of plasma accelerators, can be an inspiring piece of evidence that enables us to overcome the 'valley of death' between basic science and technological innovations, and hence meet some of the recently declared goals of the UK Industrial Strategy. ■

FROM OXFORD TO MARS

The Oxford Physics Department has an illustrious history of sending scientific instrumentation to other planets. But on Mars, we've had more than our fair share of reminders of the high risks of planetary exploration. The Atmospheric, Oceanic and Planetary Physics (AOPP) sub-department's first interplanetary foray was nearly four decades ago in 1978 when an Oxford-designed infrared radiometer was sent to Venus aboard NASA's Pioneer Venus Orbiter. This has led to further successes: AOPP-built equipment is currently operating in orbit around Saturn, the Moon, Earth and Mars. Mars has proved the most challenging to reach: attempts to send an infrared (IR) radiometer there were foiled in 1992 and 1999 when the Mars Observer and Mars Climate Orbiter, respectively, failed before going into orbit around Mars (the latter, famously, due to a metric/imperial unit conversion error). Success came at last with Oxford's contributions to a third Martian IR instrument, the Mars Climate Sounder on NASA's Mars Reconnaissance Orbiter. Orbiting Mars since 2006, this has been tirelessly mapping atmospheric temperatures and airborne dust concentrations, allowing researchers to build up an increasingly sophisticated understanding of Mars' variable climate.

More difficult than orbiting Mars, though, is landing on the planet. Mars is arguably one of the most difficult places to land in the solar system. Its variable atmosphere, with dust storms and occasional winds, leads to far greater unpredictability than one would find at an airless body like the Moon. On the other hand, its atmosphere is 50 times less dense than that of the Earth, meaning that parachutes are relatively ineffectual and airbags or rocket-powered landing systems are needed for the last portion of the descent. Due to the distance of Mars from Earth, the whole entry, descent and landing sequence must be autonomous because the two-way radio communication delay is longer than the 6-7 minute descent to the surface.

Dr Colin Wilson

LANDING ON MARS: FROM BEAGLE 2 TO THE TRACE GAS ORBITER

Few people in Oxford can be more acutely aware of the dangers of landing on Mars than I am. For my DPhil project here in AOPP, I built a Mars wind sensor for the UK's Beagle 2 lander in 2003; on Christmas day 2003 (12 days after my successful viva defence), Beagle 2 apparently reached the surface of Mars intact, but then failed to communicate. We succeeded in getting an almost identical wind sensor to be included on Europe's Schiaparelli Mars lander in 2016 – so on 19 October 2016, I was at the European Spacecraft Operations Centre waiting for Schiaparelli to land. We watched the radio signal from the lander, as monitored by an Indian radio telescope array, as it approached the Martian surface, but the signal suddenly disappeared when the lander reached the surface. A subsequent investigation revealed that the lander's guidance system had concluded that it was on the surface and so it shut off its thrusters – but that this had happened when it was still 3.7km above the ground, so it went into freefall, hitting the surface 17 seconds later. The lander was never heard from again.

Artist's impression of the Schiaparelli module with thrusters firing. Schiaparelli entered the Martian atmosphere on 19 October 2016.

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Artist's impression of the Trace Gas Orbiter (TGO, top left) and the entry, descent and landing demonstrator module, Schiaparelli (middle), and the ExoMars rover (bottom right). Under the ExoMars programme, TGO and Schiaparelli were launched to Mars in 2016, while the rover, along with a carrier module and surface science platform, will be launched in 2020.

The 2020 ExoMars mission will deliver a European rover on Mars' surface. After a nine-month journey to Mars, the rover will travel across the Martian surface searching for signs of life on the planet.

The news from Mars that day was not all bad, though. First of all, the Schiaparelli lander transmitted information throughout its descent, so almost all of the flight systems – from heat shields to parachutes – have been verified. This will increase the chances of success for future missions. But more importantly, Schiaparelli was carried to Mars by a much bigger spacecraft called the Trace Gas Orbiter (TGO); that same day, while Schiaparelli made its ill-fated descent through the atmosphere, the TGO successfully conducted a rocket firing to insert it into orbit around Mars. And the TGO's investigations promise to be very interesting indeed.

THE ENIGMA OF METHANE ON MARS: AN INDICATOR OF LIFE?

Back in 2003, three independent research groups announced the discovery of methane in Mars' atmosphere. The amounts of methane detected were frustratingly variable and faint, with reported abundances of only 0–100 parts per billion. However, this was of immediate interest, because of the possibility of biological sources. There are abiotic ways of generating methane – notably, through reactions of water with olivine or similar rocks – but most of these require liquid water which is itself of great interest for hunters of extra-terrestrial biology (exobiology). Subsequent observations often yielded only upper limits on atmospheric methane abundance, but sometimes also revealed continent-sized plumes of elevated methane levels. This defies our current understanding of Martian atmospheric chemistry, which cannot yet explain either how the methane is created in such great quantities nor how it is destroyed; in the jargon of atmospheric chemistry, we need to identify the sources and sinks of atmospheric methane.

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Artist's impression of the Schiaparelli module as it would have looked on the surface of Mars if it had landed correctly. The scene shows the module, with the parachute and rear cover of the heat shield that were jettisoned shortly before touchdown.

INVESTIGATING THE MARTIAN ATMOSPHERE

The TGO is designed to follow up on these observations. Its main observation mode is spectroscopy of sunsets and sunrises (solar occultation). The sun provides a bright source of photons and the limb-viewing geometry provides a long atmospheric path length. So this method allows extremely sensitive detection of trace atmospheric constituents in absorption spectrometry. The TGO will be able to detect not only methane at abundances down to a few parts per trillion, but also related organic and halogen species, to reveal the chemical cycles which govern their variability. Although the TGO's instruments weren't built in Oxford, AOPP scientists will be involved in interpreting its measurements, analysing the raw spectra and incorporating this information into atmospheric circulation models, to help identify sources and sinks for the different trace species.

Many of those sources and sinks are expected to be underground; so that is where the next generation of Mars exploration craft will be searching. Oxford's next chance to get instrumentation to the surface of Mars will come next year when NASA's InSight mission will launch, carrying innovative micro-seismometers manufactured at Imperial College and packaged and calibrated in Oxford. This will be followed in 2020 by the second half of ESA's ExoMars programme – a rover which will be able to drill two metres below the surface, to reach subsurface areas where organic materials are more easily preserved. Here at AOPP, we will be hoping that these missions land successfully. ■

AN ASTRONOMICAL OBSERVATORY POWERED BY A STAR

For more information go to: www.globaljetwatch.net

Professor Katherine Blundell

TELESCOPES ROUND-THE-WORLD

In rural southern India, the commissioning of Operation Solar Farmyard has recently been completed. This endeavour was designed to overcome the challenges of operating a research-grade observatory in a harsh environment where the local mains electricity is intermittent, spiky and, as we found out to our dismay, with enormous potential to destroy our cameras! The observatory in question is one of the five Global Jet Watch observatories (www.globaljetwatch.net). These five telescopes are distributed in longitude around the planet so there is always one of them in darkness, which is an essential prerequisite for optical astronomy. This enables a unique programme in the study of black hole systems in our Galaxy.

These black hole systems can now be monitored around the clock, in a way that is simply not possible from a single observatory at a fixed longitude. They are exotic and dynamic phenomena that actually change on timescales of hours and days, so to keep the watch going we need a round-the-world network of telescopes. We are investigating how matter behaves close to black holes: both how the matter is attracted and, even more dramatically, how it is expelled at speeds comparable with the speed of light itself. Each 0.5 metre telescope is equipped with a high-throughput spectrograph, designed by Steven Lee of the Australian Astronomical Observatory (AAO). These spectrographs split up the light received from Galactic black hole systems and measure Doppler-shifted emission lines from the gas being sucked onto and relativistically ejected from the vicinity of the black holes. This fleet of telescopes and associated instrumentation thereby allows us to pursue our research on their evolving dynamics round-the-clock.

SOLAR ENERGY FOR A GLOBAL PROJECT

But by design there is an important educational spin-off from this research programme on black holes. As for most of the other Global Jet Watch observatories, the India observatory is located in the grounds of a boarding school. It is a school founded by the Government of India so that the bright children of rural families can receive a formal education rather than working on the land; more than half of the children at the school are first-generation literates. Before local bedtime the schoolchildren enjoy using the telescope for themselves. When they are sleeping in their beds, we take over operation of the telescope by remote control over the internet.

Both of these two activities – engaging young people in developing countries in science as well as gaining unique spectroscopic data streams for astrophysics research – are manifestly not possible when there is no power, or following a particularly egregious electricity spike that destroys the instrumentation. Just over a year ago, a sympathetic donor (who prefers to remain anonymous) offered the funds to build a solar farmyard at the school observatory. Since then, I and two colleagues from the AAO, Steven Lee and Chris McCowage, used this generous resource to design, install and commission a 'solar system' that would avoid the perils of the local mains grid.

The main energy costs in running an observatory are the cooling of the CCD cameras to minimise noise on the detectors, powering the control PC and operating the mount on which the telescope slews, tracks and guides. On the school roof, a few metres away from the observatory, two sets of photovoltaic panels were installed, Pavo and Vela, which each comprise six square metres in four panels cabled in series and then in parallel so that the electricity can be transmitted at a high voltage, thus minimising the thickness of the cables needed. The harvested current is then fed through charge regulators into four battery banks, named Aldebaran, Bellatrix, Canopus and Diadem (all star names). These are comprised of 48 readily available lead acid 2V battery cells configured to provide 24V and collectively store 2,000 amp hours (Ah). This amount was designed to be well above the maximum we are ever likely to draw in the observatory, so that the battery life can be preserved. The observatory itself was converted to run entirely on DC electricity, rather than using lossy inverters to turn DC electricity from the batteries into AC and then turn it back into DC electricity with manufacturers' power packs incurring further losses. The supply of DC electricity from the batteries provides clean, noise-free power feeding our devices – particularly important for the cameras collecting the precious data from distant places across the Galaxy. Powering up each device is controlled remotely via IP switches specifically designed for DC control so that, thanks to the internet, everything in the observatory can be conveniently driven from rainy Oxford. Not only does the solar farmyard enable safe, ongoing measurements for astrophysics research, it also enables the schoolchildren to use the telescope for themselves. More profoundly still, these children living at their school in rural India learn something rather amazing: how energy gathered from our nearest star by day is available each night to help them explore distant stars across our Galaxy. ■

Securing the PV panels to their steel frames

Schoolgirls control the telescope at night before local bedtime

The observatory is within the heart of the school at roof height, the same height as the solar panels

Dr Phillip Tait

TO INDUSTRY AND BEYOND... THE IMPACT OF OUR RESEARCH

Working with industry is integral to the mission of the Physics Department. We aim to widen our engagement with society and recognise the potential for creating impact beyond academia, from the people, skills and technology supported through our research and teaching programmes.

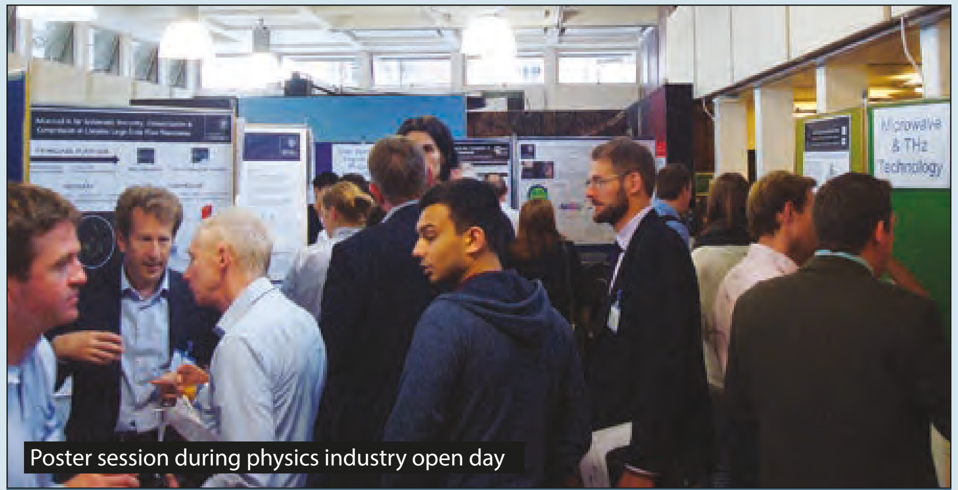
STRATEGIC SUPPORT

The Department established the Physics Industrial Liaison Committee in order to develop, promote and bring coherence to interactions between the Department and industry. The committee brings together both academics and specialist support staff from across the Department and University, including representation from Oxford University Innovation, the University's Technology Transfer office, and business development expertise from the MPLS division's Industrial Research Partnerships team. The committee's challenge is to raise awareness of existing and potential industry engagement within the Department as well as externally, and to enable an increase in knowledge exchange projects and commercialisation.

The Department has also recently recruited Dr Phillip Tait, a knowledge exchange and commercialisation professional, to provide dedicated support not only to specific projects with industry but also to support and develop an environment and culture of innovation and impact through a series of activities. By working with experts across the University, we are able to support students and staff to identify potential applications of their research all the way through to forming collaborative projects with industry or creating new spin-out companies. This coordinated resource allows us to develop more effective partnerships with industry and particularly with local businesses, including those at the Begbroke and Harwell campuses. By engaging successfully with industry, this enables the outputs of our research to reach beyond academia, to impact on society.

COLLABORATION BUILDING

We aim to embed a greater understanding of knowledge exchange and commercialisation into the environment of our students and staff. The Department has established a new Research and Industry Forum, which invites both academics and businesses to discuss industrial applications of research carried out in the Department, through a series of open seminars. We have also committed to holding regular industry-focused events in order to create new opportunities for engagement and to strengthen existing collaborations. These events invite relevant industrial contacts to the Department to meet our students and staff, and to learn about our research, technology developments, facilities and ways to work with us.



Poster session during physics industry open day

WE WORK WITH INDUSTRY TO:

- understand where our research can help solve challenges faced by society;
- collaboratively develop new technology and enable commercialisation from our research;
- ensure our training programmes fully prepare our students and staff for their careers; and
- form partnerships to access unique expertise, equipment and ideas to test new research questions.

WE OFFER INDUSTRY:

- advanced research and technology that can be developed into new products and services;
- access to our academic expertise and specialist equipment;
- opportunities to train, as well as recruit, our students; and
- partnerships that enable access to expertise and resources for collaborative Research and Development (R&D).

As part of this approach, we held a Physics Industry Open Day on 23 September 2016, with more than 60 representatives from industry visiting the Department. Each delegate was able to visit 2 of 11 facilities in the Department and meet with over 50 of our students and staff throughout the day. The event included a technology showcase with 35 of our current projects on display, as well as keynote presentations from the Department and Innovate UK. Delegates learnt about our spin-out company successes in photovoltaic technology and super resolution microscopes, our collaborative projects with industry on superconductivity and quantum technologies, as well as exciting applications in research areas, from machine learning to DNA nanotechnology.

LOOKING TO THE FUTURE

We are also planning further events to allow our students and staff opportunities to explore applications of their research and to better understand the problems faced by society on which the transformational power of physics can be brought to bear. Building on the success of last year's open day, we are currently organising the next event for industry, which will focus on satellite and space technologies. 2017 will also see the Department launch its first Innovation Competition for our students and young researchers.

To find out more about our impact in industry and to keep up to date with our news and events, please visit: www.physics.ox.ac.uk/enterprise ■

NOTES FROM THE HEAD OF PHYSICS

Prof John Wheater, Head of Department

In the last Newsletter I noted that the era of big discoveries of new particles may be over for the time being. While of course that can always turn out to be wrong, we are definitely entering into an era when precision tests of the Standard Model of particle physics will become abundant. A few days ago as I write this, the LHCb collaboration, in which Oxford Physics plays a major role, announced their latest results testing 'lepton universality'. The leptons are particles that feel only the electromagnetic and weak nuclear forces, the electroweak interaction in the language of the Standard Model. The lightest charged leptons are the electron and its antiparticle the positron. They have two heavier analogues; the muons whose mass is about 207 times greater, and the taus whose mass is about 3,477 times greater. No one knows why the masses of these particles differ so much, nor indeed why there are three different families at all, but it is a clear tenet of the Standard Model that the strengths of their interaction with the electroweak forces are the same – this is what is meant by lepton universality. However, the new LHCb results show that some B mesons (transient particles created in collisions at the Large Hadron Collider) prefer to decay to electron-positron pairs than to muon anti-muon pairs, by a factor of about 1.5. The errors on this measurement are not yet so tight that the effect could not disappear as more data is analysed, but if it does not, then lepton universality is not true. In turn this means that there have to be further, as yet undiscovered, particles which do not appear in the Standard Model. Time will tell.

Brexit continues to be a major preoccupation for us, as for everyone else in the UK. The Article 50 Act not only triggered the departure of the UK from the EU but also the end of our membership of Euratom, the European Atomic Energy Community. This unanticipated effect of Brexit is doubtless only the first surprise; fortunately, some other organisations crucial to us, such as CERN, ESO and ESA, are entirely independent of EU structures and thus definitely will not be affected. Euratom has many functions but from our point of view its importance is mainly in coordinating research into fusion and fusion plasmas, the latter in particular being a topic in which Oxford Physics leads the world. Euratom is responsible for running the Joint European Torus (JET) at Culham, for example, and almost all funding for this research area is channelled through it. We do not know how the Government plans to unpick the situation. It is certainly no one's intention that UK research ceases or is substantially damaged in such a major science and technology field but the potential for damage right now is considerable and we are working hard to get the way ahead clarified as soon as possible.

It has taken only seven months for the structure of the Beecroft Building to emerge from the huge hole in the ground and reach its maximum height; and, amazingly, right now we are still on schedule. The frame was completed in February and a brief bottoming out ceremony was held on a wet and windy day; the final concrete was somewhat inexpertly shovelled into place by the Vice Chancellor, Adrian Beecroft and yours truly. Since then the cladding has been proceeding apace and most of it is now on. Some people claim that the light coloured metallic part of the cladding is pink while others vehemently deny this. In fact, it is not pink but copper, although in certain lighting conditions I think it definitely appears pink. Second year electromagnetism and the scattering of light off metals is responsible, the effect itself will fade as the copper ages.

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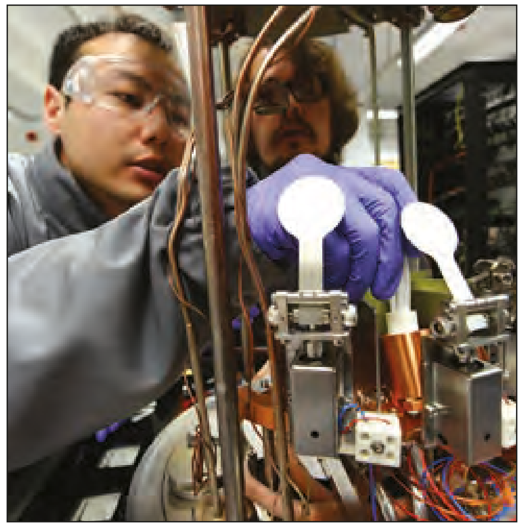

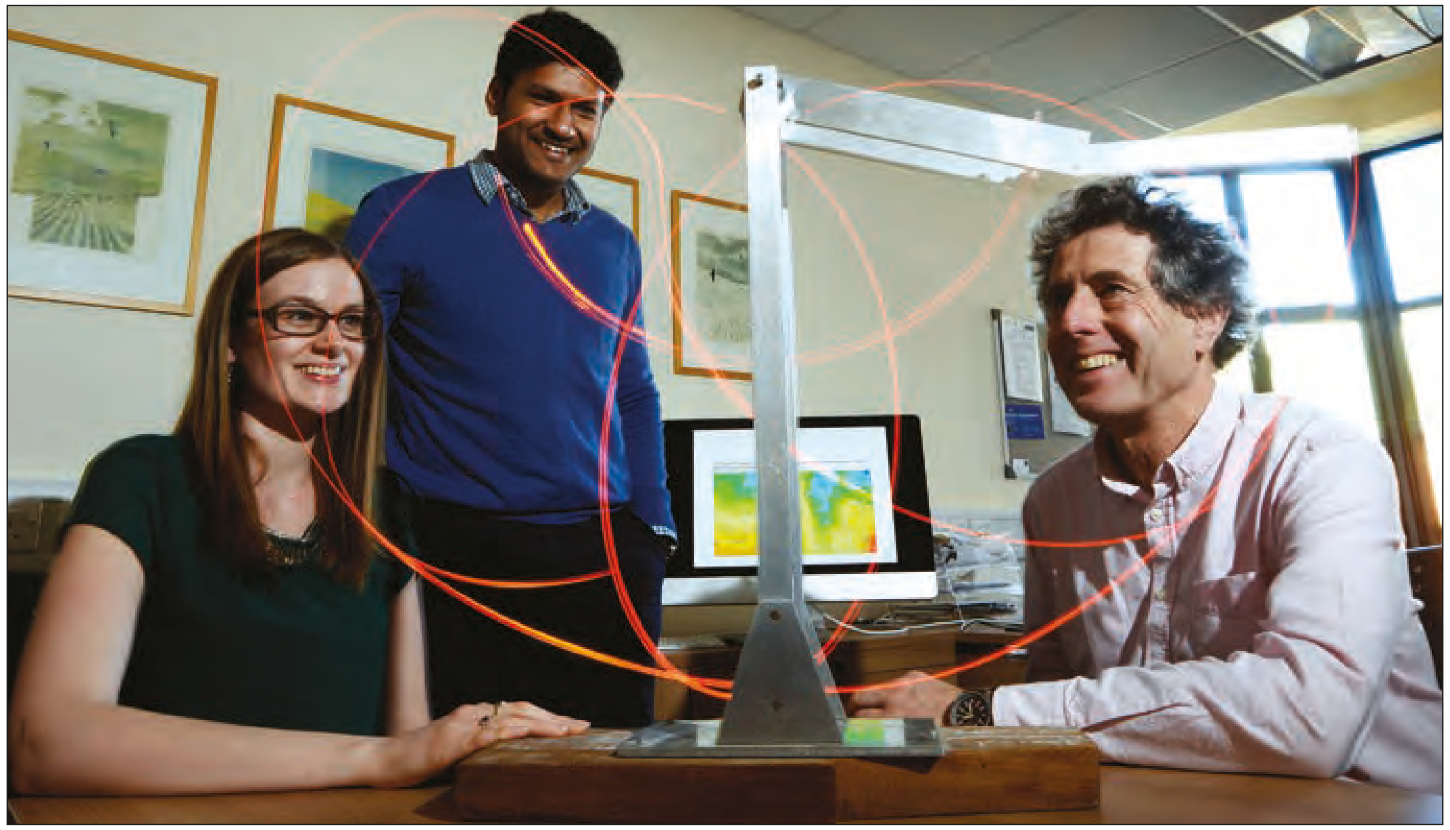

See p12 for more information about the Oxford Physics Endowment for Graduate students (OXPEG)

Opposite page, far left: DPhil student Hanyang Ye and PostDoc Josue Martinez Hardigree, working on organic solar cells in the Advanced Functional Materials and Devices Group (PI Riede); Right: DPhil student Riccardo Manenti, at the Design and Fabrication of Quantum Devices lab (PI Leek).

This page, above: Professor Tim Palmer and Drs Hannah Christensen and Aneesh Subramanian marvel at the complex motion of the chaotic double pendulum. Earth's climate is itself chaotic. As a result, distinguishing human-induced forcing of climate from naturally occurring internal variability can be extremely challenging and requires sophisticated diagnostic tools. Bottom: The Beecroft building showing some of the cladding.

The pink episode has reminded me of the late Dr Michael Grace who was once kind enough to admit me to Christ Church and Physics. He had various artefacts to probe the intuition of entrance candidates; one of these was a chunk of germanium which has very interesting optical properties as the angle of incidence changes. The feedback we get about the Newsletter often remarks on how fascinating people's memories of their time in the Department are. If you have any interesting reminiscences about the place and the people, please put pen to paper.

The last Newsletter was the final one edited by Professor Fabian Essler. I think he has done a wonderful job and would like to thank him for all his efforts. The new editor is Professor Dimitra Rigopoulou who would be delighted to hear from you through newsletter@physics.ox.ac.uk.

We are well on the way in our campaign to establish the Oxford Physics Endowment for Graduate students (OXPEG), which is planned ultimately to support 25 graduate scholarships for outstanding young physicists from around the world. The fund currently stands at about £1.1m confirmed. A big 'thank you' to everyone who responded to my email in January; contributions as a result of that are still coming in. As I said at the last Morning of Theoretical Physics event, on the whole, physicists do jobs that do not lead to enormous personal wealth; but there are a lot of us, about 11,000 in total and 9,000 plus for whom the Department has contact information. Even small contributions count; if all 9,000 of us give £50 every year that already amounts to nearly half a million pounds per annum. Of course, I hope that those who can will contribute more, and I understand that some will not be able to manage anything, but acting together we can make a difference. ■

GREENLIGHT FOR GIRLS

How do we get more girls to study – and keep on studying – science subjects? This question is important for so many different reasons, from the supply and demand of skilled people for the tech sector to the fact that, by whittling down the numbers from half the population, we must be missing out on some serious science talent. The disproportion between the genders is particularly obvious in physics, and sets in early. Although at GCSE the balance is pretty equal (after all, studying science is generally compulsory), girls make up only 20% of those who continue with physics post-16, and that ratio between men and women in physics never really recovers. In general, the work of Oxford Women in Physics Society focuses on supporting those who have made it to university or beyond, and although this is vital work, it is a support mechanism and not a solution – only one in five of those studying physics at university is female, so most of the crucial choices have already been made. But perhaps this is something we can change.

SCIENCE CAN BE FOR ANYONE

Clearly we need to engage girls early, before they start to make decisions about what subjects to keep, if we are to stop this loss of talent. This idea is at the heart of the work of *greenlight for girls*, an international organisation devoted to engaging girls with STEM subjects: science, technology, engineering and maths. Last month, Oxford Women in Physics Society teamed up with *greenlight for girls* to bring a 'g4g day' to Oxford – the first of its kind here, and only the third *greenlight for girls* event in the UK.

The Department was filled with 100 local girls aged between 11 and 14 for a day of hands-on science and technology workshops, which included an introduction to spectroscopy for astrophysics, a crash course in statistics using M&Ms, creating a model stomach, coding a simple website, using maths to understand the spread of disease, and building batteries from fruit. In groups of fifteen, the girls tried their hand at three workshops over the course of the day, and in doing so met scientists from across the University and beyond, with workshops run by, among others, Oxford Maths, Oxford Materials, Oxford Hands-On Science, and Oxford Females in Engineering, Science and Technology. The workshops let the girls explore areas of science they probably hadn't encountered before in an environment that encouraged them all to have a go and have fun in the process.

At midday, everyone headed to Pembroke College for lunch in their beautiful Hall. For many of the girls, seeing inside an Oxford college was a totally new experience, and some Pembroke undergraduates kindly gave tours of the college. Lunch was followed by a Q&A session. The panel consisted of Cesca Webb, a Pembroke physics undergraduate; Professor Daniela Bortoletto, a particle physicist; Melissa Rancourt, an engineer and founder of *greenlight for girls*; Emma Parker, a trainee clinical scientist in radiotherapy physics at the Churchill Hospital; and Merritt Moore, a DPhil student and professional ballet dancer. Questions ranged from how to pick up coding skills to balancing physics work with other interests, prompted by props that the panellists had brought including a dosimeter, a weekly planner and pointe shoes!

GOING OUT WITH A BANG!

The grand finale was provided by the enthralling Accelerate! show, a whistle-stop tour of accelerator physics via liquid nitrogen, 40,000 volts, beach balls and very loud explosions. In the capable hands of Dr Kirsty Duffy and Joe Hitchen, this was the perfect culmination of everything the day was about – bringing accurate science to life through interactivity, involvement and, above all, fun. ■

Kathryn Boast

Just a quick note to say how much the girls enjoyed Saturday. They talked non-stop all the way back, thank you, please pass on our thanks to all your volunteers as well.

A huge thank you to the team for the work you all did to make the day 'fantastic'. My daughter came away full of excitement and can't wait to go to Pembroke College.

It was a fantastic opportunity and they loved being part of it and meeting new friends, some of whom had come from so far to be part of the day.

She definitely feels inspired and is going to show her science teacher what she did during the day. Thanks so much to the team behind this event for all the hard work.

Take a chance with chocolate

Science reporters

Accelerate! time

Budding scientists at work

Hands-on science

PLEASE CUT HERE AND POST TO THE ADDRESS AT THE BOTTOM. THIS FORM IS ALSO AVAILABLE ONLINE

Oxford Thinking

The Campaign for the University of Oxford

UNIVERSITY OF OXFORD

Oxford Physics Endowment for Graduates (OXPEG)

OXPEG is an endowed fund that will provide scholarship support for the most outstanding graduate students, regardless of their country of origin, to study for a DPhil degree in the Department of Physics.

I wish to support Oxford by giving to:

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Have a look at the impact your support can have on a postgraduate student at Physics:

www.physics.ox.ac.uk/blog/alumni/2017/04/13/new-video-full-circle

Giving to Physics

Oxford Physics is one of the largest and most eminent Physics departments in Europe. Oxford physicists are probing new ways to harness solar energy, modelling the earth's atmosphere to predict future climate, exploring the potential of quantum physics to revolutionise information technologies and executing calculations that reveal the fundamental structure of space and time. They participate in many large-scale international physics projects – including the Large Hadron Collider, European Extremely Large Telescope and Square Kilometre Array.

Oxford Physics has established the Oxford Physics Endowment for Graduates (OXPEG) as its main funding priority and has set an ambitious target to establish an endowment providing scholarship funding for 25 graduate scholarships. With a fund of this scale, the Department can be confident of having the resources to attract the best possible candidates from the UK and internationally. As well as being a launchpad for their careers, graduate students contribute enormously to the work of the Department, in terms of ideas and overcoming technical challenges.

Donors who give £1,000 or more to Oxford Physics are eligible to become a member of The Henry Moseley Society. For further information about this or how to support Oxford Physics, please contact Val Crowder: email alumni@physics.ox.ac.uk.

Please note that all donations will be held as expendable endowment in the OXPEG fund, which has been established for the purposes of supporting graduate scholarships in the Department of Physics.

To make a gift, visit www.campaign.ox.ac.uk/physics

On that page, you will see links for those who would like to donate from the USA, obtain information about leaving a gift in your will and more information on tax-efficient giving.

Thank you!

OUT OF THIS WORLD FAMILY FUN DAYS

Last year we received funding from the UK Space Agency to run family fun days at two community venues (Temple Cowley shopping centre and Barton neighbourhood centre). The events aimed to provide local families with the opportunity to enjoy and learn about space science. The project was organised jointly with Oxford for Oxford, a University initiative that works to support pupil attainment in the local area, and also received support from RAL Space and the Department for Continuing Education.

The Department has a strong tradition of providing engaging space-themed activities for schools and the public; we run popular lectures, school telescope evenings and stalls at local festivals as well as an annual Stargazing open day. The public events are popular, especially with families, and we see some of the same people returning time and time again. Questionnaire feedback from Stargazing indicates that many of the adult participants at our events already have an interest in science, engage in science activities in their spare time and likely have university degrees. We therefore endeavoured to reach new family audiences in areas of the community with less tradition of attending higher education in the hope that we might highlight the opportunities that science can bring to a more diverse audience. This is particularly important for inspiring the next generation of scientists, as evidence suggests the extent to which a young person participates in science learning outside the classroom and talks about science in their everyday life are factors that influence interest and participation in science.

The events consisted of activities for parents, teenagers and younger children including planetarium shows, talks, model satellite building workshops and hands-on stalls. In Cowley we gathered crowds in the shopping centre with a dry-ice comet show and held workshops and shows in disused offices above the shops. We tested a number of new activities in the Barton neighbourhood centre including an interactive team game entitled Commanding Curiosity, where participants took the role of scientists at mission control, directing the actions of the Mars rover, Curiosity, to complete a series of challenges. Participants also had the opportunity to watch an immersive 360 degree video which let them join Dr Colin Wilson in a planetary observing trip using some of the world's best telescopes situated in Hawaii.

There was a great amount of support at the events from staff and students in the Department and we were pleased to have a total of 560 participants across both venues. Evaluation data indicated the project was successful in engaging members of the public from a variety of socio-economic backgrounds, many of whom hadn't previously taken part in a university event. We were also pleased to see some familiar faces who were happy to travel to the new venues to take part in our activities. The partnerships formed within the community venues were also a success and will pave the way for future events and engagement. ■

Left: experimenting with the plasma ball; Right: enjoying a virtual trip to telescopes in Hawaii.

AWARD WINNING OUTREACH

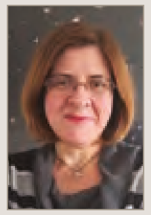
The Department of Physics has a highly active outreach programme which has engaged more than 200,000 people in the last five years through activities including research talks, workshops, shows, festival stalls, tours and competitions. This is in addition to hosting the extremely successful Zooniverse citizen science project, which has worldwide reach and impact.

In 2016 the Department was recognised for its work in this area in the first ever Vice-Chancellor's Public Engagement with Research Awards. The awards are part of the University's vision to embed high-quality and innovative public engagement as an integral part of research culture and practice at Oxford. The Vice-Chancellor said: 'I am delighted to introduce these awards to recognise and celebrate excellence in Public Engagement with Research from across the University. It has been exciting and reassuring to see the myriad ways in which people have engaged with the extraordinary research here at Oxford.' The awards are supported by the University of Oxford's RCUK Catalyst Seed Fund, which aims to improve institutional support for Public Engagement with Research.

The 12 winning entries, from a total of 84, received recognition for their achievements in an awards ceremony at Merton College. The Department was recognised in the award category for 'Building Capacity' for encouraging, facilitating and supporting high quality Public Engagement with Research. This work includes having a central outreach team to facilitate a series of successful outreach programmes and support researchers with public engagement, as well as providing funding for equipment and events. Activities such as Stargazing Oxford and other showcase events also provide central opportunities for researchers to engage the public with their own research projects. We are very pleased to have our efforts acknowledged and hope to continue to develop this area to allow even more people the chance to engage with, and hopefully be inspired by, our research. ■

Lena Shams, Sian Tedaldi and Catherine Hayer from the Physics Outreach Team collect the award on behalf of the Department.

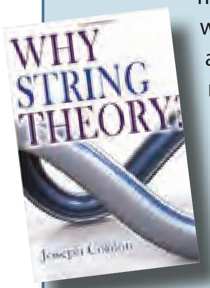
New Physics Newsletter Editor



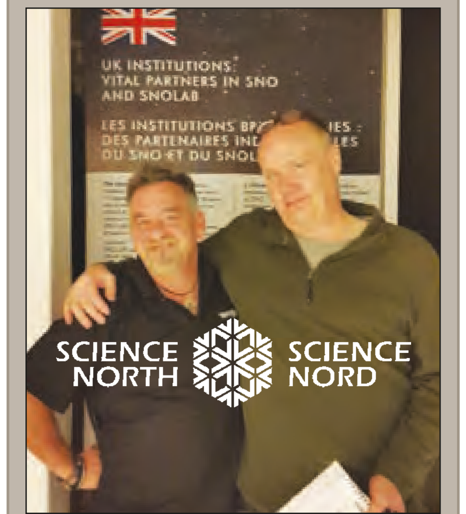
We welcome Professor Dimitra Rigopoulou as the new editor of the Physics Newsletter. Prof Rigopoulou can be contacted at **newsletter@physics.ox.ac.uk**.

PHYSICS WORLD'S CHOICE FOR THE 2016 BOOK OF THE YEAR

***Why String Theory?* by Joseph Conlon**
Abstract, mathematically complex and (so far) unsupported by direct experimental evidence, string theory attracts plenty of criticism. Yet it remains an incredibly active area of research, with thousands of physicists and mathematicians around the world working on strings and related ideas. The reasons for its continued popularity are eloquently presented in Joseph Conlon's book *Why String Theory?* – Physics World's Book of the Year for 2016.



COLLABORATION WITH SCIENCE NORTH CANADA



Old mates reunited: small world! Graham Sillman (one of our fantastic technicians, right) has worked at SNO lab in the past. He helped Science North's technician Don Greco (left) to set up the special exhibition in the DWB last autumn. This was the same exhibition some of you saw at Canada House in summer 2016.

THE FUTURE OF PARTICLE PHYSICS

The inaugural Particle Physics Christmas Lecture

The inaugural Particle Physics Christmas Lecture was held on 3 December 2016 in the Denys Wilkinson Building. The lecture was delivered by Prof John Womersley. John is the Director of the European Spallation Source in Lund, Sweden. Until October 2016 he was Chief Executive of the Science and Technology Facilities Council (STFC), the UK funding agency for particle physics, nuclear physics and astronomy, large scale science facilities and national laboratories. John earned a DPhil from Oxford and is a visiting professor here.

The event was sold out. Eighty alumni, spanning matriculation from the early 1960s to 2016, had the opportunity to hear John give an engaging talk on the status of our understanding of the nature of the universe – from the Higgs boson to detecting gravitational waves and, in particular, what we don't know; that the particles and forces we understand in ever greater detail make up only a small fraction of what's in the cosmos, and that our theoretical prejudices about what remains to be discovered may be very wrong. Looking to the new generation experiments at accelerators underground, and studying the large-scale structure of the universe, will answer these questions and raise others. This is why it is essential that the UK remains at the forefront of research of this kind and how it contributes more broadly to society.

After a delicious lunch the audience reconvened for a panel session which provided an opportunity to follow up on the lecture. The panelists were Oxford Professors John Wheater (HoD), Daniela Bortoletto, Subir Sarkar, David Wark and John Womersley.

Visits to the special exhibition 'New Eyes on the Universe' celebrating the 2015 Nobel Prize led by Profs Steve Biller and David Wark, were conducted during lunch and after the panel session. The format was very positively received and there were many requests to repeat the event in 2017. ▪

A recording of the 2016 lecture is available here:
http://media.podcasts.ox.ac.uk/physics/general/2016-1204_xmas_physics_womersley_3.mp4

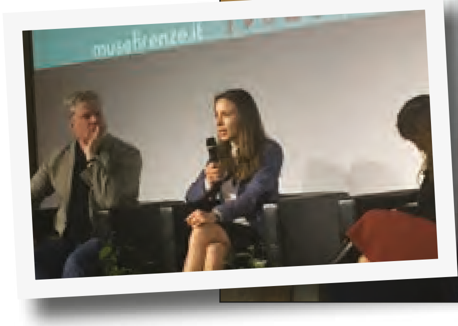
This year's lecture will be held on 2 December 2017

Guests made the most of the day, interacting with senior members of staff while visiting the special exhibition on neutrinos, on loan from Science North (Canada).

DR KARENOWSKA WILL BE OUR SPEAKER AT THIS YEAR'S ALUMNI GARDEN PARTY

Dr Alexy Karenowska is a magnetician in the Condensed Matter group in the Department. She is also a fellow of Magdalen College and Director of Technology at the Oxford Institute of Digital Archaeology (IDA – www.digitalarchaeology.org.uk).

Through her work at IDA, Alexy has taken a replica of the Triumphal Arch of Palmyra to various locations around the world, like Trafalgar Square in London, Dubai and Florence.



Dr Karenowska (far right) will be our guest speaker at this year's Garden Party in June. See below for more details.

'OPT IN' TO KEEP READING

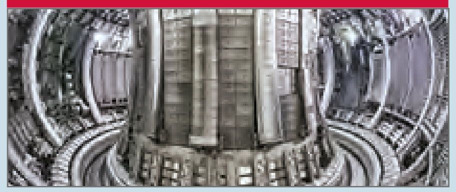
Advance notice – In a few months, the new Data Protection laws will come into place, which means we will not be able to contact you, send you this newsletter or keep in touch unless you OPT IN. We will have more information in the next issue, but please, in the meantime, bear this in mind if you are contacted by your College or central office.

FORTHCOMING EVENTS

THE HALLEY LECTURE

7 June, at the Martin Wood Complex: 'Observation of the mergers of binary black holes: the opening of gravitational wave astronomy'. Speaker: Professor Rai Weiss (Massachusetts Institute of Technology)

THE HENRY MOSELEY SOCIETY SPECIAL EVENT

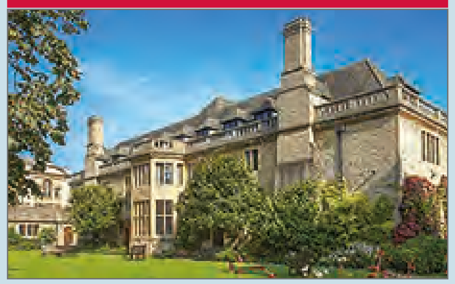


9 June This year the HMS will be visiting JET at Culham for a guided tour followed by dinner at a local restaurant. This event is for Henry Moseley members only. If you'd like to know more about the Society and how to join, visit: www.campaign.ox.ac.uk/document.doc?id=1012

STAFF AND FRIENDS OF PHYSICS BBQ

23 June For the second year, we will host this informal and fun event, a BBQ at University Parks where friends and family of staff and students are welcome. Alumni, as always, are welcome to attend.

PHYSICS ALUMNI GARDEN PARTY



25 June Prof John Wheater, Head of Department, will host this event at Rhodes House. This year, Dr Alexy Karenowska (see article above) will give a talk on her work with the Institute for Digital Archaeology.

OXFORD ALUMNI WEEKEND

15–17 September The central booking system has changed this year: all physics alumni should book Physics events directly with the Physics Alumni Office, to claim their free place. Bookings through central office will be charged.

INDUSTRY DAY

Date TBC See article on page 7. If you are interested in taking part, please contact Dr Phillip Tait (phillip.tait@physics.ox.ac.uk).

Did you know?

As physics alumni you are welcome to visit us during term time, and attend one of the excellent colloquiums of the series? They are normally held on Friday afternoons, and are followed by free coffee and biscuits. www.physics.ox.ac.uk/events

Keep an eye on our website for:

MORNING OF THEORETICAL PHYSICS
October TBC

PHYSICS ALUMNI AT THE ROYAL SOCIETY
November TBC hosted by AOPP

THE HINTZE LECTURE
15 November

THE PARTICLE PHYSICS CHRISTMAS LECTURE
2 December

PHYSICS CHRISTMAS CAROLS
December TBC

To keep up to date and book your place at our events, please visit www.physics.ox.ac.uk/events. We update the list all the time, so please check regularly!
If you have any questions about the events, contact Val Crowder: alumni@physics.ox.ac.uk

BEECROFT BUILDING TOPPING OUT EVENT

Above: Dr Bella Wheater, Prof John Wheater, Mr Adrian Beecroft, Mr Liam Cummings (Business Unit Leader, Laing O'Rourke), Mr Rob Cooper (Project Leader, Laing O'Rourke), Prof Louise Richardson (Vice-Chancellor). Far left: Mr Martin Lueck (alumnus) talks to the Vice-Chancellor and Liesl Elder (Chief Development Officer UO). Right: Prof Wheater, Prof Richardson (VC) and Mr Adrian Beecroft.

If your business or company would like to sponsor an event (UK or abroad), or you have an idea for a venue or event, please get in touch. We are always looking for new ideas to offer our alumni community. Write to alumni@physics.ox.ac.uk

PHYSICS AT OXFORD & CAMBRIDGE CLUB

Dr Sam Vinko gave a wonderful talk to Physics Alumni and Guests at the Oxford & Cambridge Club last March. His talk was titled: 'From stars to proteins: unveiling material response in intense x-ray fields'. Guests' feedback has been fantastic; they really enjoyed the occasion. This annual event is always very popular; it is great to meet new people every time. Thank you to Dr James Dodd, physics alumnus and member of the Club, for inviting us to host the event in this wonderful venue once again.

Left: Prof John Wheater talks with alumni at the Oxford & Cambridge Club
Right: Dr Sam Vinko

OUTREACH RESOURCES

If you work with schools or at an organisation that could benefit from our Outreach Resources, please get in touch with Dr Sian Tedaldi: sian.tedaldi@physics.ox.ac.uk

OXFORD PHYSICS EXPLORING THE PLANETS – AN EVENT AT THE ROYAL SOCIETY

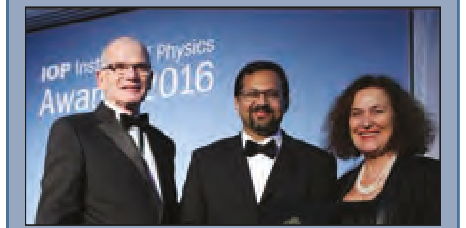
Following a climate-themed event last year, 11 November 2016 saw a Physics alumni event held at the Royal Society: 'Oxford Physics exploring the planets'. This provided a great opportunity for present researchers to meet with alumni and present some of the latest research in the Department in this exciting field. The first talk was given by Dr Colin Wilson, on the ExoMars mission which had just reached Mars a few weeks previously (see page 4). Dr Kerri Donaldson-Hanna then discussed work going on in the planetary spectroscopy lab, including characterisation of real moon rocks returned by Apollo astronauts, and preparations for upcoming asteroid missions.

Telescopes are invaluable for studying objects we can't get spacecrafts to. Professor Patrick Irwin described a series of observations charting the changing weather patterns and chemical compositions of Neptune and Uranus. Professor Neil Bowles then outlined how small satellites are now within the reach of university groups like our own; his group provided a small 4kg infrared radiometer which is currently orbiting Earth on the UK's TechDemoSat-1 satellite, and are developing plans for a small Earth-observing 'cubesat' which would be only 6 litres in volume. Finally, Halley Professor Ray Pierrehumbert further expanded the horizons of the event to consider the vast variety of different planets being discovered in orbit around other stars and the correspondingly great array of climates they must exhibit, from star-like atmospheres with metallic clouds to completely ice-covered planets. Several current students and postdocs attended the event; all enjoyed the opportunity to meet and chat with alumni. We look forward to running a similar event later this year. ■

Oxford researchers and alumni discuss planetary exploration at the Royal Society, London

Do you have a story, a memory or a photo to share? Would you like to be featured in the next 'Alumni Story'? We'd love to hear from you! We are always looking for material to share with our alumni and physics community. Please write to Val Crowder: alumni@physics.ox.ac.uk.

IOP PHYSICS JUNO AWARD



Oxford Physics was awarded Juno Champion status by the Institute of Physics at the IoP awards ceremony on 29 November 2017. Champion status recognises the excellent practice within the Department of embedding the Juno principles of promoting gender equality.

Nicola Blackwood visits Physics

Dr Matthew Levy (Royal Society Governmental Pair), organised a Poster Symposium in the Department on 2 December 2016 for Ms Nicola Blackwood, MP, Minister for Public Health and Innovation, and earlier Chair of the Commons Science and Technology Select Committee. The event, entitled 'Science & Innovation Sessions', was intended to exhibit selected topical areas of science and innovation undertaken in Departmental and Collegiate environs as well as entrepreneurial eco-systems facilitated by the University. More than 25 posters were displayed on the day, and members of staff had an opportunity to talk to our guest, who asked lots of questions and was genuinely interested in all the research.

Ms Blackwood talking to Prof Paolo Radaelli and Prof Roger Davies during her visit to Physics.

CENTRE FOR APPLIED SUPERCONDUCTIVITY OPEN FOR BUSINESS

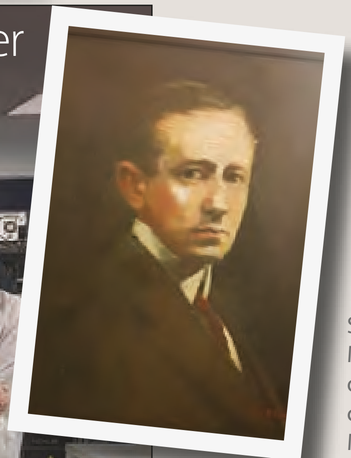
For an idea in physics to have real-world impact, you need an unbroken chain stretching from physics, through materials discovery and development, and right along to industry. Joining up these disparate areas in the field of superconductor research is the aim of a new Centre for Applied Superconductivity (CfAS), a collaborative effort between local industrial companies and Oxford University's Departments of Materials and Physics. Funding has been provided through the Oxfordshire Local Enterprise Partnership (OxLEP) and has led to the creation of new laboratories within both University departments. Much of the UK's strength in applications of superconductivity is based within a 20 mile radius around Oxford. The origin of this geographical concentration of expertise can be traced back to the research work performed in the Clarendon Laboratory more than 50 years ago that was spun out into companies such as Oxford Instruments.

The new Centre's aims are to research new superconducting products and processes; to provide world-leading problem solving expertise for industry; and to train new generations of technicians and scientists for the growing number of Oxfordshire companies working in this increasingly important technology field. CfAS was formally launched on 27 February 2017 at an event attended by the Secretary of State for Defence, Sir Michael Fallon (who was in Oxford to announce members of a Defence Innovation Advisory Panel) and Nigel Tipple, Chief Executive of OxLEP. The new laboratories in Physics have been completely refurbished and are equipped with state-of-the-art equipment, including a new 16 Tesla physical property measurement system (partly funded by Oxford's John Fell fund), which will be used to study newly developed superconductors. ■

Left: DPhil student Franziska Kirschner; Centre: Oxfordshire Local Enterprise Partnership (OxLEP) members opening the CfAS lab in the Department; Above: Prof Paolo Radaelli with Secretary of State for Defence, Sir Michael Fallon, greeting Prof Stephen Blundell and Prof Amalia Coldea at the Department of Materials during the event.

Princess Maria Elettra Marconi, daughter of Guglielmo Marconi, visited the Department of Physics and Oxford

In March, Prof Paolo Radaelli and Dr Alexy Karenowska hosted a visit from the daughter of Guglielmo Marconi, pioneer in long-distance radio transmission, developer of Marconi's law and radio telegraph systems. Among many other things, they visited the ODPM laboratory in Physics and the Museum of the History of Science, where a specially commissioned portrait of her father was unveiled, to be displayed next to his original artefacts.



Left: Elettra Marconi (centre) with Dr Alexy Karenowska and members of the Department of Physics/ ODPM lab during her visit to Physics; Centre: a portrait of Guglielmo Marconi presented to the Museum of the History of Science (MHS), Oxford; Below: Elettra Marconi with Dr Silke Ackermann (Director of MHS) and guests, viewing one of Mr Marconi's instruments currently on display at the Museum.

Dr Rebecca Bowler

WOMEN IN PHYSICS

The society is keen to hear from physics alumni about their time in the Department and where their degree has taken them. The goal is to create an online resource showcasing the varied career paths of female physics graduates. Please email: newsletter@physics.ox.ac.uk with contributions or to find out more.

The proportion of female physicists at both undergraduate and postgraduate level is at an all time high, with around 20-25% female students. In comparison to other fields of science and mathematics, the fraction of women in physics remains significantly lower, and is comparable to the uptake of the subject at Sixth Form. Beyond the doctorate level, the proportion, encouragingly, remains roughly constant to lecturer level; however, despite an upward trend in the proportion of female professors, this figure is currently only 1 in 10. As illustrated by several studies on the subject, many diverse and interweaving reasons are thought to contribute to the decline, ranging from increased career responsibilities, to unconscious biases. Certainly at school level, there is evidence that gender stereotypes play a role, with the school environment being shown to affect subject choices for both female and male students.

The Physics Department is committed to promoting gender equality, as demonstrated by the award of Juno Champion status last year and the Athena Swan Silver Award in 2015. The Oxford Women in Physics Society (OxWiP) was set up to provide additional support for women, and those who identify as women, above and beyond that provided centrally by the Department. One of the Society's key goals is to provide access to role models in an environment where the number of female scientists at the most senior levels is still only around 10%. The Society runs a mentoring scheme both for undergraduate women, who are paired with a physicist in the year above, and for postgraduate students and researchers. As well as the formal mentoring scheme, a key goal of the events we run is to increase interaction between female physicists at all levels, allowing peer support and informal mentoring to occur naturally, and providing a welcoming environment for new members of the Department.

The Society has existed for four years and now has a regular programme of events throughout the year. In Michaelmas term, more than 50 people attended our Welcome event, a record high, showing the continued interest of members of the Department in supporting diversity within physics. At the end of term we were delighted to host Professor Athene Donald (Cambridge), a leading soft matter physicist, Master of Churchill College and a vocal advocate for issues concerning women in science. Over tea and cake, the discussion ranged from gendered language in reference letters, to the importance of including everyone in the conversation about gender equality, not just women. The term also included a Christmas lunch and a banquet dinner hosted at Christ Church, which was attended by 45 people ranging from undergraduates to staff; a true testament of the strength of the Society. In Trinity Term we also had a packed programme, including fortnightly tea sessions, a dinner at Merton College and a special celebration for International Women's Day on 8 March. International Women's Day provided a perfect backdrop for the Society to celebrate the ever increasing diversity of physics and to highlight the significant number of women now following a career in this fascinating science. ■

To find out more, please see our website or join our Facebook group.

www.physics.ox.ac.uk/equality-and-diversity/women-in-physics-society

www.facebook.com/Oxford.Women.in.Physics.Society

Left: Women in Physics dinner at Christ Church

Sir Martin Wood visits the new CfAS laboratory

Far right: Dr Amir Haghighirad talks to Sir Martin Wood. Left: Sir and Lady Wood visiting the CfAS lab – a continuation of his pioneering work in the Department of Physics.

FIVE MINUTES WITH...**MARCO DEL TUTTO**

DPhil student in Particle Physics

Tell us a bit about your background…

I was born and raised in Rome, Italy, a city that I love and really miss. I got my Bachelor's and Master's degrees at the University of Rome Sapienza. I spent time at Fermilab, a laboratory in the USA, as a summer student and for my Master's thesis. I am now reading for a DPhil in Particle Physics working on the MicroBooNE neutrino experiment with Dr Roxanne Guenette as my supervisor.

When/how did you decide to become a physicist?

When I was a kid I was attracted by how electrical and mechanical equipment works. So my first thought was to become an engineer. But then I realised that I was mostly fascinated by the basic principles which govern natural phenomena. This happened towards the end of high school, when I decided to study physics.

Why do you think it is important to study physics?

Physics addresses questions of how nature works. From a philosophical point of view, this allows us to better understand the world we live in. At the same time, research in physics quite often results in technological breakthroughs and innovations.

Can you explain the work you do?

I am currently working on measuring the neutrino interaction cross section with the liquid argon (LAr) in our detector. This measurement is fundamental to our understanding of neutrino interactions and is also crucial for future neutrino experiments. This will be the first ever neutrino cross section measurement on argon in the 1 GeV energy range. This is extremely important for the next generation of LAr neutrino detectors that will operate in the same energy range, since cross section uncertainties are one of the dominant systematics for these experiments.

What are the current challenges in this field?

Neutrinos have a very low probability to interact. We have overcome this either by building large detectors or, by having an intense neutrino beam, like we have at Fermilab.

To further study neutrino oscillations and solve the mass hierarchy problem, longer baselines are needed. DUNE, for instance, is a future long baseline experiment which will use the technology already developed and optimised by MicroBooNE. We also need much higher track resolution in order to study nuclear effects in the liquid argon when neutrinos interact. This is why the MicroBooNE detector is a Liquid Argon Time Projection Chamber: this kind of detector offers exquisite image resolution.

What interests do you have besides physics?

I am very interested in science outreach and in the development and design of mobile phone apps. I combined my passions by developing a smartphone app called 'VENu: The Virtual Environment for Neutrinos'. VENu consists of data from the MicroBooNE experiment. The app explains neutrinos and enables users to play games to catch the particles in virtual reality using a smartphone paired with any consumer virtual reality headset or Google Cardboard. I am the project leader of VENu, I worked on the physics and the development and design of the app.

What scientific breakthrough would you like to see in your lifetime?

There are many of them! Of course I'm biased but I would really like to see the neutrino mass problem solved – I'm rooting for Majorana-like neutrinos!

But there are also many other things, for example the unification of the fundamental laws of physics, ie the inclusion of gravity in what will be a 'theory of everything'.

On another point of view, it would be fantastic to assist in the first human settlement on any planet apart from earth, or in the discovery of other life-forms in the universe.

But there are also others that are not directly related to physics, like the cure for cancer and illnesses like Alzheimer's disease.

What are your plans in the future?

I'd love to continue being a physicist and doing research. I like neutrino physics but also believe that changing field at some point can be of great benefit instead of dedicating all your research to the same topic. I'd also love to continue doing science outreach, I believe it is an important part of being a physicist.

Can you share the main positives of being a physics student at Oxford?

One of the main positives is that we have the opportunity to work with, and talk to, many experts in our field. Being at Oxford also means working with a number of international students. This is important as it improves the exchange of ideas, it allows you to be more open-minded and to have better human relations. Also, many tools that improve our skills and increase our knowledge are available to students. ■

For further information visit the App website **venu.physics.ox.ac.uk**. Here you will find links to download from the App Store and Google Play.

Images and background information are available at: venu.physics.ox.ac.uk/downloads.html

Launch event images and press release: venu.physics.ox.ac.uk/stargazing.html

If you are interested in contacting the developer, email Marco at marco.deltutto@physics.ox.ac.uk

Below: Marco explaining VENu

LETTER TO THE EDITOR

Letters are welcome and should be addressed to ***newsletter@physics.ox.ac.uk***

I read with interest Prof Terence Meaden's memories of the Clarendon in the Autumn 2016 edition of the Department of Physics Newsletter, but my own recollections differ from his in a number of instances.

First, he mentions that Nicholas Kurti did not speak perfect English. In fact, Nicholas spoke English impeccably albeit quickly and with a fairly strong accent. He was my supervisor, and when I was writing my DPhil thesis, although I thought that I was reasonably proficient in English, Nicholas suggested a number of amendments that improved the grammatical construction of the work. He also spoke French and German very well. Further, he was a wonderful, generous gentleman.

Secondly, after the retirement of Lord Cherwell, Sir Francis Simon was appointed Dr Lee's Professor of Experimental Philosophy and Head in 1956 but unfortunately died shortly afterwards. It was then that Brebis Bleaney was appointed to the position.

Thirdly, Prof Meaden mentions that Martin Wood was 'already experimenting with superconducting magnets' in 1957. This seems a little early. There had been some pioneering work on superconducting magnets in the United States when I started my graduate studies in 1959. In the next year, S H Autler reported the use of niobium wire to produce solenoids giving fields up to 0.43 T (*Rev. Sci. Instr.* 31, 1960, 369). After reading Autler's paper, I wound a solenoid of niobium for use in our nuclear orientation experiments, replacing the cumbersome external electromagnets that were used to magnetically saturate our specimens and that hampered the detection of gamma-rays from the samples. Later, we used molybdenum-rhenium alloy coils that had a larger critical field. In the nuclear cooling group, Bob March and Orest Symko also started to use superconducting magnets in thermal switches between the paramagnetic and nuclear cooling stages. The area of high-field superconductors grew over this short period, 1960-62, culminating in the development of niobium-titanium and niobium-tin magnets. Martin Wood was Senior Research Officer in charge of magnets and a foremost expert in the design of high-field, water-cooled copper solenoids. He realised the huge potential of superconducting magnets in scientific applications and also started to experiment with them in this period. He went on to build the first commercial magnets at Oxford Instruments.

I do agree with Prof Meaden that this was a memorable and exciting period to be in the Clarendon laboratory.

With best wishes,
Brian Turrell
Professor Emeritus
University of British Columbia

OXFORD ALUMNUS SHARES THE 2016 NOBEL PRIZE IN PHYSICS

Michael Kosterlitz, who read for his DPhil at Brasenose College between 1966 and 1969, has been named a Nobel Laureate for his pioneering work to help reveal the secrets of exotic phases of matter.

Professor Kosterlitz, now of Brown University, USA, shared half the prize with Professor Duncan Haldane of Princeton University, USA, with the other half going to Professor David Thouless of the University of Washington, USA.

The Royal Swedish Academy of Sciences cited the three scientists' 'theoretical discoveries of topological phase transitions and topological phases of matter'.

Topology is a branch of mathematics that deals with the idea that some things can be smoothly deformed into each other, whereas other things cannot without something disruptive happening along the way. For example, a soccer ball can be smoothly deformed into a rugby ball, but not into a coffee cup, because there would be some distinct moment when the handle of the cup has to be closed up.

The Academy said: 'This year's Laureates opened the door to an unknown world where matter can assume strange states. They have used advanced mathematical methods to study unusual phases of matter, such as superconductors, superfluids or thin magnetic films. Thanks to their pioneering work, the hunt is now on for new and exotic phases of matter.

'The three Laureates' use of topological concepts in physics was decisive for their discoveries. Topology is a branch of mathematics that describes properties that only change step-wise. In the early 1970s, Michael Kosterlitz and David Thouless overturned the then current theory that superconductivity or suprafluidity could not occur in thin layers. They demonstrated that superconductivity could occur at low temperatures and also explained the mechanism, phase transition, that makes superconductivity disappear at higher temperatures.'

Frank Close, Professor of Physics at Oxford University and a Fellow of Exeter College, Oxford, shared an office with Prof Kosterlitz when they were studying for their DPhils in Oxford in the late 1960s. He recalled: 'Mike was at that time working in theoretical particle physics from Monday to Thursday, but on Friday he would disappear and head off in his car to the Scottish mountains for the weekend. Mike was an avid climber, and to reduce the likelihood of falling off a rock-face he had a wrist strengthener, which he would squeeze in his left fist while writing with a pen in his right hand (those were the days when people actually wrote on paper rather than typed on laptops). Whenever he paused for thought, he would put down the pen and transfer the wrist strengthener to his right fist.

'After he left Oxford he moved into condensed matter physics and did his great work on what became known as Kosterlitz-Thouless vortices. And he kept climbing. I am delighted that he has reached the top of another mountain.' ■

Professor Michael Kosterlitz

IMAGE CREDIT: N. ELMEHED. © NOBEL MEDIA 2016

REPRODUCED FROM OXFORD UNIVERSITY NEWS PAGE WWW.OX.AC.UK/NEWS/2016-10-04-OXFORD-ALUMNUS-SHARES-NOBEL-PRIZE-PH

ALUMNI STORIES

We welcome stories from all alumni. Please email: ***contact@physics.ox.ac.uk***

CHRISTOPHER ROSE-INNES, MERTON COLLEGE, 1944-54

A somewhat varied career: started as a lawyer, became a physicist, ended as an artist.

In 1944, having only just turned seventeen, I entered Merton to read Law. In those days, a third of the first year law course consisted of Roman law studied in Latin. Nevertheless, after two terms I passed Law Mods, much to my surprise as I had spent more time sailing on the river than studying law. It was still wartime, and I joined the Oxford University Naval Division, which prepared us for service in the Navy. Part of our training was on the Isis on a whaler which had a destroyer's bridge mounted on it. It was so top-heavy that if one altered course by more than a few points it was liable to capsize!

I then joined the Royal Navy. At the initial interviewing board I was told that, as I had an elementary qualification in law, I was clearly suitable to be a radio and radar maintenance instructor! I was sent on an admirable course on electricity and electronics at what was then Northampton Polytechnic (now City University), arriving on the day the first V1 flying bomb attack on London began. After nine months, I joined HMS Collingwood, the Navy`s electrical and electronics school, where we were taught the details of naval radio and radar sets and how to maintain them. I was then selected to be an instructor, and sent on an excellent teaching course, which stood me in good stead in my subsequent academic career. I was specially involved with the 271 gun-ranging radar, which was at that time one of the most advanced pieces of electronic equipment.

Plaque erected in 1988 by English Heritage at Railway Bridge, Grove Road, Bow, London E3, London Borough of Tower Hamlets.

It was designed for ease of servicing, which was necessary, because it had more than 300 electronic valves, each of which had only a limited lifetime. My experience with radar kindled in me a dormant love of physical science. When I left after four years and returned to Merton, I changed to reading Physics, and in 1951, as the OU degree certificate puts it, 'appeared' to have satisfied the examiners.

RESEARCH AT THE CLARENDON

At that time, it happened that a visiting fellow in the Clarendon Laboratory's Low Temperature Group, Dr Dirk Bijl, was looking for a research student with experience in microwaves because he wanted to start research in paramagnetic resonance at low temperatures. We designed and built an X-band ESR spectrometer which could operate down to about 5K. We obtained this temperature by desorption of helium from charcoal. In those days, before liquid helium could be bought, every low temperature apparatus had to incorporate its own 'refrigerator' and we had to use as little helium as possible. Helium was rare and expensive so, to encourage thrift, research students had to pay for any that was lost out of their own pockets! The particular research project with which I was engaged, was rather pedestrian and to my good fortune the Clarendon Laboratory liquefier which supplied the liquid hydrogen, in those days essential for low temperature work, blew up, so low temperature work was not possible for several months. We therefore had to look for another project. It happened that a chemist, Dr Kainer, was looking at mechanisms which stabilised organic free radicals and because free radicals have non-zero electron spin they can be detected in an ESR apparatus. We agreed to cooperate and so, my DPhil research was on organic chemistry. This shows that with a physics training one can do anything!

On leaving Oxford I was recruited into the Services Electronics Research Laboratory (SERL) to build a low temperature laboratory for research into semiconductors and superconductors. SERL, as part of the Royal Naval Scientific Service did research on electronic devices for the Government, in general.

FROM SERL TO UMIST

After ten years at SERL I was invited to join UMIST, The University of Manchester Institute of Science and Technology, where I became professor of Physics and

Christopher Rose-Innes

Christopher during his time at Physics

CALLING ALL ALUMNI: WE WOULD LIKE TO HEAR YOUR STORY

Please email us at:
alumni@physics.ox.ac.uk

Electrical Engineering. This was a joint chair and I taught and conducted research for both departments. It is an interesting facet of scientific history that, at that time, Electrical Engineers were using the 'new' mks units but physicists were using the traditional 'mixed' esu/emu units (does anyone remember 'mixed' units now?) and one of my tasks was to persuade the physicists to convert to mks.

Yet again, I set up a low temperature laboratory and initiated low temperature research. The research consisted of developing new techniques for obtaining, controlling and measuring low temperatures, and our research at these temperatures concentrated on superconductivity. Later, I became Dean of the Faculty of Technology of Manchester University and served a term as Vice Principal of UMIST.

FROM SCIENCE TO ART

In addition to my interest in physics, I had always had an interest in art, attending evening classes in drawing and sculpture, and I decided that before I went senile I would like to do this 'properly'. I took slightly early retirement and at the age of sixty-three enrolled as an undergraduate fine art student at Manchester Polytechnic (now MMU). The experiences of an elderly ex-physics professor in a class of 20-year-old art students could make an article in itself. At the end of the four year course, specialising in sculpture, I graduated and I now practice as a professional artist, mainly involved in sculpture.

I am, of course, often asked how different do I find life as an artist compared to that of a scientist. My answer, which usually surprises, is that I do not find that much difference. As an academic scientist, I was not told what to do but was expected to think up my own ideas. The same goes for an artist. As an experimental physicist I had certain tools such as instruments, chemicals, vacuum pumps etc to put my ideas into effect. As an artist, I use tools such as clay, mallets, paint etc to produce art from my ideas. More significantly, I experience the same emotional highs and lows in both science and art, feeling one day that I am achieving something worthwhile but, at another time, that what I am trying to do is doomed to failure. I find going into the studio little different from going into the laboratory.

Of course, it would be silly to say that science and art are exactly the same. When one has produced something

V1 flying bomb; Fieseler Fi 103; Flakzielgerät 76 (FZG-76) (Source: Wikipedia)

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in science, it will become clear whether it was right or wrong. Others repeat your experiments, check your calculations and usually there will be agreement as to whether your work was right or wrong. The situation in art is, of course, quite different, there are no absolute criteria. One of my biggest shocks, when I became a very mature art student, was that one tutor would look at the work I was doing and say 'that is rather promising, I think you should develop that'. Another tutor would look at the same work and say 'I don't think much of that, you should try a different approach', but I am not complaining, this is the way art is.

I now practice as a professional sculptor and artist. Does my scientific background show in my sculpture and other art work? No, I do not think so. Except that my work tends to be rather neat, planned rather than spontaneous. I may be missing a great source of inspiration but it seems that science and art occupy different areas of my brain.

Examples of my art work can be seen on the websites of The Royal British Sculptors Society and the Stockport Art Guild. ■

Christopher Rose-Innes by Stephen Ashurst

COMINGS, GOINGS & AWARDS...

IN REMEMBRANCE

It is with great sorrow that we mourn **EDMUND 'TED' WILSON**, who died on 3 November 2016 after a short illness. Ted was born on 18 March 1938 in Liverpool, the son of school teacher John Wesley Wilson and nurse Anna Wilson. He was a great accelerator physicist and an inspired and inspiring teacher. He was an engaging and entertaining companion, being one of those people who, while being quite serious about everything, never takes themselves too seriously; he lived life to the full, doing as much good as he could along the way. Ted is survived by his wife Monika, his three sons, Martin, Alexander and Nicholas and five grandchildren. Our thoughts are with them. He will be greatly missed.

COMINGS...

PROF STEVE COWLEY Professorial Research Fellow | Theory

DR RICK HAMILTON Senior Research Assistant | CMP

DR IAN HEYWOOD Hintze Research Fellow | Astro

DR DAVID JENNINGS Royal Society Fellow | ALP

MRS GALE LOCKWOOD Interconnect Operations Manager | Particle

PROF BRIAN SMITH Programme Leader | ALP

DR MIKA VESTERINEN STFC Ernest Rutherford Fellow | Particle

GOINGS...

DR PATRICK BAIRD Head of Graduate Studies | ALP

PROF JOHN COBB Research Reader | Particle

DR IGOR MEKHOV EPSRC Career Acceleration Fellow | ALP

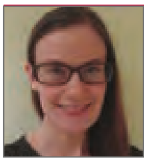
DR JUAN ROJO STFC Rutherford Fellow | Theory

DR SONIA TRIGUEROS Post Doctoral Research Assistant | CMP

DR BOB WATKINS Research Assistant | AOPP

AWARDS

PROF ROGER DAVIES will become President of the European Astronomical Society with effect from July 2017.

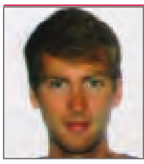


DR HANNAH CHRISTENSEN was a runner up for the Lloyds Science of Risk Peter Taylor Prize.

PROF CHRIS DAMERELL was awarded the 2016 Glenn Knoll Radiation Instrumentation Outstanding Achievement Award by the IEEE Nuclear and Plasma Science Society.

PROF ACHILLEFS KAPANIDIS has won an MPLS Impact Award in recognition of his research that led to the development of the Nanoimager; a compact, robust, easy-to-use high-resolution fluorescence microscope based on detecting single molecules.

PROF MYLES ALLEN received the MPLS Lifetime Award in recognition of his work engaging the public and advancing public understanding of anthropomorphic climate change and its links to extreme weather. Prof Allen has pioneered the use of 'citizen science' through public-participation computer modelling experiments under the climateprediction.net and weather@home initiatives.



DR JOEL SPRATT received the 2016 Arthur Cooke Prize for distinguished work by a first year research student in Condensed Matter Physics.

PROF SUBIR SARKAR was awarded the 2017 IUPAP-TIFR Homi Bhabha Medal and Prize for his distinguished contributions in high energy cosmic ray physics and astro-particle physics.

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