Summer 2012, Number 2

Department of Physics
Newsletter

UNIVERSITY OF OXFORD

Stargazing Oxford...

Phil Marshall

On Saturday, 21st January, passers-by on Banbury Road were met with a remarkable sight: a queue of people stretching from the door of the Denys Wilkinson Building all the way to the bottom of the steps. This was "Stargazing Oxford," our first ever space science festival.

Between 2pm and 10pm, we welcomed nearly 1200 people into the Physics Department, to hear about the latest research results in astrophysics and planetary science, and to learn how to get started observing the night sky.

The rooftop observing sessions, with Abingdon Astronomical Society, were a big hit. Inside, we put on short research talks in the Dennis Sciama lecture theatre, and filled the cafeteria with village fete-style stalls, manned by research staff wearing red T-shirts marked "got questions?". We told everyone who was queuing to get in that the DWB was a building full of people whose job it was to ask questions, and so they were to ask us anything they wanted. It seemed to work: one office door in the Beecroft Institute (BIPAC) was covered in questions about space, many of them at the research level despite the childish handwriting! How many solar systems are there? How was the first galaxy made? Wouldn't we all like to know!

Other favourite activites included "Universe-ity Challenge" (our own version of the popular BBC game show), "Dark Matter" (an installation by local modern artist Marion Yorston in the seminar room, blacked out for the occasion), and "AstroCrafts" (immensely popular with children of all ages). We even borrowed an inflatable Planetarium from the University of Kent, which proved to be a very popular way in to space science. It was a long, tiring but hugely successful day: the feedback forms we collected were universally positive, with our visitors excited and inspired by their time spent inside the Oxford Physics Department.

This was really the goal of "Stargazing Oxford": to reach out to people in the local community who may not have been to a University event before, but who were interested in astronomy and wanted to find out more. The event was planned as one of the local activities associated with the BBC's "Stargazing Live" programme, which aired on BBC2 the week before Saturday 21st. The series was excellent – not only for featuring several Oxford Physicists!

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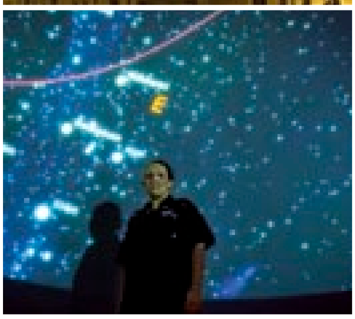


© JOSEPH CARUANA

INSIDE: VIRTUAL STARGAZING • PREDICTING PREDICTABILITY • MAPPING FERMI SURFACES OF IRON-BASED SUPERCONDUCTORS • NANOTECHNOLOGY & LIVING CELLS • A STATE-OF-THE-ART BUILDING FOR OXFORD PHYSICS • WILL.I.AM VISITS OXFORD • EVENTS • PEOPLE • AND MORE

Virtual stargazing

Andrew Pontzen

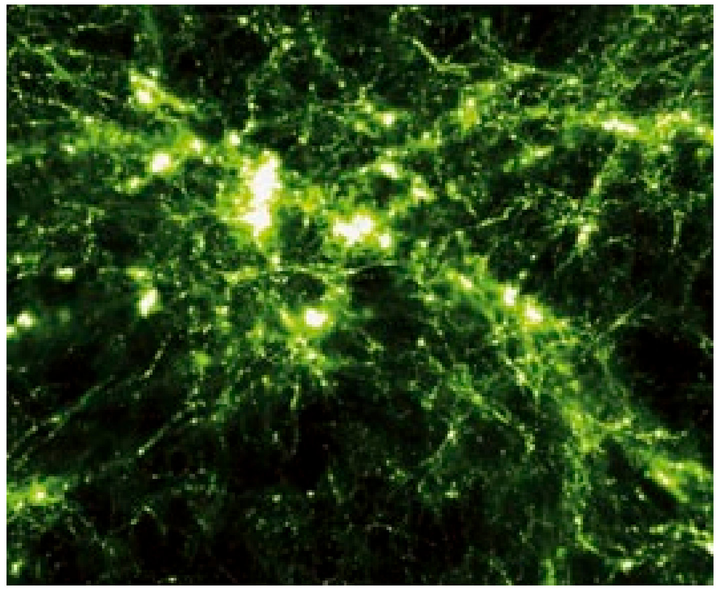
Astronomy has a gift: whenever we want to convince people we're doing good work with telescopes, we can turn to a rich archive of gorgeous imagery. While not a substitute for good science, it certainly helps. But for those of us who work on modelling the universe inside a computer, things are a little harder.

I've been developing methods for turning computer simulations of galaxies into images for a while, as part of my open source project pynbody (**http://pynbody.googlecode.com**). It's hugely important in scientific analysis: whether we want to create a literal analogue to a telescopic picture, or a more metaphorical representation of the contents of our virtual universe, distilling millions of numbers into an image is a critical step.

But these days that's not enough. Static images just don't cut it in the age of YouTube. And the cosmos really is a fairly static place on human timescales; galaxies evolve only over billions of years. This is where us computer nerds have the edge over observers of the real universe: the process of simulation involves calculating and storing the state of the computerised cosmos from its early stages through to the present day. That means there's nothing to stop you from taking a picture of it at any stage of its development. Or, better, taking a whole series of pictures at subsequent steps. To jazz it up, you can start moving the virtual telescope through space. And, before you know it, you have a Hollywood-style movie of how galaxies form and evolve – but all based on real physics.

Last November, luck sent the production team of BBC2's Stargazing Live in my direction. They were looking for ways to discuss the evolution of the cosmos. Having seen a movie I'd made based on a previous paper, the production commissioned a series of videos taking us from the Big Bang through to a present day 'Milky Way'-like galaxy. Using a portion of Oxford's Berg supercomputer, it was possible to generate 10TB of data and distill it into about 50,000 separate images to create the final footage in just over six weeks.

Watching the videos has given me a whole range of ideas for new science we can do with these simulations. We're inherently visual creatures; nothing compares to seeing things unfold in front of our eyes. While you've missed the chance to see it on live TV, there's a digested version here: **http://youtu.be/77ZoF7Y1pNk**.



Left: The distribution of dark matter over tens of millions of light years during the formation of galaxies.

Follow the Astrophysics blog!

Read about our research, and see our weekly "What's Up?" column for what to look out for in the night sky.

http://facebook.com/OxfordAstrophysics

Stargazing Oxford

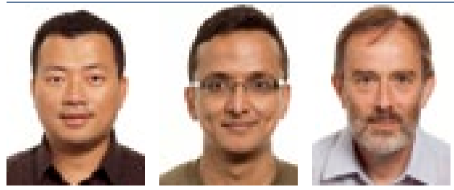
Continued from page 1...

Inspired viewers could then look on the BBC "Things to do" website, and find out about Stargazing Oxford. We thought we might get quite a lot of interest, but the response was amazing: not many of us had imagined people queuing for 45 minutes in the cold to get into our building! For us, Stargazing Oxford was incredibly exciting, and also quite humbling: the public's delighted fascination with space science made a big impression on us all.

Until the return of BBC Stargazing Live next January, Stargazing Oxford will carry on in one form or another throughout the year. We invite the public into the Department once a month for more focused stargazing evenings, using the 0.4m Philip Wetton Telescope (when the moon is full and the Masters students' targets are too faint compared to the night sky).

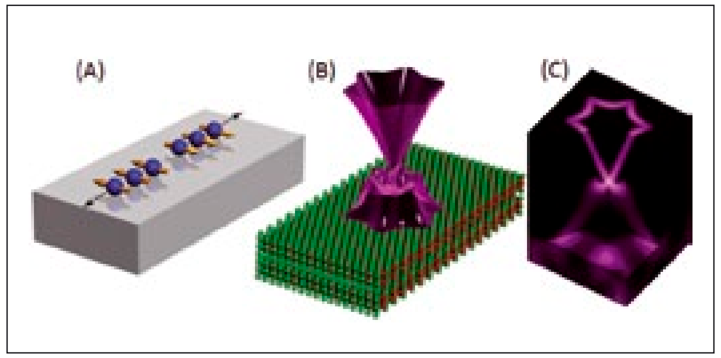
Physicists from Oxford University also regularly get out and about to other local science festivals, working with Science Oxford and the local community astronomy societies to bring the latest in space science to the people of Oxfordshire.

Topological Insulators



Yulin Chen, Rahul Roy and John Chalker

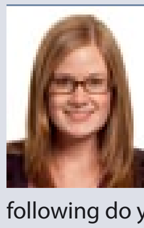
One of the successes of physics in the 1930s was the use of quantum mechanics to understand the difference between metals and insulators in terms of electron energy bands. Remarkably, we have discovered over the past few years that a key feature was missing from the picture we've accepted for nearly eight decades. This is that insulators come in two types, now known as 'ordinary' and 'topological'. Oxford Physics is closely involved with these developments: one of the leading theorists in the field, Rahul Roy, spent two years in the Oxford Condensed Matter Theory group as a postdoctoral research fellow before moving to a faculty position at UCLA; and Yulin Chen, an expert in the experimental techniques used to probe these new materials, has recently joined the Department from Stanford.



Surface conduction of topological insulators: (A) The spin of electrons on the surface is correlated with their direction of motion. (B) The lattice structure of Bi_2Te_3 and the predicted relativistic "Dirac cone" like electronic structure formed by the surface electrons. (C) The electronic structure measured by angle-resolved photoemission that confirmed the theoretical prediction and the topological nature of Bi_2Te_3.

Rahul Roy writes: Imagine taking a block of wood and coating its surfaces with silver. Then the block would be a bulk insulator with a metallic conducting surface. A 'topological insulator' is similar to a coated block, but whereas cutting the wood block would create new insulating surfaces, cutting a topological insulator creates new conducting surfaces. My work uses the mathematics of topological invariants to predict that certain insulating materials will have surface modes for electrons, which are robust because they are protected by symmetry from, for example, the effects of impurity scattering. Experiments with a number of materials, ranging from HgTe/HgCd heterostructures to Bi_2Te_3 have vindicated these predictions, and many examples of topological insulators are now known.

Yulin Chen writes: Oxford is setting up a programme to study the physics of these novel materials and find how we can tailor them to potential applications. The taskforce will include several local institutions: Oxford Physics, where a laboratory is being constructed for advanced angle-resolved photoemission spectroscopy (ARPES) so we can directly measure electronic structures; the Diamond synchrotron light source; and the central laser facility of the UK Scientific and Technology Facilities Council. This coalition will bring our research to the forefront of this exciting new field.



Hannah Arnold

You want to go to the beach at the weekend: which of the following do you think is the more useful weather forecast: a) next weekend will be dry; or b) next weekend the probability of rain is just 10%? Both are possible ways of presenting the same forecast, though only the second acknowledges that our prediction about next weekend's weather involves uncertainty.

There are two main sources of uncertainty in our weather forecast, both of which must be accurately represented. The first is initial condition uncertainty. The atmosphere is a chaotic system, so errors in the starting conditions for our forecast (i.e. errors in the measurements we make of the weather today) can lead to large deviations in the predicted weather for the weekend. The second is model uncertainty. In order to make the forecast, we have had to represent the atmosphere, oceans and land, and their many interactions, in a piece of computer code, which introduces other errors. In particular, we have to represent unresolved small scale processes, such as clouds, in some way, which involves major simplifications and approximations. My D.Phil. work involves developing a new technique (involving stochastic mathematics) for representing the small scales in an atmospheric model, providing a physically motivated way of representing model uncertainty. We have found the forecasts made using this technique are very reliable; if you look at all the occasions when we have forecast a 10% chance of rain, on average it rains 10% of the time. This is very important for climate change prediction, where we are interested in how the statistics of the weather will change due to anthropogenic forcing. We must be confident that our model accurately represents today's climate in order to trust the climate it predicts for the future.

In the atmosphere, it has been found that certain weather patterns are very predictable – the errors due to initial condition and model uncertainty stay small as we look to the future. However, on other occasions, including these representations of uncertainty leads to a large divergence in the forecast for the weekend, indicating the atmosphere is in a very unpredictable state. It is only by accurately representing uncertainty that we can estimate how predictable the atmosphere is now, and tell you whether taking an umbrella to the beach next weekend might be a good idea or not!

Mapping Fermi surfaces of iron-based superconductors using high magnetic fields

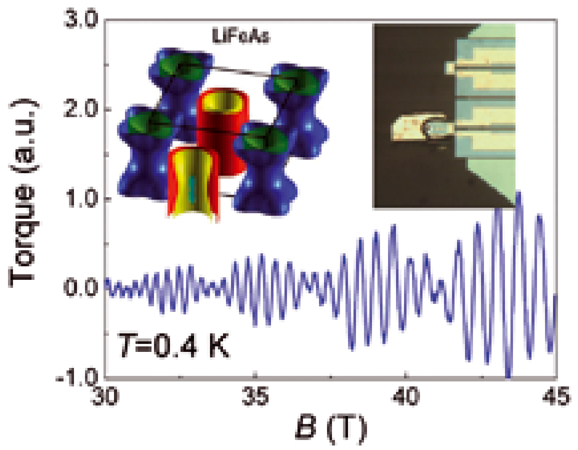
Amalia Coldea

In 2008, new classes of high-temperature superconductors containing iron were discovered. This discovery was most unexpected, as a material that is strongly magnetic, like iron, usually destroys a superconducting state. These iron-based superconductors offer a new area of exploration and understanding of superconductivity. It was found to exist in many other different structural families, which shared common conducting layers of tetrahedra, formed of iron atoms bonded with elements from the nitrogen or the oxygen groups. Between these conducting layers one can place single elements as spacers or as dopants of electrons and holes. The largest value of the transition temperatures reached by these materials is 55 K, which is only slightly below 77 K, the temperature of liquid nitrogen at which many more practical applications of superconductivity would become much more cost effective.

Quantum oscillations allow us to map out the full Fermi surface of a superconducting system, usually in its normal metallic state, and probe its bulk properties. These oscillations are determined by the Landau quantisation of energy levels in high magnetic fields and are usually observed at very low temperatures and in single crystals without impurities. By knowing the exact nature of the quasi-particles in the normal state and the degree of electronic correlations, one can simplify and restrict the theoretical models required to understand the pairing mechanism in superconductors, which would help us to design materials with improved properties. The experimental determination of the temperature and the magnetic field-dependence of the fundamental amplitude from quantum oscillations, provide precise values for the cyclotron orbital effective mass or the orbitally averaged electron lifetime, respectively. The advantage of quantum oscillation measurements is that the information obtained is localised in k-space and the values of the observed frequencies are directly related to the extremal areas on the Fermi surface normal to the applied magnetic field. Other measured quantities such as the masses and scattering rates or the quasiparticles are only orbital averages, rather than averages over the entire Fermi surface, so that the quantum oscillations effect serves as a 'k-space microscope'.

In the case of iron-based superconductors we have found that the Fermi surface is in broad agreement with the prediction of the band structure calculations, being composed mainly of up to five different iron bands that have differing orbital characters and are very sensitive to the chemical pressure applied by replacing different chemical elements with a similar number of electrons. The quasi-particles' masses, and the effect of the electronic correlations determined experimentally, are strongly related to transition temperatures found in different materials. This suggests that the higher transition temperature can only be achieved by the increase of correlations that are likely to be mediated by magnetic fluctuations (as the superconducting phases are often found in close proximity to magnetic order, sometimes even co-existing with magnetic order).

The success of these type of measurements and their understanding comes from a combination of access to high magnetic fields and low temperatures, micron-size high quality single crystals (usually smaller than the thickness of a human hair) and highly sensitive experimental tools like the atomic force microscopy piezolevers (three orders of magnitude better sensitivity than a commercial SQUID) that can detect very small changes in the magnetic properties when varying the magnetic field. The quantum oscillations are measured experimentally at very low temperatures and very high magnetic fields, either in Oxford up to 21 T, or international high magnetic field facilities up to 100 T. The results are then compared with first principle band-structure calculations. The interdisciplinary nature that comes from the combination of experiments, theory and synthesis of high quality crystals makes this type of fundamental research possible. It is not only applicable to understanding superconductivity but also other quantum materials that have metallic properties and it may find application in the new topological insulators, where metallicity is reduced to the surface states.



Quantum oscillations in magnetic torque as function of magnetic field in LiFeAs, an iron-based superconductor discovered in Oxford (S. Clarke, Chemistry).

The inset shows the Fermi surface calculated using band structure calculations (left) and a micron-size single crystal placed on a piezocantilever (right).

These results were published in Physical Review Letters. 108, 047002 (2012).

STOP PRESS! **CERN ANNOUNCES DISCOVERY OF HIGGS BOSON!**

Just as we are about to go to press, on 4th July CERN has announced the discovery of a Higgs-like boson in two of the main experiments at the LHC. For the latest news on Oxford's involvement in this exciting result, see **www.physics.ox.ac.uk/news**

SCIENCE NEWS
www.physics.ox.ac.uk/research

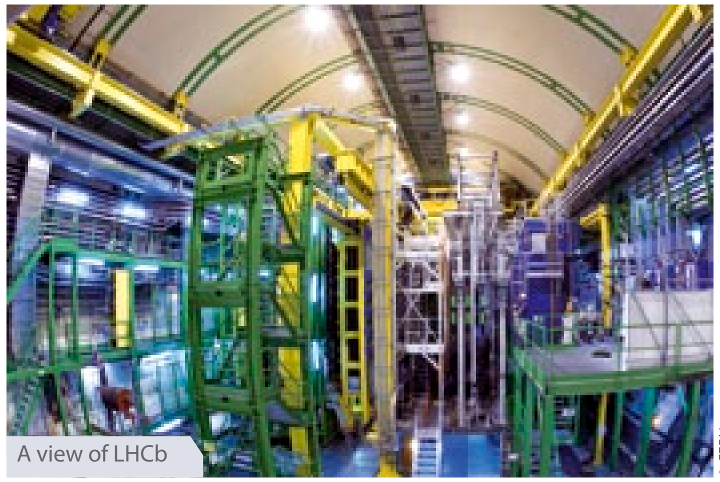
LHCb seeks new physics with charm

Matthew Charles

Oxford has played a central role in the LHCb experiment from its founding. After years of painstaking work to design, build, and commission the detector, especially its state-of-the-art Ring Imaging Cherenkov and Vertex Locator subsystems, data from the highly successful 2011 run are now in hand. Oxford physicists are now searching them for hints of new physics beyond the Standard Model (SM). The approach is to make precise measurements of processes that are well predicted in the SM but could be affected by new physics. The main focus is on B and D hadrons, which contain beauty and charm quarks, respectively. Many of the key measurements probe CP violation (CPV), which manifests as differences between the decays of particles and their antiparticles.

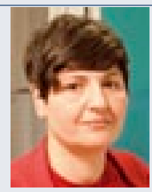
LHCb has published a new study (arXiv:1112.0938, accepted by Physical Review Letters) showing evidence for CPV in D^0 decays, led by researchers from Oxford and Bologna. The technique used was to compare two different decay modes, $D^0 \rightarrow K^+K^-$ and $D^0 \rightarrow \pi^+\pi^-$, and look for a difference in their asymmetries. This difference is particularly sensitive to new physics and robust against systematic uncertainties. The result, $(-0.82 \pm 0.24)\%$, differs from the no-CPV hypothesis by 3.5 standard deviations and if confirmed would be the first time CPV has been seen in a charm decay. The measured value is also larger than the prior expectation from SM calculations (0.1%) and is provoking much interest. Ongoing theoretical work stimulated by the LHCb result now suggests that a larger SM effect cannot be excluded, but many new physics models can also generate such a signature naturally.

More work is needed to confirm or disprove such a tantalising hint. Oxford is at the forefront of studies to repeat the measurement on more data and to crosscheck it with a different methodology.



A view of LHCb

Nanotechnology uncovers mechanical complexion of living cells



Sonia Trigueros and Sonia Contera

As the basic unit of life, the cell is a biologically complex system, the understanding of which requires a combination of various approaches, including mechanics. With recent progress in cell and molecular biology, the field of cell mechanics has grown rapidly over the last few years.

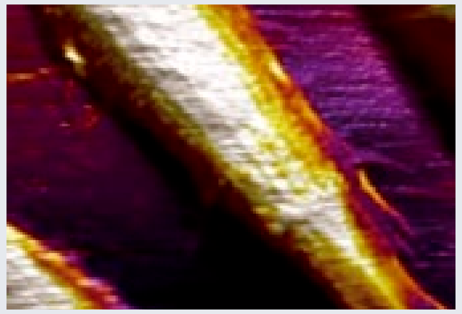
A single cell can detect, modify, and respond to the physical properties of its environment. Cells have the ability to resist deformation, to transport intracellular cargo and to change shape during movement; all these functions rely on the cytoskeleton, an interconnected network of filamentous polymers and regulatory proteins. Moreover, cells communicate with each other through chemical and physical signals, which are involved in a range of processes, from embryogenesis and wound healing, to pathological conditions such as cancerous invasion. Cell mechanics is central to understanding these principles.

As cell mechanics draws from the fields of biology, chemistry, physics, engineering and mathematics, to aim for a progression in this field, a multidisciplinary research approach is required. This is not to provide a collection of research methods, but to develop a common language among scientists who share an interest in cell mechanics but enter the field with diverse backgrounds.

A new approach to measure the mechanical properties of living cells has been developed by researchers from Oxford Martin Programme on Nanotechnology based in the Physics Department, in collaboration with Purdue University's Birck Nanotechnology Center. Using an atomic force microscope with a tiny vibrating probe, researchers have been able to discover detailed quantitative information about living cells on the nanoscale (billionths of a metre). This means that scientists will be able to map the evolution of mechanical properties of cellular structures, for example as cells adhere to tissues or communicate with each other, effects that are critical for many diseases and biological processes.

Existing methods to map the local mechanical properties of cells using this instrument are slow, offer low resolution and most of the cases only work on preserved, not living, cells. The innovation overcomes these limitations, mostly through improvement in signal processing and theory, allowing us to use conventional instruments to boost pixels per minute and obtain quantitative information on different types of living cells.

Next, the Oxford Martin Programme on Nanotechnology will study the mechanical properties of cells under the influence of antibiotics, chemotherapy drugs and nanomedicines, to learn more about the mechanisms involved.



AFM map of a live fibroblast cell. Different parts of a cell with different mechanical properties, whether they are soft or rigid or squishy, can be clearly identified.

DEPARTMENT NEWS & EVENTS

New building for Oxford Physics

A note from the Chairman

John Wheater

The Physics Newsletter aims to open a window for our alumnae and alumni onto the fascinating world of physics today. I was particularly struck by the number of letters we received in response to the first issue, commenting on how quickly the subject had changed over the past few decades. Despite this rapid evolution, the facilities we need are often large and expensive and slow to bring to fruition, and the outstanding scientists of the future who will use them need many years of education and training. It has never been more necessary to plan ahead.

These days, young scientists come from all over the world to work and study with us. Even at the undergraduate level, a significant proportion come from overseas; the Physics Department is a cosmopolitan place. This diversity brings its own challenges; for example at the graduate level we do not at present have the resources to offer funding to all the outstanding applicants who satisfy our academic requirements.

The Department is a vibrant and largely youthful community, but its buildings were not designed with 21st century science in mind. Our most modern building is the Martin Wood Lecture Theatre complex in the centre of the Clarendon Laboratory, which was completed in 1999 and generously financed by Sir Martin Wood. Increasingly, we struggle to maintain our laboratories at the cutting edge and, after a comprehensive review, now have a redevelopment plan. The New Clarendon Laboratory project has several stages, ultimately resulting in all of Physics being located on the Clarendon Laboratory site.

The first phase is to construct a new building on the car park in front of the Clarendon Laboratory. The University has already invested £1.1m in the design process. The competition to choose the architects was won by Hawkins\Brown, and planning permission has been granted by Oxford City Council.

The building will provide a high quality laboratory environment in two basement levels, with very low vibration levels and excellent temperature control. Above ground there will be seminar rooms and accommodation for Theoretical Physics. The atrium will contain a hierarchy of spaces suitable for discussion groups of a couple of people up to a dozen or more. The whole building will be linked to the existing Clarendon Laboratory at three levels, and is designed to encourage fluidity of movement between its various elements.

The next challenge is to raise the £34m construction cost in these financially difficult times. We have established a Development Board, chaired by Sir Christopher Llewellyn Smith (New College, 1961, former Director General of CERN and Director of the Culham Centre for Fusion Energy), to oversee our fundraising campaign and have made a good start, with the very generous pledge of £1m from Adrian Beecroft (The Queen's College, 1965).

If you would like to see the design, or participate in fundraising, visit:

www.physics.ox.ac.uk/about-us/clarendon-2-cl2-building

New building – Architects' impression

Will.i.am visits Physics

Prof Myles Allen and Will.i.am (Black Eyed Peas) met in May to discuss climate science, the latest technology trends and the power of computers in helping us understand what is happening in our planet today.

Prof Allen leads many exciting projects; one of them is **weatherathome.net**, which seeks to understand the role of climate change in damaging – or beneficial – weather events affecting people's lives in different regions of the world.

Will.i.am is Director of Creative Innovation at Intel, famed for their ground breaking computer processors, and also leaders of 'Progress thru Processors' initiative, which encourages the use of computers across the world for public good, including the *weatherathome* project.

Professor Allen is keen to encourage many more people to join *weatherathome*. He said "It was inspiring to see Will so enthusiastic about how we can use computer technology to improve people's lives – and also thinking deeply about how technology may be changing us. He is also committed to science education and encouraging students from under-privileged backgrounds to aim high – which, of course, are high priorities for Oxford Physics."

Members of the public can sign up, free, to **www.climateprediction.net/weatherathome**.

DON'T MISS OUR FANTASTIC PUBLIC EVENTS!

SUBSCRIBE FOR AUTO UPDATES!

The Department of Physics hosts and organises a variety of events, from lectures given by world renowned individuals, to family and school-friendly activities.

www.physics.ox.ac.uk/events

BIG BANG! *Physics joins social networks!*

Help us build a strong community @ Oxford Physics, find us and exchange ideas via:

Facebook: University of Oxford Physics

Twitter: OxfordPhysics

LinkedIn: Oxford Physics

Physics celebrates 'GrahamFest'!

On 30 September 2011 people from all over the world gathered for a meeting in the Sciama Lecture Theatre to celebrate the contributions of retiring Professor Graham Ross FRS to theoretical physics. See **www.physics.ox.ac.uk/GrahamFest** for further information.

NEW ALUMNI RELATIONS OFFICE AT OXFORD PHYSICS

A warm welcome to Val Crowder, our new Alumni Relations Officer.

The Department of Physics Alumni Relations Office works to develop, nurture and promote a continuing relationship between the Department and its alumni.

We also work with current students, staff, researchers and friends of the Department, aiming to enhance the experience of being part of one of the largest and most successful Physics Departments in the world.

We will be developing a series of events and projects to facilitate interaction and networking, creating relationships that keep growing beyond graduation day.

If you have ideas, queries or suggestions, Val would be pleased to hear from you: email her at **contact@physics.ox.ac.uk**, or Tel. **+44 (0)1865 282065**.

Keep your diary free for the Alumni Weekend!

14-15 September 2012

Physics is opening its doors to alumni and friends, as part of the University's Alumni Weekend! Come and participate in exciting events, attend a lecture and meet the physics community.

TELESCOPE EVENING

Friday 14 September

Denys Wilkinson Building, Keble Road

Join us for a tour of the Philip Wetton telescope – a fantastic resource for teaching in Oxford, and for local schools and colleges. The telescope, built in 1995 by the Meade Corporation of California, was given to the University so that undergraduate and graduate students could observe the night sky as would a professional astronomer. Its location is a fabulously-positioned, purpose-built observatory atop the Denys Willkinson Building in Keble Road, the first new observatory built in Oxford for over a century. Each year the telescope is opened to schools, community groups and the general public, so that everyone can enjoy the excitement of practical astronomy.

VIEW THE ALUMNI WEEKEND PROGRAMME

There is a lot to see and do at Oxford this weekend, from talks and tours, to tastings and more! For full details of the weekend's activities, go to www.alumniweekend.ox.ac.uk.

Booking closes 31 August, so don't delay, book now!

If you are currently part of the Department, and would like to show your work during the Alumni Weekend, or contribute ideas or suggestions, email Val Crowder at **alumni@physics.ox.ac.uk**

PHYSICS OPEN DAY

Saturday 15 September

Clarendon Laboratory, Parks Road

We are delighted to be able to offer an opportunity for alumni, families and friends to visit our Department, and welcome all interested in our work, even if you didn't do Physics!

MINI MOTORS

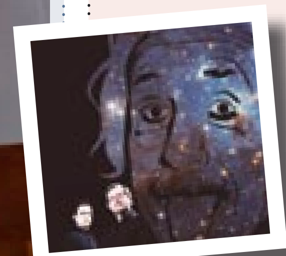
2–6pm

Join Dr Helen Carstairs and researchers from Biological Physics for hands-on demonstrations of the way nanoscale biological motors work.

ZOONIVERSE: WHAT TO DO WITH HALF A MILLION SCIENTISTS?

2–3pm

Dr Chris Lintott and Dr Rob Simpson explain using 'citizen power' to expand our knowledge of the Universe.



EINSTEIN'S UNIVERSE

3.15–4.45pm

Professor Brian Foster and Jack Liebeck (violinist) will present Einstein's universe in the context of the music he loved.

PHYSICS IN THE 21ST CENTURY – AN EXCITING TIME FOR PHYSICS AT OXFORD

5–6pm

Come and hear from Dr John Wheater, Chairman of the Department, and other members of the Physics team about all the latest projects and ideas that we are working on.

DRINKS RECEPTION

6–7pm

Have a look at the plans for the proposed new building for Physics and find out how to keep in touch with the Department.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For more information and to keep up to date with the alumni weekend plans:

www.alumniweekend.ox.ac.uk

Alumni stories

In the last newsletter we invited alumni to contact us and tell their stories. Three of you have been kind enough to send us a contribution, revealing three diverse careers. We hope you enjoy reading these. Please keep these contributions coming!

Lance Miller (Editor).

Adrian Beecroft


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Adrian Beecroft


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The Queen's College

I arrived at Queen's as a physics undergraduate in 1965. Having attended a few lectures, I decided my time would be better spent in the library! It was noticeable that the more eminent the lecturer, the less comprehensible was the lecture. However, I very much enjoyed my tutorials with Dr Moffatt, who later became Provost of Queen's. He was (and remains) a shy man but a great teacher, with endless patience, and I owe him a lot.

There was vague talk from one of my tutors of a D.Phil, but I felt I wanted to see more of the world outside academia. So I joined International Computers Ltd (ICL), then Britain's answer to IBM. I thought I'd be a technical person in ICL but I overcame the Englishman's natural aversion to sales when I realised that sales people had more fun, earned more and told the techies what to do! After five great years I got an offer I thought too good to be true, with a shipping company. My initial analysis proved correct, so after a year I went to Harvard Business School instead. That was a wonderful two years, working hard for six months a year and travelling the other six. My wife Jacqui came with me and we made some lifelong friends.

My friends thought I was mad, as in those days people only joined little companies if they couldn't get a job with a big one!

The terms of the Harkness Fellowship that funded me, together with my determination to play more cricket, dictated that I should return to the UK. I joined the London office of the Boston Consulting Group (BCG), which then had fifteen people. We described ourselves as strategy consultants, and argued that the fact that we didn't, in most cases, know anything about the client's industry was an advantage as we came to their problems with an open mind. Strategy consulting has moved on a lot since then! For eight years I toiled away, travelled endlessly, enjoyed it enormously, became a Vice President (Partner) and then decided that I wanted to do rather more than to advise, and to work more with science/technology based companies. I therefore left to help start Apax Partners, then a venture capital firm with a £10m fund and three professionals. My friends thought I was mad, as in those days people only joined little companies if they couldn't get a job with a big one! Backing small, high tech firms in the UK was (and remains) an exciting, fascinating, frustrating and stressful way of earning a living, and the recession of the early '90s didn't help. But we had a few winners (Autonomy, Waterstones) to compensate for the duds and by the time I left in 2008 we had grown to 150 professionals with 10 offices around the world and more that £20 billion under management. My physics training was helpful in analysing quite a few of the thousands of business plans that I've seen over the years (including two thinly disguised perpetual motion machines). My time as a salesman had engendered the healthy dose of scepticism that is essential if you're going to be a success at venture capital. When researching a potential investee, their potential customers often say they find that company's product or service really interesting, but you only know they're not just being polite when they sign the order! More broadly, I'm convinced that physics is an excellent training for business, as every senior position requires an analytical, curious and numerate mind. Apax has a large proportion of physicists among its staff!

Since leaving Apax I've been on a few Boards, become Chairman of Dawn Capital, a small venture firm much like Apax was in its early years, and done a bit of philanthropy, including sponsoring the Institute of Particle Astrophysics and Cosmology at Oxford, and an Academy school (also in Oxford). In addition, I Chair a charity called Chance to Shine, which is bringing back cricket to state schools, more for the wider educational and social benefits of learning to take part in a team game rather than in hopes of producing another Andrew Flintoff. We coached our millionth child last year.

By the time I left in 2008 we had grown to 150 professionals with 10 offices around the world and more that £20 billion under management.

More recently, I was asked to prepare a report for the Government about how employment law could be changed to remove some of the red tape that hampers businesses and discourages people from hiring new employees. Many of the recommendations have been adopted, but one in particular has been controversial. I have learnt that if part of the press don't like an idea, they feel they can help to kill it off by shooting the messenger. It's been very uncomfortable at times, but I'm glad I did it.

There are three pieces of advice I'd give to someone who's looking for a job in business or finance. First, join an organisation or an industry that has the capacity to grow quickly. Growth always provides opportunities for young people: there's no waiting for dead men's/women's shoes as there is in mature, slow growth companies. Second, work with products or services that you find really interesting rather than for the company that will pay you the most on day one. I've taken a reduction in salary every time I've moved jobs and only regretted it once. Third, always be nice to everybody. The world is a small place and you never know when, and in what position, people will reappear in your life.

Susan Cox

Susan Cox: "I decided to take one more leap..."

When I arrived at Oxford, I knew what I was going to do with my life. I was going to become a theoretical physicist and spend my time contemplating the universe. This is the story of how that didn't happen.

My first year was the normal mix of parties, lectures, parties, tutorials and parties. Through the haze of sleep deprivation I gradually realised that I actually found physics hard. Since budding Feynmans probably didn't start to struggle in their first year, I had to reconsider my options. Maybe there was a less competitive area that I could excel in? An area that no-one seemed to like, that everyone complained about, and was openly despised by the lofty theorists who I had hoped to join? So I turned my attention to the practical physics course.

Susan Cooper pushed me outside my comfort zone. She taught me to question what I thought I knew, both about physics and my abilities.

I put the idea of actually reading the practical sheets in advance, and doing all the optional parts, to my long-suffering practical partner, Chris, who agreed to give it a try. Surprisingly, it turned out to be fun – the best bits of the practicals were generally hidden in the extensions at the end. This taste of research whetted my appetite, and led to two hugely enjoyable summer projects doing atomic force microscopy.

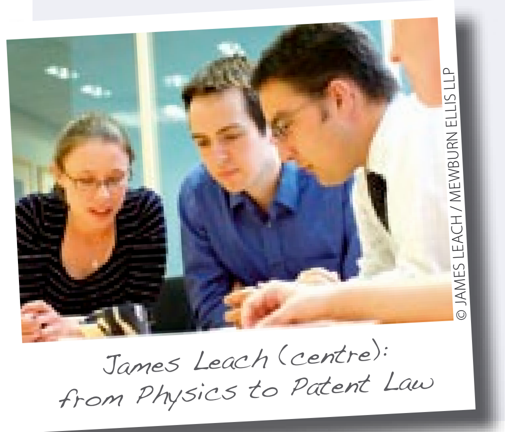
In my third year I started Susan Cooper's particle physics course. I had always thought I performed quite well in tutorials, but Susan pushed me outside my comfort zone. She taught me to question what I thought I knew, both about physics and my abilities. I also very much enjoyed the condensed matter physics course, particularly John Singleton's lectures. This led to a PhD studying strongly correlated electron systems. In the third year of my PhD I happened to encounter John again on a visit to Los Alamos, where he had now moved. As soon as we met, we started exchanging ideas about experiments, and less than a year later I was doing a postdoc with him. I spent late nights in the lab and long days snowboarding. It was fantastic.

However, after three years, and having been through a fruitless round of job applications, I was again faced with a decision: should I stay in condensed matter physics? An advert for a postdoc in biophysics caught my eye, and the idea of looking at living systems was so exciting that I decided to take one more leap. The award of a Royal Society University Research Fellowship has allowed me to continue struggling with biology for the foreseeable future.

I guess if this story has a moral, it is that if you want to feel like you know what you're doing, don't go to Oxford. But if you want a research career where every day is like a jump off a cliff into the unknown, then it's a good place to start.

James Leach

Oxford in the summer is always beautiful, and never more so than when physics finals are over. As I neared the end of my degree, I remember relaxing in University Parks with friends, looking back on four truly fantastic years. Despite the joy and relief, I recall a gnawing feeling in the pit of my stomach, asking "what next?". Throughout my degree, I had studiously avoided this question. However, having decided against further study, and with my bank balance firmly in the red, the time had come for me to find something productive to do. Ideally, I wanted a career that would make use of my physics degree, without tying me to a laboratory. A friend suggested I consider a career as a patent attorney, so I fired off some applications and was lucky to be offered a position at a top UK patent law firm. Seven years on, I am happy to say I am still here!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James Leach (centre): from Physics to Patent Law

As a patent attorney, I work at the interface between science and law. The role of the patent attorney is to secure effective legal protection for new inventions. We handle a wide range of applications each week, so it is virtually impossible to get bored; there is always something new around the corner.

Physics graduates tend to work mainly on patent applications relating to mechanical/electrical/software-type inventions, such as medical devices, mobile phones and search engines. There is, however, no such thing as a "typical" patent application: I have worked on some surprising inventions, including a beer cooler, a tilting train and even an inflatable car! Although the inventions mentioned above are not usually the direct subject of a physics degree, a physics background is ideal for getting an in-depth understanding of how things work, meaning that high-quality physics graduates are among the most sought after recruits in the profession.

I have worked on some surprising inventions: a beer cooler, a tilting train and even an inflatable car!

Most people are surprised to learn that one does not need any legal knowledge or experience before joining the profession. The requisite legal expertise is normally learnt on the job, by working as a trainee under the supervision of a qualified patent attorney, usually for three to four years. You then take your qualifying exams.

If you are interested in finding out more about a career as a patent attorney, the Inside Careers Guide (**www.insidecareers.co.uk**) provides in-depth guidance to the profession. If, on the other hand, you have recently devised an invention which you think might be worth protecting, please get in touch with your nearest patent attorney!

*James Leach works for Mewburn Ellis LLP (**www.mewburn.com**) and can be contacted at **james.leach@mewburn.com***

Comings...

PROF STEVE BALBUS will be the Savilian Professor of Astronomy from October 2012.

DR MATT JARVIS will join Astrophysics in October 2012, working on Square-Kilometre Array science.

DR IVAN KONOPLEV joined the Department in 2011 as a University Lecturer in Accelerator Science.

PROF MICHAEL THORPE will be Visiting Professor in Theoretical Physics.

Goings...

PROF KEN PEACH retired in 2012.

We report with great sadness the passing of **PROF STEVE RAWLINGS**, in January, aged 50. Steve first came to Oxford as a PPARC Advanced Fellow in 1991, and was Head of Astrophysics, 2005-10. He is remembered fondly by his many undergraduate and postgraduate students. Steve not only supervised his postgraduates on their thesis projects, he also mentored and supported postgraduate and postdoctoral researchers in their careers and became a close friend to many. Steve was a highly respected friend and colleague of all those who worked with him. In his career Steve published more than 160 papers in refereed journals and was a lead scientist in the Square Kilometre Array (SKA) project. The SKA arguably will be the most ambitious astronomical telescope ever built, which Steve championed tirelessly, and he would have been delighted to have seen the adoption in May 2012 of Australia and South Africa as the telescope sites. Steve is sorely missed in the Physics Department.

PROF GRAHAM ROSS retired in 2012.

PROF JOE SILK, Savilian Professor of Astronomy, retired in 2012.

PROF FRED TAYLOR retired in 2012.

Awards...

PROF DAME JOCELYN BELL BURNELL was published in The Times 'Eureka 100' – a guide to the most important contemporary figures in British science.

PROF ANDREW BOOTHROYD was awarded the IOP Superconductivity Group Prize for his contributions to our understanding of the interplay between magnetism and superconductivity using neutron scattering techniques.

PROF JOHN CARDY was awarded the Dirac Medal and Prize for his pioneering work on field theoretical methods to the study of critical phenomena and phase transitions.

DR AMALIA COLDEA was awarded the Euromagnet Prize for her work on topological changes of the Fermi surface and the effect of electronic correlations in iron pnictides.

DR JO DUNKLEY, as a member of the Wilkinson Microwave Anisotropy Probe (WMAP) team, shares in the 2012 Gruber Cosmology Prize. The prize was awarded for WMAP's exquisite measurements of anisotropies in the relic radiation from the Big Bang – the Cosmic Microwave Background.

PROF NEVILLE HARNEW was awarded a European Research Council (ERC) Advanced Grant to develop a particle physics detector known as TORCH (Time Of internally Reflected Cherenkov light).

PROF CAROLE JORDAN was granted an IOP Honorary Fellowship for her outstanding career and commitment to science.

DR CHRIS LINTOTT was awarded the Royal Society Kohn Award for his excellent engagement with society in matters of science and its societal dimension.

JOHANNES MOELLER was awarded the Arthur H. Cooke Memorial Prize 2011 for distinguished work by a first year research student.

DR KEVIN O'KEEFFE was awarded the Cavendish Medal for his research into the use of high-intensity laser pulses to generate coherent beams of soft x-rays.

PROF TIM PALMER was awarded the European Meteorological Society's Silver Medal for his pioneering work on predictability of weather and climate. He was also awarded an ERC Advanced Grant for a project entitled 'Towards the Prototype: Probabilistic Earth-System Model for Climate Prediction'.

PROF DAVID SHERRINGTON has been elected Chairman of the Academic Council of EURASC (European Academy of Sciences).

PROF JOE SILK was awarded the Balzan prize for his pioneering work on the early evolution of the universe.

DR ANDREI STARINETS was awarded the IOP Maxwell Medal for his contributions to our understanding of the transport properties of systems of strongly coupled quantum fields.

DR ANDREW STEELE won FameLab 2012, a science communication competition, with his pitch on quantum mechanics and how it can help us to understand the world around us.

PROF ANDREW TURBERFIELD was awarded a Royal Society Wolfson Research Merit Award. He was also awarded the IOP Tabor Medal for his seminal contributions to nano-science.

DR SAM VINKO was awarded the IOP Culham Thesis Prize for excellence in scientific method.

PROF IAN WALMSLEY was elected Fellow of the Royal Society and awarded the IOP Young Medal for his innovative contributions to optical physics and technology.

PROF JULIA YEOMANS was awarded an ERC Advanced Grant to investigate questions that combine hydrodynamics and statistical physics.

For latest news on developments at the Oxford Physics Department, see www.physics.ox.ac.uk/about-us

To contact the Physics Department, email contact@physics.ox.ac.uk

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