UNIVERSITY OF CAMBRIDGE
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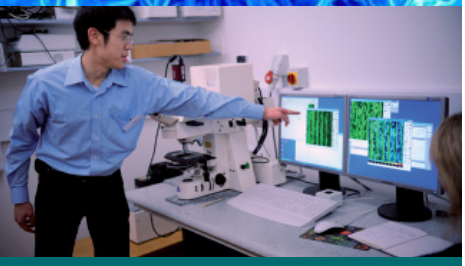
CavMag

February 2009 Issue 1

News from the Cavendish Laboratory

Inside...



www.phy.cam.ac.uk

Welcome to the first edition!

We were gratified to receive a great number of responses from many alumni to the Cavendish brochure that we sent last year - and one of the principal requests was for more news about the department. Hence this - the first Cavendish newsletter.

The Cavendish enters 2009 in fine fettle. Our research programmes - never static - continue to develop and evolve. Our research covers wide areas of science: from topics like solar cells and plastic electronics to our major programmes for detectors at CERN; from the study of quantum fluctuations in superconductors in the laboratory on the nanoscale to quantum fluctuations in the early universe; from the theory of drug design to the theory of everything. We are proud of the fact that we comfortably support both pure and applied science and that we house an interdisciplinary community where unexpected and productive interactions arise frequently.

The first major construction for several years is taking place in the Department. From my window my previous bucolic view across the fields to the Vet School is now interrupted by a huge new laboratory for the Physics of Medicine, officially opened in December by the Vice-Chancellor and our very own alumnus Sir Aaron Klug, a pioneer in molecular biology. A new Kavli Institute for Cosmology is being built in conjunction with the Institute of Astronomy, in the first stage of our plan to unify Astrophysics on a single site. We have entirely new research groups in atomic, mesoscopic and optical physics, and in nanophotonics, studying the fundamental science and applications of quantum systems.

The strength of our longer-established efforts is validated by a strong showing in the government's Research Assessment Exercise 2008. This review of research in all disciplines across the country, which influences a substantial part of our research support, recognised our combination of research quality and depth. Together with the Institute of Astronomy, we entered over 140 research active staff - the largest of any physics department - and 65% of the submissions were judged world-leading or internationally excellent.

To quote from that assessment:

"The department is regarded as very strong, well resourced, and supportive to both academic staff and to research students. The industrial and other external engagement is both successful and beneficial to the department. The present vitality and prospects are exciting and well-founded, and the department has a convincing vision of its future development which it is energetically bringing to fruition."

In the last three years we have hired over a dozen faculty, both to establish our new programmes in biology and atomic physics, and to fuel the established ones in condensed matter physics, particle physics, and astronomy. Two of the senior professorships in the department have changed hands: James Stirling comes from Durham as the new Jacksonian Professor, replacing Malcolm Longair who remains in the department as Director of Development; and Jeremy Baumberg comes back to Cambridge from Southampton as the more prosaically titled 2006 Professor, following the retirement of Sir Mike Pepper. Sadly, we must also report the death of Sir Brian Pippard, Cavendish Professor 1972-82, and tragically, that of Professor Tony Bland.

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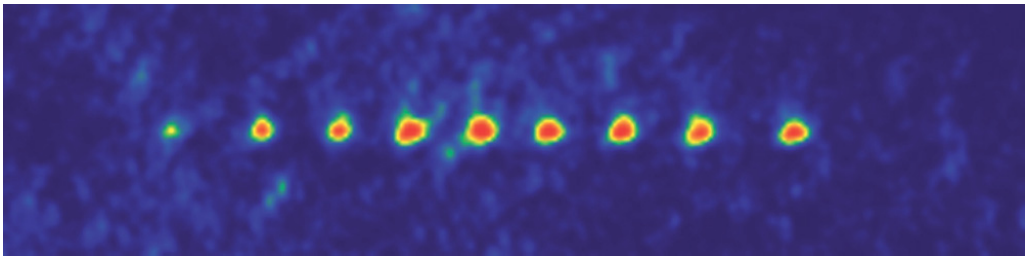


Single trapped atomic ions constitute the world's best controllable quantum systems. The image shows single trapped atomic ions stored in a radio-frequency trap at a temperature less than one thousandth of a degree above absolute zero. Single atoms are used in modern quantum computers and for exploring the foundations of quantum mechanics. This is one of the first results by Michael Köhl and his colleagues in the new AMOP group.

Continued from page 1

Students and teaching are of course the fundamental fuel for our work. Our students are no less extraordinary than they have always been, with a commitment to testing themselves against the boundaries of the discipline that is inspirational. Since the move over a decade ago to a four-year Natural Science Tripos leading to an MSci, the Cavendish has pioneered interdisciplinary courses in Part III so that our students can exploit their skills in wider areas such as entrepreneurship and climate change. We remain profoundly convinced that training in physics provides a grounding for all walks of life, and expect that they will make their mark in diverse fields, as you have.

Peter Littlewood

Editorial

Welcome to the first edition of CavMag, the newletter of the Cavendish Laboratory. We have felt the need for such a vehicle for many years, but now we have taken the plunge and made an effort to assemble interesting material which will be of interest to alumni, members of the laboratory and our colleagues in other departments. We plan to publish the Newsletter every six months or so, a period over which we anticipate there will be breaking news, important discoveries, new initiatives and so on. We aim to maintain a balance between the new, the exciting, the historical and particularly the human face of the Laboratory.

The first step in the process of broadening engagement in the work of the Laboratory was the publication of the *Cavendish Laboratory 2008* booklet, which brought together for the first time in many years the many diverse areas of research which now constitute Physics . We always emphasise, "Physics is what Physicists do", as will become abundantly clear from the articles in this newsletter. The response by alumni to the booklet was very positive and the vast majority of those who kindly filled in the questionnaire were delighted to be kept informed about our research programme. We were very aware, however, that, in order to cover the vast diversity of topics being actively studied, the summaries were terse and on occasion somewhat technical. We had also intentionally made the presentation somewhat impersonal, in that we avoided mentioning individuals who were carrying out the research. They can be tracked down on our redesigned website, but still the *Cavendish Laboratory 2008* booklet is a moderately austere document. This newsletter is intended to be much more human.

Pride of place in this issue goes to Athene Donald who features in two major articles, highlighting her award of the 2009 L'Oreal Prize and her new role as the first Director of the Physics of Medicine initiative, following the opening of the Physics of Medicine Building in December 2008. Part of the drive behind that initiative was the desire to develop Physics for the benefit of society. This will continue to inform our research efforts, another splendid example being David Mackay's remarkable new book *Sustainable Energy – without the Hot Air*.

Malcolm Longair and Peter Littlewood

We mourn the passing of Sir Brian Pippard, who impacted the physics education of so many alumni and for whom John Waldram has written an authoritative and moving obituary. Also in this issue, we introduce new appointees, such as James Stirling, the new Jacksonian Professor of Natural Philosophy, and the four lecturers in the Physics of Medicine. Then there are the challenges of running the teaching, research grant and graduate training programmes. An important regular feature of the newsletter will be our efforts in outreach to schools and the general public, and Lisa Jardine-Wright has provided details of many of the programmes that she organises. She will be delighted to hear from those who wish to take part in these activities, particularly from young people and their teachers. There will be regular items about historical topics, this month the highlight being the unveiling of the statue of James Clerk Maxwell in Edinburgh.

This is our first attempt to produce an attractive and interesting newsletter that alumni, staff and colleagues will enjoy reading. Please get in touch with us about your views on the contents, style and approach – we are on the learning curve.
We hope you have a splendid 2009.

Malcolm Longair

Opening of the Physics of Medicine Building

The opening of the Physics of Medicine Building is the first step in the reconstruction of the Cavendish Laboratory to provide facilities that will enable our colleagues to remain world-leading in their research programmes. The opening on 16th December 2008 was the culmination of efforts by many people to bring about an innovative approach to areas where physics research can contribute to key problems of importance to society at large.

The concept came about through the coincidence of the arrival of Professor Chris Dobson in Cambridge, and the generous endowment of a Herchel Smith Chair of Physics by the Herchel Smith foundation. Chris came to Cambridge with a vision of expanding the role of physics and chemistry into the biological and clinical medicine areas. This matched the Cavendish's aspirations to develop a major initiative in the area of biological physics. But the vision went much further and, at a meeting between Chris, Sir Keith Peters, then Head of the Clinical School, Sir Tom Blundell, the Head of Biochemistry, Richard Friend and me, a broad interdisciplinary approach to the challenges in the area of biological physics and medicine was defined. Among the objectives was to bring the culture of physics to bear upon some of the most challenging problems in these areas. As a contribution to this initiative, the Herchel Smith Chair was dedicated to the Physics of Medicine and we look forward to filling this post in the near future.

This initiative met with the enthusiastic support of the associated Schools of the University and by the University itself as exactly what Cambridge should be doing in key areas of interdisciplinary research. With the generous support of the Wolfson Foundation and the University, the first phase of the Physics of Medicine Building was approved. Our architects, BDP, did a spectacular job in creating an extremely functional and yet inspiring design which has the capability of being easily reconfigured in response to new research requirements. We are delighted to be the occupiers of

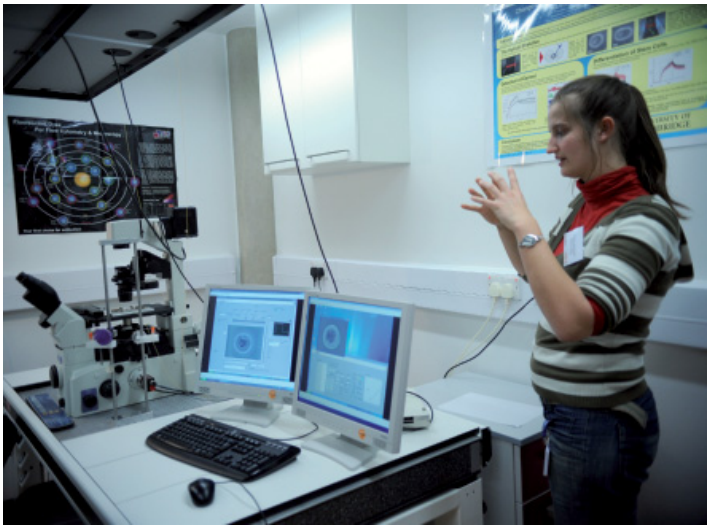
a state-of-the art physics building, which meets the requirements of experimental work in physical, chemical, biological and medical areas. Athene Donald is the first Director of the Programme in the Physics of Medicine and in the accompanying article she introduces the four new physics lecturers appointed to support the work of the programme.

We were delighted that the Vice-Chancellor Professor Alison Richard, Sir Aaron Klug, past President of the Royal Society, and Professor David Delpy, Chair of the Engineering and Physical Sciences Research Council, were the guests of honour at the opening ceremony. In his address, Sir Aaron described the work which led to the award of the Nobel Prize in Chemistry 'for his development of crystallographic electron microscopy and his structural elucidation of biologically important nucleic acid-protein complexes'. That work, in conjunction with Crick and Watson's discovery of the structure of the DNA molecule in 1953, brought home to all of us that the Physics of Medicine initiative is a welcome return of the physics of biology in its widest context to the programme of the Cavendish. Phase 1 of the programme has been dedicated to the provision of laboratories for the many departments and disciplines which bear on the programme. Phase 2 has the highest priority in our planning, in order to extend the experimental facilities and provide space for theoretical and computational activities in the general area of the Physics of Medicine.

In parallel with the opening of the building, the third Physics of Living Matter Symposium was held, with support from Agilent Technologies, Carl Zeiss, Leica, Olympus and the Royal Society's Journal *Interface*. This reinforced our view of just how important physics approaches and techniques are for the understanding of biological and medical phenomena. For example, Ben Simons, Professor of Theoretical Physics in the Cavendish, and Phil Jones of the Hutchison/MRC Research Centre are collaborating to apply approaches from theoretical physics to experiments which study the fate of stem cells during the maintenance of the epidermal skin layer. The modelling work has shown that the standard dogma about epidermal maintenance is false and provides a quite different approach and framework involving scaling procedures that are commonplace in theoretical condensed matter physics research. At the symposium the second Laurence Bragg Lecture, sponsored by Aligent, was given by Professor Xiaoliang Sunney Xie of Harvard University, who is regarded as the founding father of single molecule enzymology, the study of enzymes.

Malcolm Longair

Sir Aaron Klug, Professor David Delpy, Vice-Chancellor Professor Alison Richard and Professor Athene Donald outside the newly-opened Physics of Medicine Building.



Ph.D student Franziska Lautenschlaeger explains the use of an optical stretcher to study the mechanical properties of cells and other biological structures.

Professor Sunney Xie of Harvard University at the opening of the Physics of Medicine building. He gave the Laurence Bragg lecture at the Physics of Living Matter symposium.

Michael Bienias, Director of Estate Management and Building Services, Athene Donald and Mike Hart, Managing Director of Willmott Dixon, topping out the green roof of the Physics of Medicine Building.

What is the Physics of Medicine?

With the opening of the Physics of Medicine building in December 2008, the enterprise to stimulate new interactions between physicists and the life and clinical sciences is well and truly underway. There have already been four appointments made in the general area at lectureship level.

First to take up post in October 2006 was Pietro Cicuta, already a research fellow at the Cavendish. Pietro came to Cambridge from Milan to study for a Ph.D in 2000 and has been here ever since. His interests lie in interfaces – initially the conformation of biopolymers at the air-water interface, but more recently this has extended to cell membranes, their deformations and interactions using techniques such as optical tweezers and light scattering. He has built up a strong link with the Vet School in the area of infection, using the tweezers to manipulate objects in the vicinity of cells and to watch how the cell engulfs foreign bodies.

In January 2007 Jochen Guck arrived from Leipzig. He also has a strong research programme using optical approaches, having developed a technique known as the 'optical stretcher' with his Ph.D supervisor Josef Käs in Texas. The optical stretcher is a novel laser tool that can be used to trap and deform individual biological cells, the forces arising from the momentum transfer of light to the surface. This can be used, for instance, to distinguish the response of healthy from cancerous cells. Thus strong links have been made with researchers from the Cancer Research Institute. Additionally, Jochen is interested in understanding what prevents nerve cell regeneration after traumatic injury, and is working with researchers in the Brain Repair Centre in this area.

In the summer of 2007 Julian Huppert arrived as a Research Councils UK Academic Fellow, with a lectureship associated with this post in five years time. Julian did his Ph.D in the Chemistry department with Shankar Balasubramanian and then became a Trinity research fellow, spending some time at the Wellcome Trust Sanger Institute. He is interested in unusual conformations of DNA and RNA, such as four-stranded G-quadruplexes; he uses computational and experimental approaches to unravel the sequences that facilitate their formation, their importance in telomeres, and their role in the development of cancers. He will also play an important role in the development of a Master's course in Scientific Computing.

Finally, Ulrich Keyser joined us in August 2008, also from Leipzig. Ulrich carried out his Ph.D in Germany in semiconductor physics, and then, wanting to broaden his background, he moved to Delft to work as a postdoc in the group of Cees Dekker. He developed a new single molecule technique combining solid-state nanopores with optical tweezers for single molecule studies of biopolymers in confinement. Back in Germany as a junior research group leader, Ulrich started to extend the technique to biological nanopores, and this will be one of his main objectives here in Cambridge. Besides the development of new single-molecule techniques, his research is focused on the transport of DNA, RNA and proteins through lipid membranes and biological nanopores.

These four new appointees will build up an exciting programme, reaching out to biomedical scientists around the university in collaboration with other members of the department. We are confident that the Physics of Medicine initiative will start to solve new problems by bringing a physics perspective to important problems usually seen as remote from our discipline.

Athene Donald

Clockwise from top left: Pietro Cicuta, Jochen Guck, Ulrich Keyser and Julian Huppert.

Athene Donald wins the L'Oréal UNESCO Award for Women in Science

Created in 1998, the L'ORÉAL-UNESCO Awards for Women in Science were established as the first international awards dedicated to women scientists around the world. The award is made in the physical and life sciences in alternate years, with one winner from each of five geographical regions. In 2009 it is the turn of the physical sciences. As the L'Oréal/UNESCO press release states, 'The Laureates serve as role models for future generations, encouraging young women around the world to follow in their footsteps.'

I was delighted and honoured to receive the prize for Europe for 2009, because it celebrates both my science and the work I have been doing within the university and nationally to encourage women in science. It was interesting to read the two different citations. The one for the scientists read

"For the development of novel electron and x-ray scattering methods and their applications in soft matter physics."

In contrast, the citation for the general public read

"For her work in unraveling the mysteries of the physics of messy materials ranging from cement to starch."

Either description highlights the importance of studying everyday but complex materials from the realm of soft matter physics, an area that the Cavendish has increasingly invested in, including the recent appointments in the Physics of Medicine. The field of soft matter is rich and intriguing, and the Cavendish is ahead of many physics departments in the country in ensuring our undergraduates are exposed to the subject during their third and fourth years. The recent Wakeham review on the state of Physics in the UK highlighted the importance of breadth in teaching, and remarked

that too many physics departments offer only very traditional courses, unlike ours.

When I was an undergraduate I remember there were only eight girls in the final year physics lectures out of around 100 students. The numbers have increased somewhat, but we still have only about 20-25% girls each year. In other science subjects within the university the numbers may be much higher, for instance around 70% in Veterinary Science, but the proportion falls off further up the ladder. In physics the problem in getting girls into the subject starts at school, where too many are put off, and the L'Oréal/ UNESCO awards may play a part in inspiring more of them to keep on in the subject.

WiSETI , the University's Women in Science, Engineering and Technology Initiative, of which I am the Director, is also keen to give support, advice and insight to women scientists starting out on an independent research career. We are setting up a new series of workshops for research fellows in conjunction with the local Schlumberger research centre, who likewise find their early stage female research scientists leave the company in greater numbers than their male equivalents. The first session in January was kicked off by the Vice Chancellor, who holds these gender issues close to her heart. Furthermore, the department has signed up as 'supporters' to Project Juno, the IOP scheme which offers a practical set of ideas for actions that departments can take to address the under-representation of women in university physics.

To return to the actual prize, L'Oréal have been working hard to attract media interest in my award. I had to take a crash course in media-training to cope with talking to newspapers and radio stations, but it is clearly important to use this media interest to get the message across that girls and science do mix, and that diversity in the scientific workplace is very important. I have found discussions with people like Jenni Murray difficult, as my desire for scientific objectivity sometimes clashes with the desire for a simple story in which everything is black and white. But I am rapidly learning the importance of explaining my science in simple terms, whilst keeping the essence true. I have also had to endure long photographic sessions – 3 x 5 m billboards are mounted in the Paris airports – with two days of videoing still to come, as well as the actual award ceremony in Paris in March.

Athene Donald photographed against the double helix sculpture in the Physics of Medicine Building. Athene is the first Director of the Physics of Medicine Programme. Photography by Micheline Pelletier / Corbis.

Associated web-sites:

WiSETI:
www.admin.cam.ac.uk/offices/hr/equality/wiseti/
Project Juno:
www.iop.org/activity/diversity/Academia/Juno/page_27807.html
Wakeham Review: The State of Physics within the UK
www.rcuk.ac.uk/review/physics/default.htm

Athene Donald

New Jacksonian Professor

James Stirling. Photography by Quentin Maile.

It was a tremendous honour to be appointed Jacksonian Professor of Natural Philosophy last year. It is with some trepidation that I follow in the footsteps of some of the most illustrious figures in 20th Century physics, many of them household names. I am also proud to be the first Jacksonian Professor working in the area of high-energy physics.

Cambridge is in fact where my research career started, some thirty years ago. I studied for a Ph.D, under the supervision of John Polkinghorne, on aspects of the strong interaction field theory, Quantum Chromodynamics. It was a time of transition in the subject, with the old 'Regge theory' approach to strong interaction physics being replaced by a deeper and quantitatively more powerful approach based on relativistic quantum field theory. Having read for the Mathematics Tripos as an undergraduate (taking the 'with Physics' option in Part IA) it was natural to base my Ph.D studies in the Department of Applied Mathematics and Theoretical Physics, then in Silver Street. We occasionally ventured 'out west' to the Cavendish Laboratory for joint seminars, but in those days there was not as much interaction between the theoretical and experimental sides of the subject as one finds today. Indeed, the close collaboration between theory and experiment, and between the Cavendish and DAMTP, is today regarded as one of the key strengths of Cambridge particle physics, and has great personal appeal.

After postdoc positions at the University of Washington, Seattle and at CERN, I was appointed to a "new-blood" lectureship at the University of Durham, where I remained for 22 years. My principle research interest was, and still is, particle physics 'phenomenology' – the interface between theory and experiment – with a particular emphasis on the physics of the Standard Model as probed in high-energy particle colliders. In 2000 I co-founded and became the first Director of the new Institute for Particle Physics Phenomenology (IPPP) at Durham University, a unique centre of research excellence serving the national and international particle physics community. In 2005 I was appointed Pro-Vice-Chancellor for Research at Durham University, a post which I held for three years before moving to Cambridge in September last year. As PVC I had responsibility for all aspects of the academic research carried out within the University, including the entire submission to the 2008 Research Assessment Exercise.

So what attracted me to the Jacksonian Professorship? Apart from the obvious answer, the opportunity to work in one of the world's leading physics departments, I was particularly

attracted by the particle physics research environment here. Taken together, the particle theory groups in the Cavendish and DAMTP represent one of the largest research groups anywhere in the world, with an impressive breadth of coverage across the subject. At the 'phenomenology' end of particle theory, there is a very close working relationship between the theorists and the Cavendish experimentalists, exemplified by the world-renowned 'Supersymmetry Working Group'. I will bring to the existing research activity complementary expertise in precision Standard Model physics.

With the anticipated start of the Large Hadron Collider at CERN (after some well-documented teething problems in recent months) particle physics is about to enter one of its periodic 'golden eras', in which a step-change in our knowledge of the fundamental constituents and forces in the Universe can confidently be predicted. It is a great privilege to be able to be part of this excitement here in the Cavendish Laboratory.

James Stirling

Unveiling James Clerk Maxwell

The statue of Maxwell in George Street, Edinburgh
All photography by James Rautio

James Clerk Maxwell was the first Cavendish Professor of Experimental Physics and was responsible for designing the Laboratory and equipping it for experimental physics research. He is unquestionably Scotland's greatest physicist and a household name among physicists – Maxwell's equation for the electromagnetic field, the Maxwell-Boltzmann distribution, Maxwell's relations and so on. In his native land, however, he has scarcely been recognised. Fortunately, amends have now been amply made with a splendid classical statue of Maxwell by the sculptor Alexander (Sandy) Stoddart, located at the east end of George Street, not far from the Royal Society of Edinburgh. The unveiling ceremony was carried out by the Presiding Officer of the Scottish Parliament, Mr. Alex Fergusson MSP on 25th November 2008.

There are various reasons for the popular neglect of Maxwell, not least being his own modesty and the fact that his key role as the essential link between the physics of Newton and Einstein is not so easy to explain to the lay-person. Sir Michael Atiyah, past President of the Royal Society of London and until recently of the Royal Society of Edinburgh, was determined to remedy this omission during his Presidency. His campaign to raise £300,000 for a statue was warmly received and the money was raised by public appeal at a remarkable pace.

I was involved in the project as physics advisor to Sandy Stoddart, and we had a remarkable series of exchanges about Maxwell and his science. Sandy had clear views about the statue, which had to match the five other statues that confer dignity to George Street. Maxwell is portrayed in his maturity, reflecting upon the work of his youth, holding the colour-wheel that he used to determine the colour equations of the eye while at Trinity College, Cambridge. As a country gentleman, many of the pictures show him with his dog and I urged Sandy that Maxwell's dog Toby should be portrayed in the statue. Sandy has created a wonderful image of what he refers to as inter-species sympathy, quoting his favorite philosopher Schopenhauer as the source of the inspiration. My guess is that Toby will soon rival Greyfriars' Bobbie as the canine icon of affection amongst the Edinburgh public.

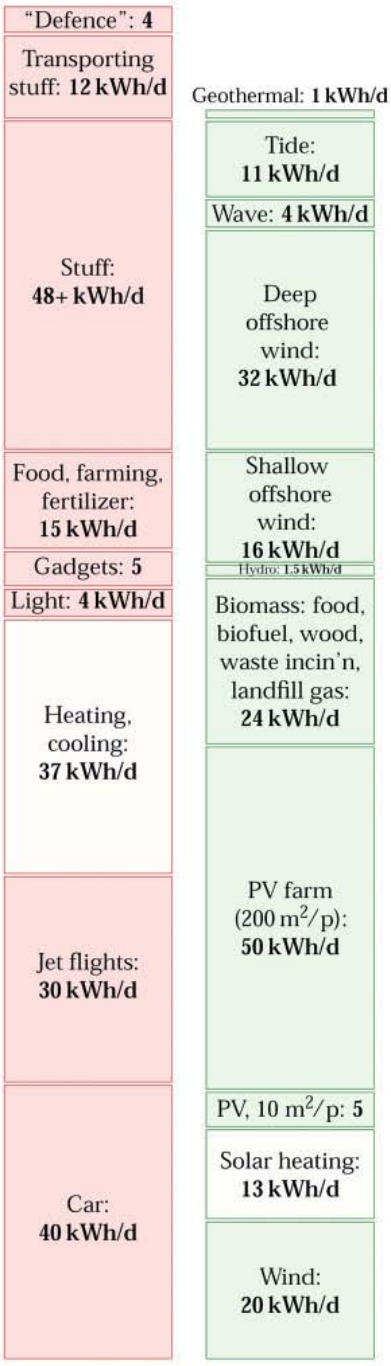
School of Newton

School of Einstein

The side-panels on the plinth represent the physics of Newton and Einstein. In our discussions, I suggested that light was the simplest link to portray these relations. On one frieze, Sandy has created a vision of what he calls the School of Newton, a classical-style image of Newton demonstrating the *experimentum crucis* which showed that once light is passed through one prism, it cannot be split into further colours on passing through a second. The other frieze is a classical-style image of Einstein illustrating the distortions of space-time by a massive body, an effect which results in the bending of light by the Sun, one of the key tests of general relativity. The friezes are shown above, and the reader is invited to deconstruct all the classical iconography and symbolism which Sandy has built into his splendid sculptures. Those wishing for more details of what was involved in the project, and explanations of the iconography, may enjoy the little book published by the Royal Society of Edinburgh to celebrate the occasion, *Celebrating the Achievements and Legacy of James Clerk Maxwell*, available from the Society.

The shell of Maxwell's country house at Glenlair

Sustainable Energy – without the Hot Air



Pink stack:
Energy consumption per person for affluent Europeans.

Green stack:
Estimate of maximum conceivable power per person from renewables in the UK, ignoring economic, social and environmental constraints.

The public discussion of energy options tends to be intensely emotional, polarised, mistrustful, and destructive. Every option is strongly opposed: the public seem to be anti-wind, anti-coal, anti-waste-to-energy, anti-tidal-barrage, anti-fuel-duty, and anti-nuclear. We can't be anti-everything! We need an energy plan that adds up. But there's a lack of numeracy in the public discussion of energy. Where people do use numbers, they select them to sound big, to make an impression, and to score points in arguments, rather than to aid thoughtful discussion.

My motivation in writing *Sustainable Energy - without the hot air* is to promote constructive conversations about energy, instead of the perpetual Punch and Judy show. I've tried to write an honest, educational and fun book. I hope the book will help build a cross-party consensus in favour of urgently making an energy plan that adds up. *Sustainable Energy - without the hot air* presents, from first principles, the numbers that are needed to answer the following questions:

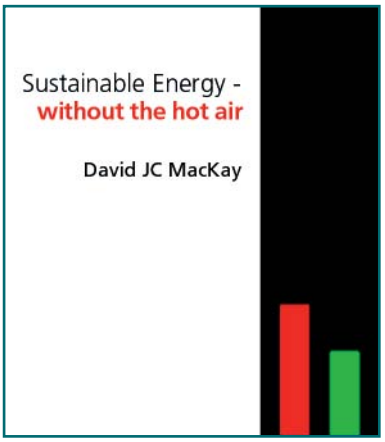
How huge are Britain's renewable resources, compared with our current energy consumption? How big do renewable energy facilities have to be, to make a significant contribution? How big would our energy consumption be if we adopted strong efficiency measures? Which efficiency measures offer big savings, and which offer only 5 or 10%? Do new much-hyped technologies such as hydrogen or electric cars reduce energy consumption, or do they actually make our energy problem worse?

Wherever possible, I answer these questions from first principles, using simple back-of-the-envelope methods. To make the numbers comparable and comprehensible, I express all energies and powers in a single set of units: energies are measured in kilowatt-hours, and powers are measured in kilowatt-hours per day per person. Everyday choices involve small numbers of kWh per day. If I have a hot bath, I use 5 kWh of energy. If I were to drive from Cambridge to London and back in an average car, I would use 130 kWh.

Let me give three examples. First, switching off the phone charger. I think I first heard this idea from the BBC, the idea that one of the top ten things you should do to make a difference to your energy consumption is to switch off the phone charger when you are not using it. The truth is that leaving the phone charger switched on uses about 0.01 kWh per day. This means that switching the phone charger off for a whole day saves the same energy as is used in driving an average car for one second. Switching off phone chargers is like bailing the Titanic with a teaspoon.

Second, hydrogen for transport: all hydrogen-powered transport prototypes increase energy consumption compared to ordinary fossil-cars; whereas electric vehicles are significantly more energy efficient than fossil-cars. So hydrogen vehicles make our energy problem worse, and electric vehicles make it better.

Third, we often hear that Britain has a "huge" wave resource, and that is indeed true. But how huge is the technical potential of wave power compared with our huge consumption? If 1000 km of Atlantic coastline were completely filled with Pelamis wave machines, the average power delivered would be 2.4 kWh per day per person. That is a huge amount of power, but today's British total energy consumption for all forms of energy - electrical, transport, heating - not just electricity - is on average 125 kWh per day per person. So a country-sized wave farm would deliver an average power equal to 2% of our current power consumption. I'm not saying we should not invest in wave power. But we need to know the truth about the scale of renewables required.



This message applies, sadly, to almost all renewables in Britain. To make a substantial contribution, renewable facilities have to be country-sized. And this is perhaps the most important message: the scale of action required to put in place a sustainable energy solution. Even if we imagine strong efficiency measures and smart technology-switches that halved our energy consumption (which would be lower than the per-capita consumption of any developed country today), we should not kid ourselves about the challenge of supplying 60 kWh per day without fossil fuels. Among the low-carbon energy supply options, the three with the biggest potential are wind power, nuclear power, and concentrating solar power in other peoples' deserts. And here is the scale that is required if we wanted to get one third from each of these sources: we would have to build wind farms with an area equal to the area of Wales; we would have to build 50 Sizewells of nuclear power; and we would need solar power stations in deserts covering an area twice the size of Greater London. It's not going to be easy to make a energy plan that adds up; but it is possible. We need to get building.

David MacKay

Professor Sir Brian Pippard (1920-2008)

Professor Sir Brian Pippard, who died last September, was Cavendish Professor from 1971 to 1982. He grew up in Bristol, and for a time at Clifton College considered a career in music. However, in 1938 he entered Clare College to read Natural Sciences, and, doubting his mathematical ability, chose at first to study chemistry before switching to physics to make himself more useful in the war effort. He worked at Great Malvern on a radar device for tracking mortar projectiles, returning to Cambridge in 1945 for a Ph.D with David Shoenberg in the Royal Society Mond Laboratory, financed by a Stokes Studentship at Pembroke College. His flair for research rapidly gained attention, and he was appointed to the Cavendish staff in 1947, returning to Clare as a Fellow.

His research, chiefly on superconductors and normal metals at low temperatures, included both ingenious experiments and innovative theory. He will be particularly remembered for his work in superconductivity. As a pioneer who helped lay the foundations for its eventual theoretical explanation, he championed the idea of the coherence length, now recognised to underlie the behaviour of practical superconducting magnets. He later carried out subtle work on the conversion of normal current to supercurrent at NS boundaries. He was also a major innovator in the physics of normal metals at low temperatures, where he established our understanding of the anomalous skin effect and famously used it to make the first experimental determination of a Fermi surface, that of copper. He became a guru on most aspects of Fermi surface physics, especially magnetoresistance. To advance such research he built an ambitious and productive high magnetic field facility, opened in 1961 in the old cyclotron lab.

During the late 1950s, he became the front man, under Neville Mott, for promoting the move of the Cavendish to West Cambridge, and then for ensuring that our new building was practical, with the right services provided. In 1966 he became first President of the newly founded Clare Hall, and moved into the President's Lodge, with Charlotte, their three daughters and his grand piano. He and Charlotte succeeded in making the College an informal and happy home for graduates, distinguished visitors, and their families.

He was elected Cavendish Professor and Head of Department in 1971. He discouraged horse-trading of appointments between research groups, aiming to establish laboratory-wide standards. He encouraged innovative research, trying persistently, though not always successfully, to close down areas judged to be more plodding. He strengthened the Teaching Committee, was proactive in the reform of undergraduate teaching, and demanded high lecturing ability in promotions and new appointments. Though choosy about what he undertook at national level, he was President of the Institute of Physics from 1974 to 1976. He was knighted in 1974.

As supervisor and lecturer Brian was always stimulating, often adopting an unexpected and disconcerting Pippard approach. Past students may recall him, always in a turtle-necked sweater, teaching a wide range of courses, notably Thermal Physics, the Wave Mechanics course in the new Advanced Half-Subject in 1958 (delivered from memory without notes) and various versions of the opening course in Part IA, which led to his book *Forces and Particles*. He had a strong sense of style in spoken and written English, and his perceptive *Elements of Classical Thermodynamics* and challenging *Cavendish Problems in Classical Physics* excited and tormented generations of students.

He excelled at intuitive semi-quantitative concepts, but distrusted mathematical formalism, preferring for instance to think of quantum problems in terms of semi-classical wave packets, never eigenfunctions and eigenvalues. He also loved phenomenological theories such as classical thermodynamics itself, and dimensional analysis, which he used extensively. Of physicists, interestingly, he particularly admired two theorists, Onsager and Landau, who combined mastery of the illuminating idea (which he loved) with mastery of difficult formalism (which he probably felt was beyond him).

Brian could be idiosyncratic. He was capable of great kindness, but also had an enormous boyish relish in simply being clever, which all who knew him will remember vividly: his inaugural lecture as Cavendish Professor was planned around an intriguing series of bench experiments whose outcomes the assembled practitioners, young and old, were invited to predict by show of hands. We duly got most of our predictions wrong, as he intended.

There will be a scientific meeting to celebrate Brian Pippard's life and work to be held at the Cavendish on Monday May 11 2009. Further details will be i ncluded on our web-site in due course.

For a fuller obituary, see

www.admin.cam.ac.uk/news/dp/2008092302

John Waldram

The Laboratory will never be the same without ...

Terry Stubbing, Anton King and Roger Halls

The summer saw the retirement of three long-serving members of the Department. Roger Halls retired after 38 years in Electronics. Terry Stubbing retired after 46 years, the last 19 as Head of the Main Workshop. Anton King served 48 years, latterly as part of the central services section, but previously as Principal Technician in the old Microstructural Physics Group. Their contributions will be sorely missed and many friends and colleagues gathered at events to mark their departure.

Peter Robinson also retired in the autumn after 17 years in the Accounts Office.

Outreach and schools

The Cavendish Laboratory aims to stimulate interest and encourage wider participation in physics amongst 11-19 year olds, and to provide support for their teachers through a wide ranging programme of educational outreach activities. I am employed as full-time outreach officer and coordinate these activities, including the two major projects, Physics at Work and the Senior Physics Challenge.

25th Physics at Work – 15-17th September 2009 (14-16 years)

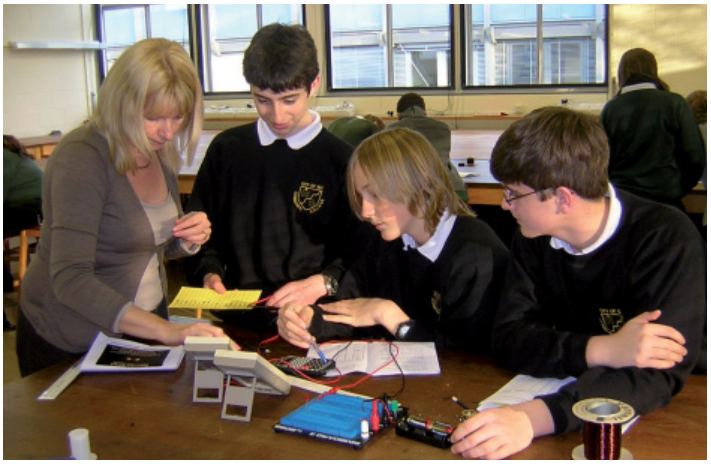
The primary aim of this exhibition is to showcase the many and varied ways in which physics is used in the everyday world. Interaction with active scientific researchers enables us to spread the excitement of modern physics research to students who will soon be making career and examination choices, and is a vital component in encouraging the next generation of scientists.

The Physics at Work Exhibition runs over three days, with morning and afternoon sessions on each day. Approximately 20 exhibitors participate each year. Some of the exhibitors are from research groups within the Cavendish Laboratory and the others are from industry, including companies such as Rolls-Royce, Domino Printing Services and The Technology Partnership. Each half-day session has a capacity for about 350 students. The students are split into small groups of about 15, and each small group is accompanied by a teacher as they follow a route defined by the organisers. Each small group, with its teacher, visits six exhibits over a period of about three hours, including a short break halfway through. Each exhibit usually consists of a short presentation, practical demonstrations, opportunity for hands-on involvement and time for asking questions. A booklet of information is provided to support the exhibition, allowing teachers to build ideas into their lessons later in the year. This structured approach has developed over 25 years and allows the students to engage thoroughly with the science on display.

Registration for Physics at Work 2009 will be available online at

www-outreach.phy.cam.ac.uk/physics_at_work/2009/

from 11th May until 22nd June 2009.



City of Ely Community College students solving physics problems at the Cavendish

Senior Physics Challenge (AS students)

In collaboration with the University of Cambridge, we have devised a national schools physics development programme and university access initiative, the Senior Physics Challenge (SPC), directed at AS-Level students. Higher physics demands fluency and ability in physical and mathematical analysis, areas not given prominence in school physics syllabi. Some students are increasingly surprised and disadvantaged by the discrepancy between their expectations and the reality of physics admissions and subsequent University courses. Students can be especially disadvantaged by their unfamiliarity with the skills and preparation universities are seeking. We wish to

demystify, and make more accessible to a wider range of students, the transition to university physics in the UK.

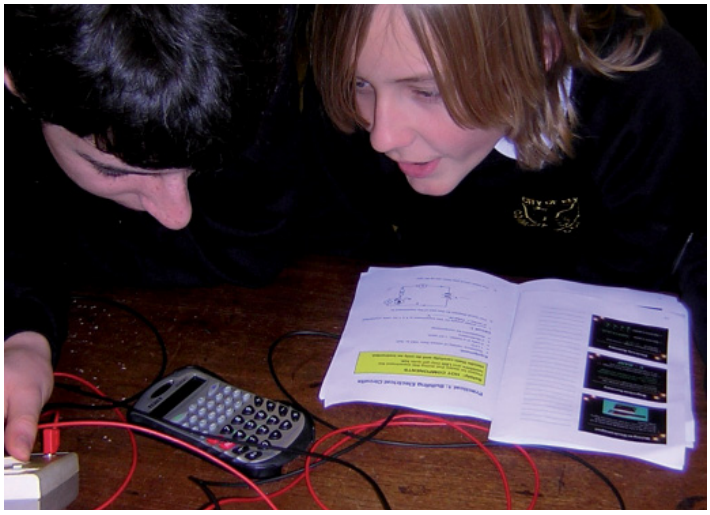
Among many activities during the five day summer school students will participate in:

- General physics/research lectures

- Practical lab classes
- Evening entertainment (physics estimation)
- Admissions talks

Students will be accommodated as the guests of a small number of Colleges. Intensive tuition will emphasise the development of problem-solving and experimental skills. The group will eat together in various Colleges in the evening.

In 2009 the course will provisionally run from 28th June, arrival late afternoon to Thursday 2nd July, finishing after lunch. Interested teachers should register online so that we may contact them personally when applications open early this year.



Further Activities

There are many other activities for schools including:

- Schools Workshops for 11-13 years & 14-16 years
- Teachers Workshops
- Cambridge Physics Centre Lectures (16-19 years)
- Undergraduate Open Days

All details can be found on our outreach website

www-outreach.phy.cam.ac.uk

Registration for any of our initiatives can be completed online and any interested teachers should also visit this page for news, updates and details of new schemes..

Lisa Jardine-Wright

Administering the Cavendish 2009

The administration of the Cavendish is led by the two Department Secretaries, known as the Academic Secretary and the Administrative Secretary, titles since copied by the University's central administration in line with the Cavendish's pioneering tradition. Between them the two Secretaries, assisted by a strong central team, provide the support for what is in essence a medium sized business with 700 personnel, including 300 graduate students, and annual income and expenditure in the order of £28M. In addition, Research Group Administrators play a crucial role.

Delving into archived records reveals the stark comparison with the Cavendish of 30 or 40 years ago. Not only was the Department much smaller, but statutory requirements were clearly less burdensome and day-to-day administration much less demanding. Letter or memo, hand written or typed with carbon copy, rather than email, was the main vehicle of communication and the style was altogether more formal.

Over the last 10 years, the Administrative procedures have become very much more complex, requiring a major upgrading of the skills and competencies of all members of the Administrative Section. Administration provides personnel services, from recruitment of both staff and graduate students through career management to departure, infrastructure support through the supply of offices; and properly serviced laboratories and other services. Income is sustained through Research Grants - applications and awards are processed by administration - and central Government funding streams which require regular submission of key data. Managing all these resources is a key responsibility.

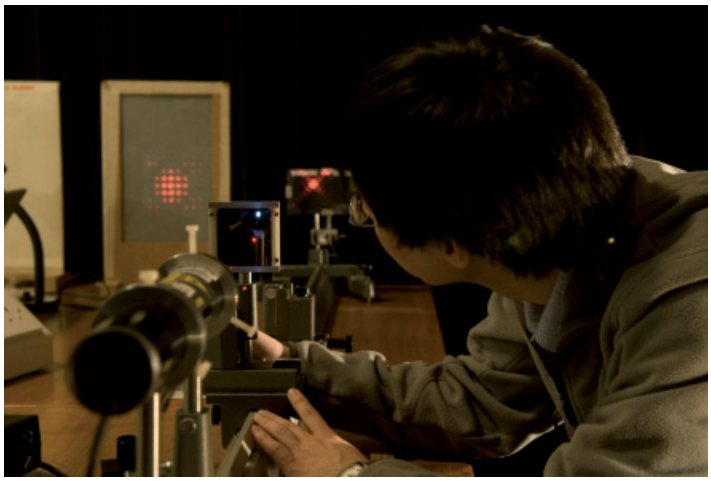
In all areas there is an ever-increasing demand not just to ensure but to demonstrate legal compliance and proper use of public funds. This requires the maintenance of detailed information for audit purposes. IT systems are a major feature in University administration, and administrators often have to handle a broad range of systems to deal with finance, personnel and student administration.

The major challenge is to maintain the provision of essential services to a very large body of highly motivated researchers. The Government provides resources for the teaching of the undergraduate programme, but all the resources needed to support the research programme have to be won from the Research Councils. In fact, of the annual turnover of £28M, about 70% has to be won through the research grant stream. The magnitude of this administrative task can be appreciated when it is realised that there are about 250 active research grants at any one time, and one person joining or leaving the Department each day. We are fortunate in having a truly excellent administrative section who are crucial to maintaining our world-leading position in Physics.

David Peet and Robert Hay

Challenges for the Undergraduate Teaching Programme

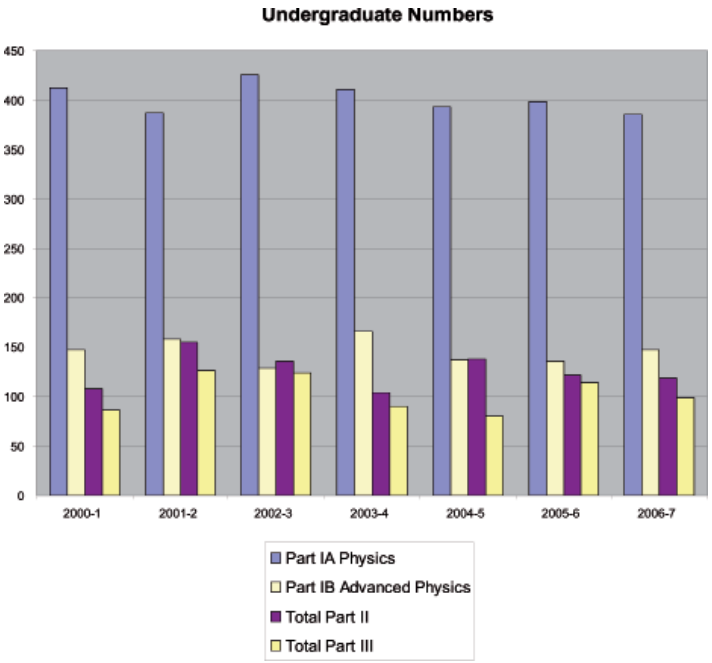
The Cavendish currently faces two main challenges. Firstly, we have to deal with students entering the university with a much more varied physics background. Secondly, we increasingly need to provide a broad preparation for the interdisciplinary nature of the research that many physicists will have to embrace in their future careers. At the same time, we need to ensure that we deliver a thorough exposition of the core topics of physics, for example, dynamics, electromagnetism, optics, thermal physics and quantum mechanics. The fact that physics in Cambridge is taught as part of the Natural Sciences Tripos poses particular problems, but also offers many advantages when compared with other Universities. The students necessarily acquire knowledge of other sciences, but the actual time available to teach them Physics is more limited.

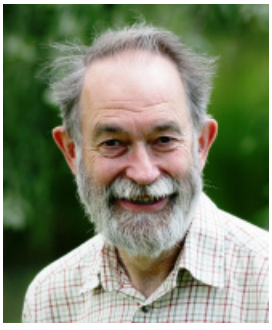


Demonstrating Fraunhofer diffraction

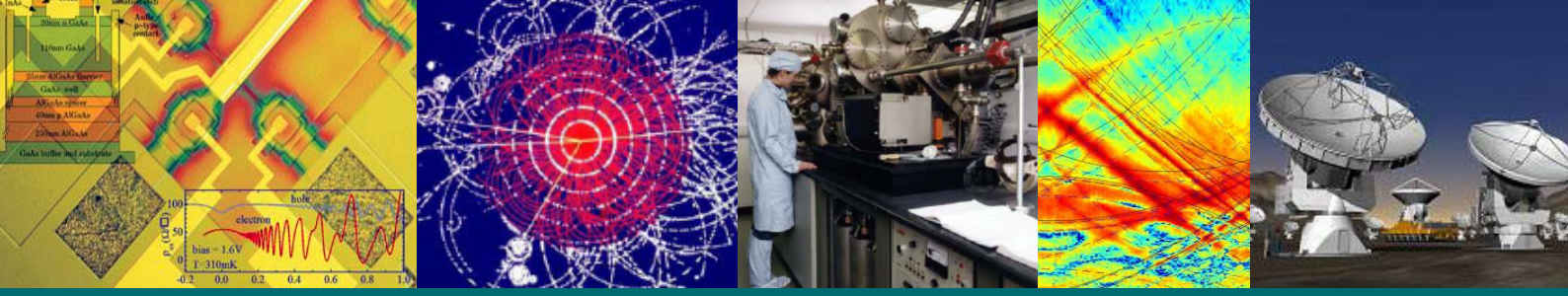
Despite the falling numbers of students taking physics at A-level nationally, numbers reading physics at Cambridge remain buoyant, with around 400 first year students, and 130 in Part II in the current year. The first year course in particular needs to reflect developments in schools. A couple of years ago, the Teaching Committee launched a major revision of the first year practical work, with a view to making it more attractive and relevant. This included a substantial investment in new experiments and provision of a laptop computer at each bench for data processing, graph drawing and so on. These days we find that some of the incoming students have had little hands-on practical experience, and we have improved and restructured the manuals and the ways in which they write up their work so as to develop the necessary skills. The practical classes now attract better feedback from the students than the lecture courses! As the second phase of this project, we are now revising the first year lecture courses, again in order to take account of changes at A-level. Now that mathematics has been largely excluded from physics A-level, many students enter University lacking the tools to analyse physical problems and set them up in a mathematical form suitable for solution. We need to structure the course so as to allow us to develop the students' skills more systematically.

In the later years of the course - Part II and especially Part III - a major theme has been increased collaboration with other departments in the University. For many years, we have provided interdisciplinary courses in Part III in Geophysics, Medical Physics and Entrepreneurship, taught by colleagues from outside the Cavendish. We are working increasingly closely with the Institute of Astronomy to share courses in both Part II and Part III between Physics and Astrophysics. We now share nearly half of our Part III courses. Last year saw the introduction into Part III Natural Sciences of a group of 'interdisciplinary' courses on environmental sciences, including Climate Change, Renewable Energy and Atmospheric Chemistry, which can be taken by students reading either Physics, Chemistry or Geology. This year we are exchanging courses with Engineering, so that physics students can take a course on Nuclear Power Engineering, and the engineers can take our course on Information Theory. We expect these exchanges to develop in the future. Finally, and reflecting the ubiquity of physics in scientific research, we find that our students are much in demand to carry out final year research projects in other departments, such as Addenbrooke's Hospital, Earth Sciences, Materials and Chemistry, and may end up doing research in these areas.





David Ward and Rachel Padman



The Response to the Cavendish Brochure and What Happens Next

We have been delighted by the positive response to the *Cavendish Laboratory 2008* booklet and the accompanying questionnaire. Towards the end of July 2008, we sent out 5,600 copies of the booklet to physics alumni with the excellent support and assistance of the University's Development Office. We have already received over 1000 responses to the questionnaire, which in the marketing world would be considered an outstanding success. We are most grateful to everyone for their assistance. The analysis of the data is on-going, but already some trends are clear.

About 30% of the respondents have indicated that they would like to help with the development programme in some way. About 55% would like to renew links with their contemporaries and staff members from their days in the Cavendish and about 70% would like to visit the Cavendish to see for themselves what the Laboratory is like today. We are planning to take forward our development programme in the following ways:

1. In summer 2009, we will be sending out a booklet describing the Cavendish's development programme, indicating the many ways in which alumni and friends can help shape the future of the Cavendish's teaching, research and outreach programmes. As we emphasise, development means many things, ranging from spreading the good word about our activities to becoming involved to huge projects such as the provision of major new laboratory facilities.

2. The best way of enabling alumni to visit the Laboratory is to coordinate such visits with the University's increasingly popular Alumni Weekend which this year will take place from Friday 25 September to Sunday 27 September 2009. We always host visits to the Laboratory during Alumni weekend, but 2009 is special being the year of the 800th Anniversary of the founding of the University. This seems an ideal time to open the Laboratory for a much larger group of Cavendish Alumni. So details will be sent out with the Cavendish Development Programme booklet during the summer, but in the meantime, please note the dates.

3. We plan to develop web-based means by which physics alumni can get in touch with former colleagues if they wish within, of course, the constraints relating to protecting confidentiality of data. More information will follow in due course.

In addition to bringing our records up-to-date, the responses to the questionnaires have provided us with remarkable insights into the career paths of Cavendish Alumni. These data are still being analysed, but already it is apparent that a very large fraction of respondents have had successful careers in physics-related industries, in academe, in finance and in school teaching. The range of careers is quite staggering and a tribute to the multi-faceted skills and interests, and the desire to engage with the world of our graduates. We like to think that their training in physics has contributed to this, and indeed many of the written responses to the questionnaires testify to the value which alumni have derived from their experience in the Cavendish. A more extensive analysis of the data will appear in the next newsletter.

Malcolm Longair

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