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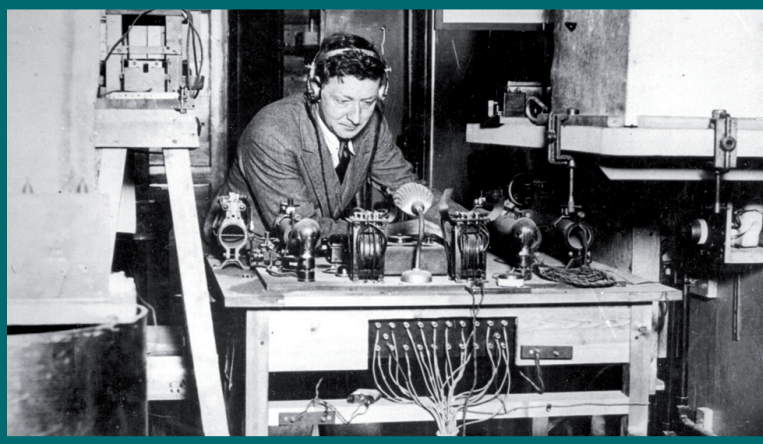
Special Development Edition

The Cavendish in 2024

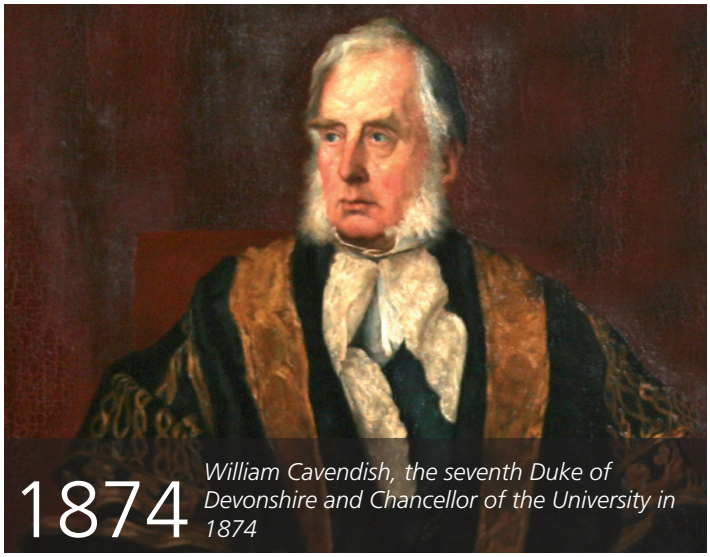
The Cavendish Laboratory is strongly committed to a future in which the highest standards in physics research and teaching continue to result in world-leading achievements. As part of the University's 800th Anniversary Campaign, we have established a Development Programme that represents a focused approach to maintaining the long-standing tradition of excellence at the Cavendish, through investments in people, research, and infrastructure, including:

- The support of very talented young people at the undergraduate and graduate levels from the UK and abroad;
- The expansion of our outreach and public awareness programmes in order to communicate the nature and fruits of our research activities and to inspire young people;
- The endowment and re-endowment of Professorships, Readerships and Lectureships;
- The development of a research support fund to pump-prime imaginative and risky innovations in physics and provide significant start-up funds for new appointees;
- The provision of new research infrastructure, particularly new buildings and facilities.

In this brochure we outline our Development Programme, and highlight the important role that generous benefactors have played and can play in making our ambitious plans a reality. Just as important is spreading the good word about the on-going success of our activities in research and teaching as the Cavendish advances towards its 150th Anniversary in 2024.

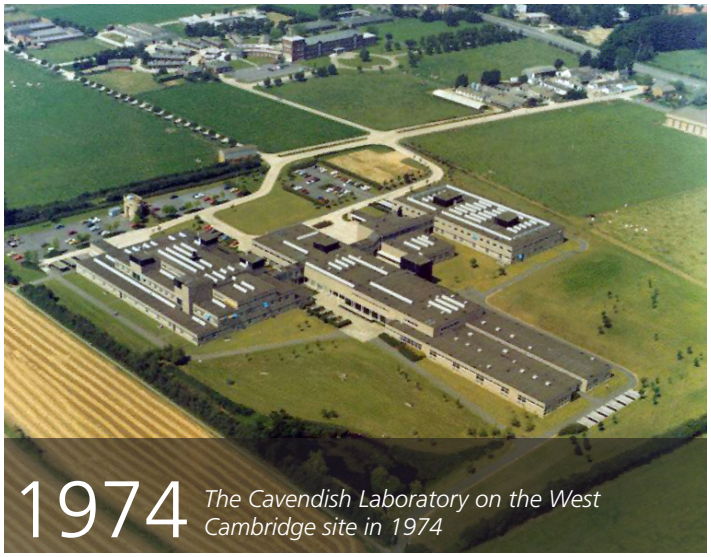


A Vision for Physics



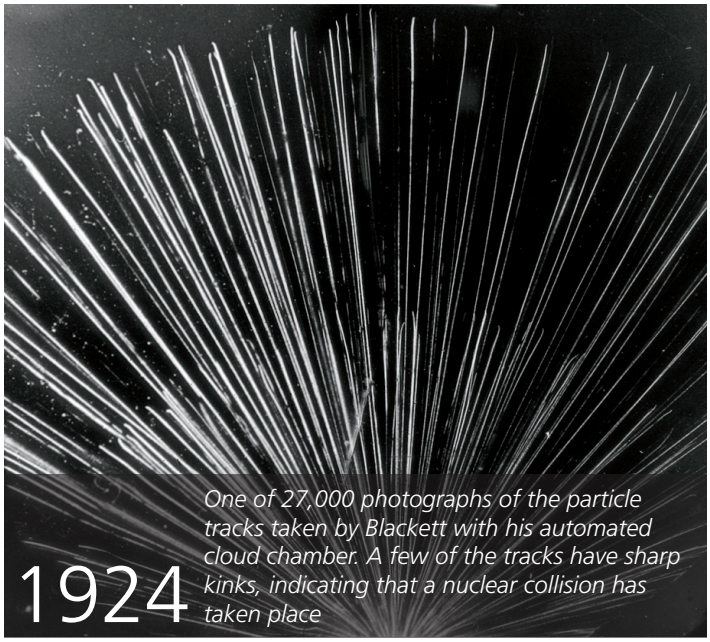
1874 *William Cavendish, the seventh Duke of Devonshire and Chancellor of the University in 1874*

The Cavendish Laboratory was founded in 1874, thanks to a generous benefaction of £6,300 by William Cavendish, the seventh Duke of Devonshire and then Chancellor of the University. James Clerk Maxwell, the first Cavendish Professor, was responsible for the design and construction of the new Laboratory, which became the leading state-of-the-art facility for physics research, making breakthroughs such as the discovery of the electron by Nobel Prize winner J J Thomson in 1897.



1974 *The Cavendish Laboratory on the West Cambridge site in 1974*

In 1974, one hundred years after its foundation, the Laboratory moved from central Cambridge to the West Cambridge site. Physics had changed dramatically. Many aspects of the discipline had become 'big-science' – radio astronomy and particle physics, for example – and needed new large scale facilities, often involving international collaboration. The computer revolution was in full swing, completely changing the approach to precise experiment, data analysis, theoretical modelling and simulation.



1924 *One of 27,000 photographs of the particle tracks taken by Blackett with his automated cloud chamber. A few of the tracks have sharp kinks, indicating that a nuclear collision has taken place*

Fifty years after its foundation, Ernest Rutherford was Cavendish Professor and physics had changed out of all recognition compared with the classical physics of Maxwell. Rutherford had discovered the atomic nucleus and had carried out the first demonstration of the transmutation of the elements by bombarding nitrogen nuclei with α-particles, which he had shown were helium nuclei. Symbolic of that enormous change of perspective were Blackett's astonishing photographs of 1924 showing these nuclear transformations taking place in an automated Wilson Cloud Chamber.

2024 *A surface wave device for quantum logic. Such devices may eventually contribute to the construction of quantum computers*

In 2024, the Cavendish Laboratory will be 150 years old. We can be certain that the face of physics will continue to change, as much as it has over each successive fifty year interval. The young people who are doing spectacularly well in their undergraduate physics courses today will, by 2024, be the leaders of the new physics. We owe it to the next generation of rising stars to provide the same opportunities that so many of us have been lucky enough to enjoy over our careers in the physical sciences in Cambridge.

The Cavendish's Influence Beyond Cambridge

We believe passionately in the central role that the Cavendish Laboratory has to play in physics teaching and research for the benefit of the UK as a whole. If evidence of that were needed, the remarkable response to the Cavendish questionnaire, which we sent out last year, shows the extraordinary success of Cambridge alumni in holding many key roles in academic research, school teaching, UK industry, financial institutions and many other diverse careers, all of them directly related to increasing the prosperity of the UK. It is remarkable how many Cavendish alumni are now CEOs of thriving physics-related companies. We see evidence of the continuing quality of the young people in the Cavendish every day through their enthusiasm for the serious challenges we present to them in their undergraduate and post-graduate research projects. We know that these students will be the future leaders of UK science and science-related fields, as well as in all the diverse areas in which Cavendish alumni have made such a mark.

The Challenge for Physics at Cambridge

The Cavendish Laboratory is strongly committed to maintaining its world-leading position in physics, and sustaining its tradition of excellence into the future. In order to continue to attract a vibrant community of scholars, dedicated to the very highest standards of attainment in physics teaching and research, we must be able to rival the facilities and opportunities offered by other world-leading institutions.

The University's 800th Anniversary Campaign aims to raise £1 billion to secure the future of excellence in teaching and research across the University. The goals of the Cavendish map directly onto the Campaign goals: from the support of undergraduate and post-graduate students; to the need to provide pump-priming funds for innovative research that is beyond the scope of Research Council funding; to upgrading the physical infrastructure of the Laboratory to provide facilities of the highest standards.

The generous support of benefactors now plays an increasingly important role in achieving our goals. The Cavendish has created a strategic Development Programme, which sets out the key areas where philanthropic support would have a transformational impact on physics teaching and research at Cambridge. Equally important is the help of our alumni in spreading the word about the Cavendish's ambitious plans for the future and our need to find new ways of supporting the very best of academic science. In the following sections we highlight the key areas of our Development Programme.

The Cavendish Development Programme

Young People

At the heart of the University's 800th Anniversary Campaign is the need to support young people in coming to Cambridge, and ensuring their material and intellectual well-being once they are here. The University has put a particular emphasis upon providing support for undergraduates from disadvantaged backgrounds where parental contributions to fees may not be possible. The expectation is that this will become an increasing problem as all Universities seek to charge higher fees. We fully support the need to provide studentships to ensure that access to Cambridge is possible for talented young people, whatever their background.

Brian Josephson wrote his famous paper on the Josephson effect as a second year graduate student. This was not the main topic of his thesis, but it won him the Nobel prize

From the perspective of research in the Cavendish, it is equally important to ensure that the brightest graduates from Cambridge and elsewhere are given the opportunity to carry out post-graduate research at the forefront of current activity. While the academic staff provide the inspiration and leadership of the research programme, the hard work on the ground is largely carried out by the population of graduate students and post-doctoral fellows, who are the lifeblood of our organisation. Cambridge offers unparalleled opportunities to its graduate students, but if we cannot present comprehensive financial support packages to applicants at an early stage in the recruitment process, we risk losing the top candidates to wealthier rival institutions. The main sources of funding for UK graduate students are the Research Councils, whose grants have reduced considerably in number in recent years. We need to find alternative means of funding. Increasing the number of graduate studentships, and the speed with which they can be offered, will greatly strengthen the Cavendish's ability to attract the best and brightest candidates from both the UK and around the world. Our aim is to develop a programme of prestigious Cavendish graduate studentships to be awarded to outstanding individuals, to whom early offers can be made.

The same reasoning applies to the provision of post-doctoral fellowships. While we have had remarkable success in

attracting fellowships from organizations such as the Royal Society and the Research Councils, these are limited in number. In particular, there is a strong need to be able to offer five-year fellowships in new interdisciplinary areas where the physicists need to become familiar with new disciplines and where a substantial injection of new blood and new approaches is needed. The security of five-year fellowships is needed to enable physicists to learn new disciplines and approaches and then to transfer the methodology and techniques of physics to these new disciplines.

Outreach, Public Awareness and the Cavendish Physics Centre

Outreach to young people, schools and the general public is a key aspect of the work of the Cavendish, and another area where philanthropic support would have a hugely positive impact. From our perspective, outreach is not an option but a mandatory part of our role in communicating the nature and fruits of our research to the public, and inspiring young people to take up careers in areas that are vital for the future prosperity of our country. This is a particularly pressing problem with the decreasing number of school pupils taking up the challenges of the physical sciences, and the catastrophic decline in the number of school teachers who have first degrees in physics.

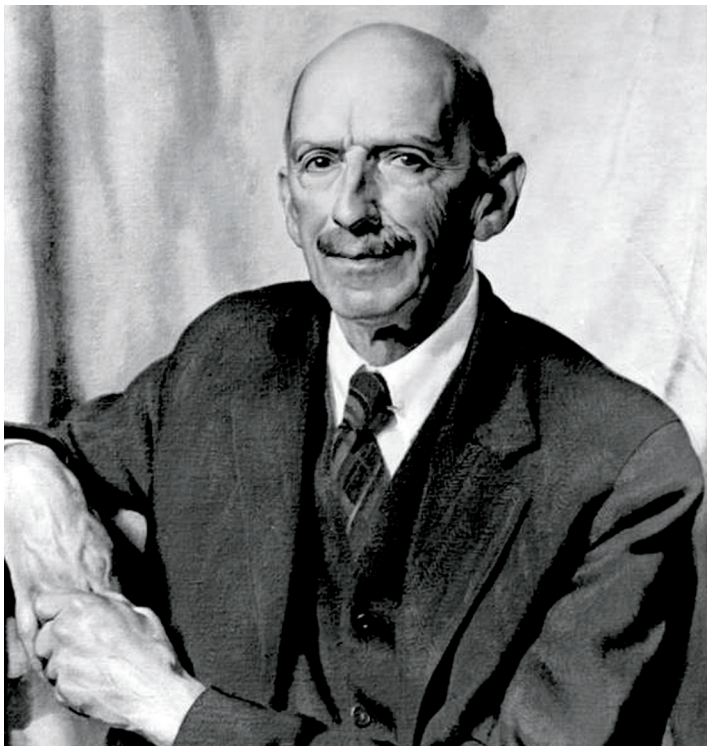
Volunteer undergraduate and graduate students who helped demonstrate hands-on physics experiments during Science, Engineering and Technology Week 2009

The Cavendish has an active and dynamic programme of activities and events, which are described in the Cavendish Laboratory 2008 brochure and the CavMag newsletters. Using our own resources, we employ a full-time Schools' Liaison Officer who runs programmes such as 'Physics at Work', which brings in about 2000 school students over a three-day period, as well as providing support, courses and training material for physics teachers. Many school parties visit the Cavendish to learn about the great discoveries made here, and about its current programme of research. As an experiment, we ran the 'Senior Physics Challenge' for the first time in 2006, a week-long residential course that took school students far beyond what they could learn at school. This course has been called 'physics with the mathematics put back in', and following its enormous success has been repeated annually ever since.

The examples of outreach activities described above were supported by a variety of one-off sources of funding. With sustained funding we can turn them into long-term sustainable activities. Our ambition is to develop a thriving and innovative Cavendish Physics Centre, designed to cater for the needs of young people and the general public. We feel a special responsibility in these areas because of the remarkable history of discovery in the Laboratory and our central role in science internationally.

Endowment of Chairs, Readerships and Lectureships

One of the most effective ways of enhancing the research and teaching activity in the Cavendish is through the endowment of Chairs, Readerships and Lectureships. These provide ideal opportunities for bringing in physicists with new and different approaches to key problems of physics and physics-related disciplines. Such appointments have many extended benefits, with post-holders bringing in additional resources from grant-awarding bodies through the post-doctoral workers, graduate students and research facilities that they attract. Examples of the new areas where leadership would be of particular benefit are in materials for energy, quantum communication and computing, advanced astronomical instrumentation and high-level scientific computing. The priority areas are continually evolving in response to discoveries and innovations in the physical and cognate sciences and so it is important to have maximum flexibility in being able to respond to these.



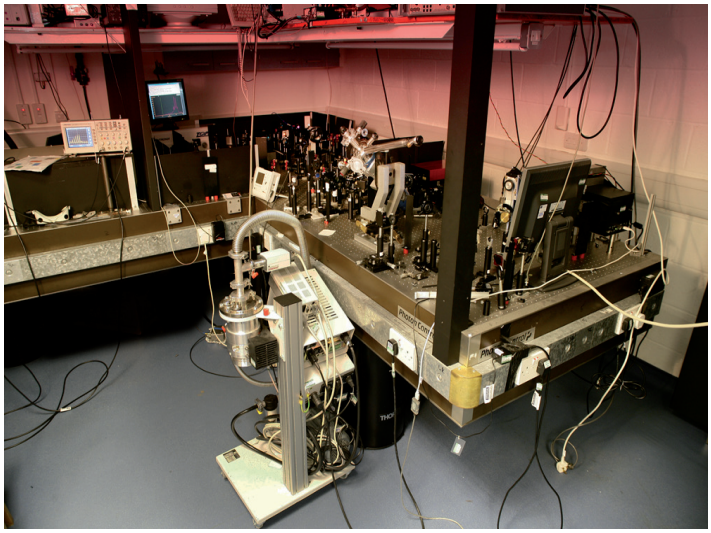
Jacksonian Professor of Natural Philosophy: C.T.R. Wilson, the inventor of the Wilson Cloud Chamber

In addition to establishing new positions, an extremely effective way of supporting the work of the Department is through the re-endowment of existing chairs. Chairs such as the Jacksonian Chair of Natural Philosophy and others were originally supported by modest endowments, but can no longer be supported by these and so fall upon the general University funds for their continuation. Contributions to such endowments can be matched by various schemes within the University and so are very attractive in releasing resources to do new things.

Research Support and Pump-Priming Resources

One of the most important areas where small contributions can make an enormous difference is in the provision of a research support fund. This has a transformative impact on the work of the laboratory in many ways, through:

- enabling investment in innovative new research ideas that are too early in development to be supported by the Research Councils;
- enabling the provision of start-up funds for new appointees. A large investment is often required in order to attract the best physicists to the permanent academic staff, usually for the purchase of specialised equipment and the reconstruction of existing laboratories. A proportion of this funding comes from sources such as the Government's Science Research Infrastructure Fund, but normally the Cavendish has to contribute very significantly, particularly for appointments at the Professorial level;
- adding value to existing research grants for innovation and exploitation.

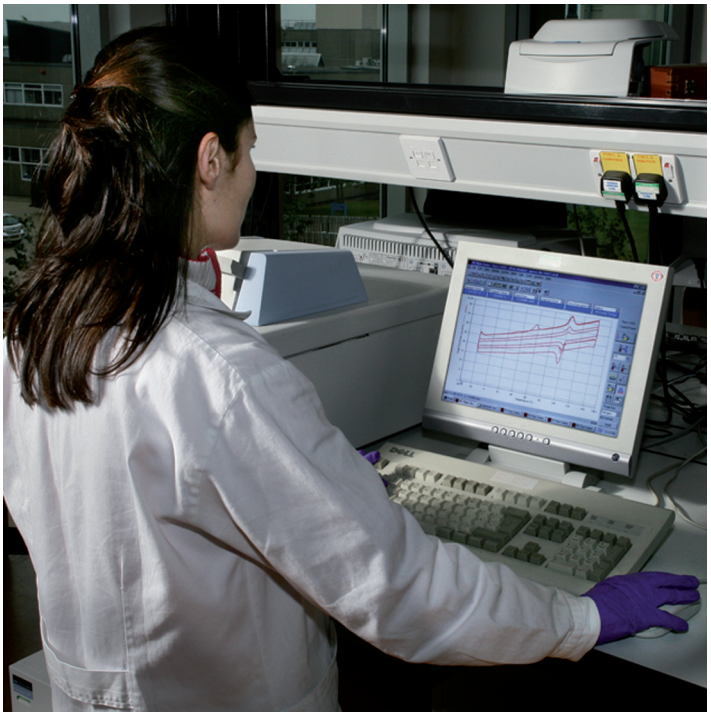


The refurbished laboratories in the Microelectronics Building for the study of organic semiconductors and the creation of electronic circuits by ink-jet printing

The strength of the fund lies in its flexibility, allowing the Head of the Cavendish to fund people and projects that are outside the remit of Research Council funding. Most importantly, it enables the Head to fund risky, innovative projects, which lie at the heart of many of the most important breakthroughs in physics and its cognate disciplines.

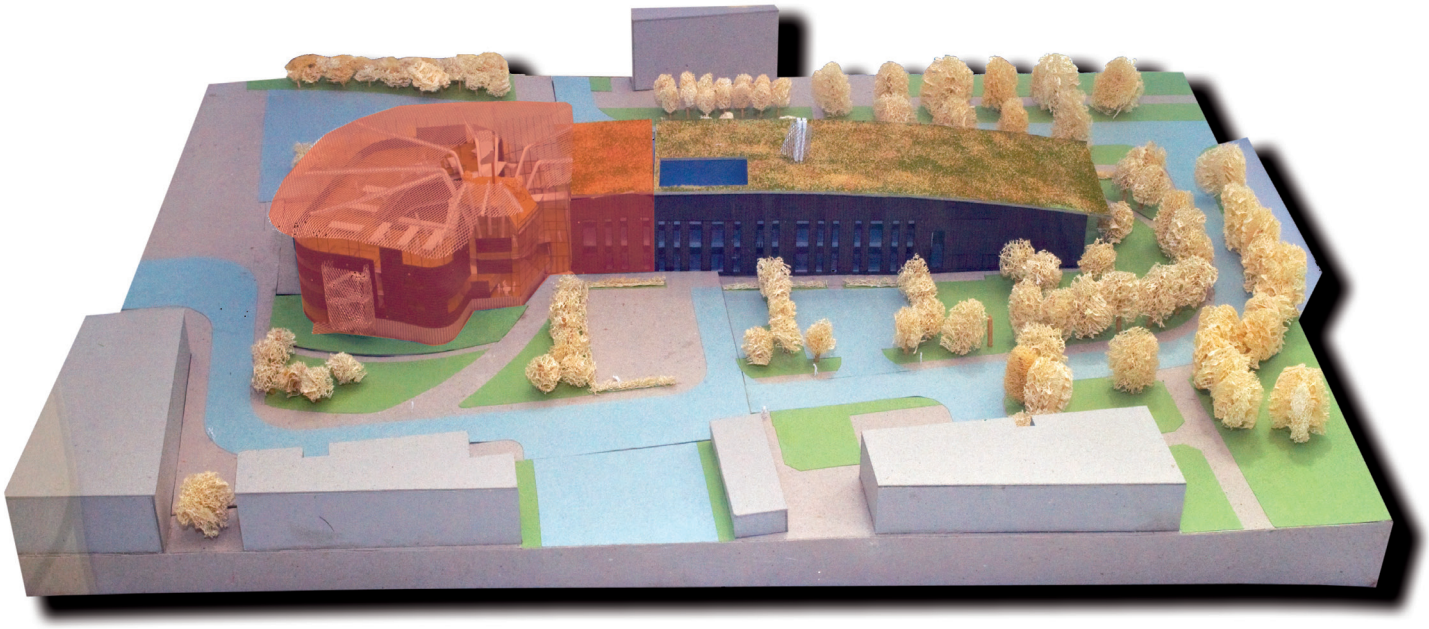
Research Infrastructure and New Building Projects

The most ambitious part of the Development Programme is the provision of new infrastructure and buildings for the Cavendish. Originally constructed in 1974, the building enabled the relocation of the Cavendish from its cramped accommodation in central Cambridge, to modern, spacious facilities on the West Cambridge Science and Technology Campus. By 2000 the Laboratory was in serious need of a major refurbishment to meet the changing requirements of the Cavendish's world-leading research and teaching programmes.



One of the new laboratories in the Physics of Medicine Building

The University has recognised that is it now essential to rebuild the Cavendish, and has ambitious plans for a programme of redevelopment through a phased reconstruction of the entire Laboratory on its present site. The first fruit of this programme has been the construction of the Physics of Medicine Building, which has proved to be an outstanding success. The building is custom-designed as an interdisciplinary centre bringing together physicists, chemists, biologists, geneticists, biochemists and specialists in clinical medicine, as well as theoretical and computational physicists. The initiative was contingent upon the Department winning external support, in this case a successful bid to the Wolfson Foundation. This enabled us to re-house the experimental activities of staff working in the areas of soft condensed matter physics, biological physics and our new appointees in the physics of medicine.



Physics of medicine Phase II. A model of the complete Physics of Medicine building. Phase I shown in natural colours is completed. Phase II, coloured red, will contain further experimental laboratories, computational facilities for the physics of living matter and undergraduate practical laboratories.

The Kavli Institute for Cosmology, approaching completion in May 2009

Another success follows a major donation from the Kavli Foundation, which leveraged resources from the University for the construction of a new Kavli Institute for Cosmology. When completed, the Institute will bring together astronomers, astrophysicists and physicists in state-of-the-art facilities on a site at the Institute of Astronomy, enhancing cooperation and synergies between academics from the Institute of Astronomy, the Cavendish and the Department of Applied Mathematics and Theoretical Physics.

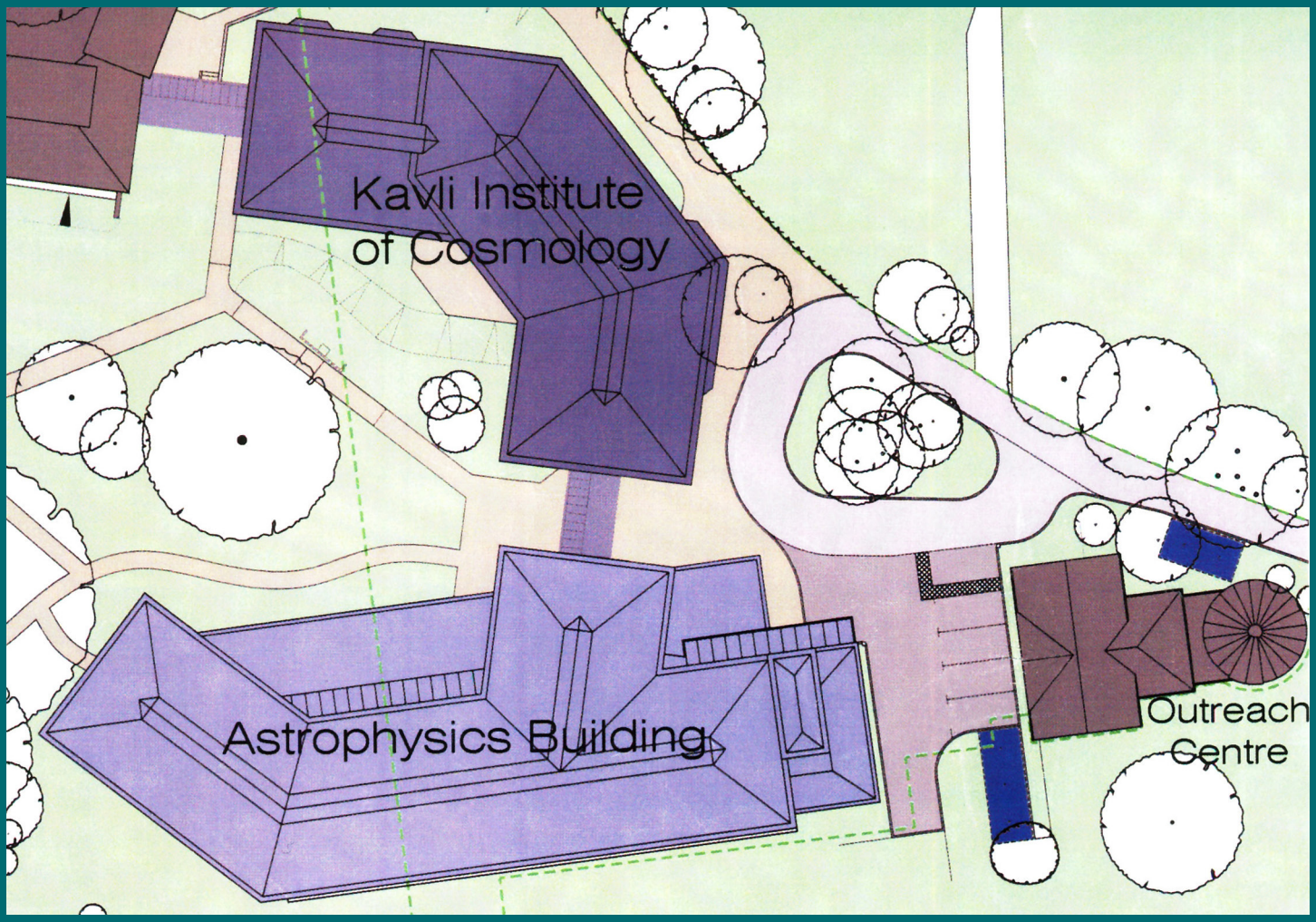
In working towards our goal, we must continue to attract contributions from external sources, and use these to leverage significant resources from the University through a variety of funding schemes for infrastructure renewal. Amongst the most urgent elements of this redevelopment programme are:

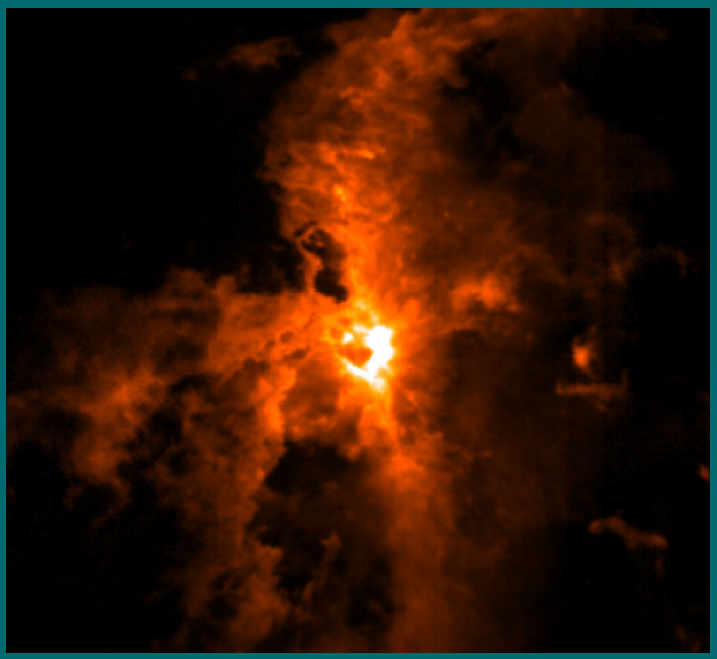
Physics of Medicine Phase II

We are delighted by the success of what we have already achieved in the Physics of Medicine initiative, but this represents only phase one of a two phase project. Phase two will provide increased experimental laboratory space, as well as offices for staff members and, in particular, for computational initiatives in the area of the Physics of Living Matter. The new building will include practical physics laboratories, which will be used for the teaching of experimental physics during term time, and as a centre for outreach programmes outside of term. Among the initiatives we wish to pioneer is the concept of family learning, whereby people with little contact with the physical sciences can enjoy learning about science together as a family.

Centre for Experimental Astrophysics

Most of our experimental astrophysics activity is carried out in the Cavendish Astrophysics Group. It is imperative that these staff members join with the astrophysicists on the Institute of Astronomy site as soon as possible. Planning permission has already been granted for the construction of a new building on the Institute of Astronomy site, which will be become a new Centre for Experimental Astrophysics. This development will provide modern laboratory facilities and clean rooms for the construction of advanced instrumentation in radio, millimetre, sub-millimetre, infrared and optical astronomy, building on the unique expertise in these areas within the Cavendish and the Institute of Astronomy, particularly in the area of interferometry.

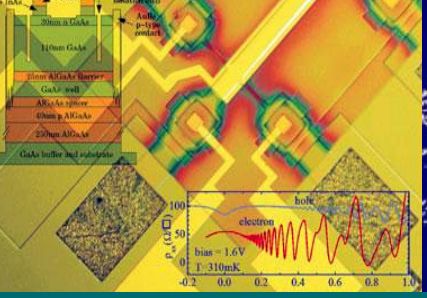


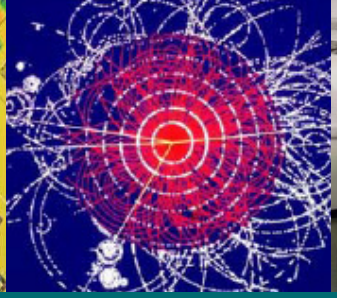


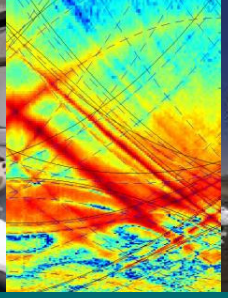
Top: *A plan showing the proposed location of the Centre for Experimental Astrophysics relative to the Kavli Institute for Cosmology. Addition of the Astrophysics Building to the Kavli Institute and the existing Institute of Astronomy buildings will form a "courtyard" where astronomers, theorists and instrumentalists will interact informally on a daily basis.*
Left: *The 16-detector 350GHz heterodyne receiver HARP on the James Clerk Maxwell Telescope in Hawaii. This array detector was built by the Cavendish Astrophysics group for the rapid spectral mapping of star forming regions in the sub-millimetre waveband.*
Right: *The Orion Nebula and surrounding Giant Molecular Cloud observed in carbon monoxide by the HARP array spectrometer on the James Clerk Maxwell Telescope in Hawaii. The cold molecular gas extends over vast regions and provides the material for the formation of new stars within the Giant Molecular Cloud.*

Figure captions for cover:

Top: *Peter Littlewood and Jeremy Baumberg lecturing during 2009 Science, Engineering and Technology Week 2009.*
Second top: *John Cockcroft with his apparatus for detecting the products of nuclear intereactions. Later, he was to be appointed Jacksonian Professor of Natural Philosophy.*
Second bottom: *The completed Phase I of the Physics of Medicine building.*
Bottom: *A work bench in the Physics of Medicine building.*





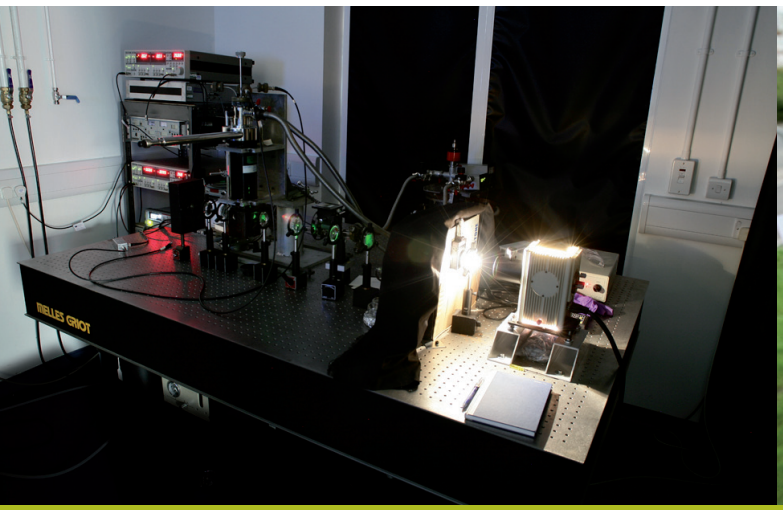



Reflections

There is no question that our Development Programme is ambitious and expensive. On the other hand, we have been encouraged by the University to develop these concepts since we have a long and proud tradition of innovation and excellence in physics. We all believe profoundly that physics has a uniquely important role to play in the future well-being of society, and as a world-leading physics department we need to be ambitious and challenging.

The important lesson we have learned is that the various types of development outlined above all need external sponsorship, which can then be use to leverage other sources of funding. The involvement of our alumni in this process, at whatever level they feel able to contribute, is something that we greatly appreciate and cherish. As we have stated before, involvement in development means more than making financial contributions. It means spreading the word about the value of the Cavendish to UK society as a whole, and about what it takes to maintain the organisation as a leader on the international scene. Tell your friends about our ambitions, and come and see for yourselves the vibrant state of Cavendish research and teaching.

If you would like to discuss how you might contribute to the Cavendish's Development Programme, please contact either Professor Malcolm Longair (msl1000@cam.ac.uk) or Professor Peter Littlewood (HoD@phy.cam.ac.uk), who will be very pleased to talk to you confidentially. Further information about how donations may be made to the Cavendish's Development Programme can be found at the Cambridge University Development Office's web-site at: **www.alumni.cam.ac.uk/campaign**



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