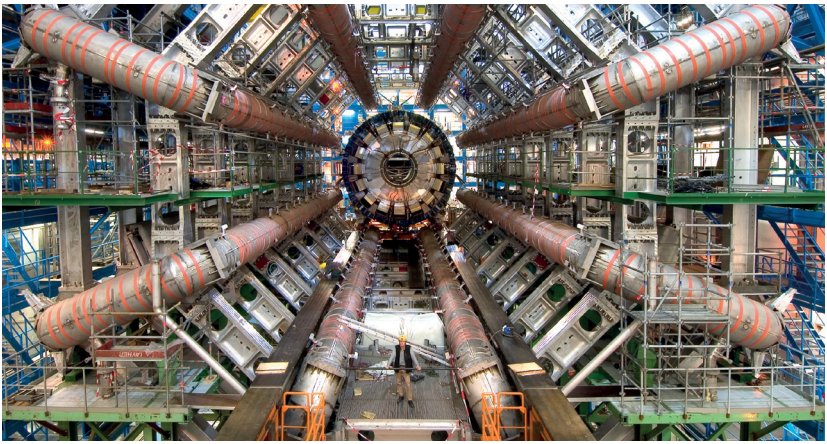
Physics at Oxford

From quantum to cosmos: Science at the cutting edge

UNIVERSITY OF OXFORD

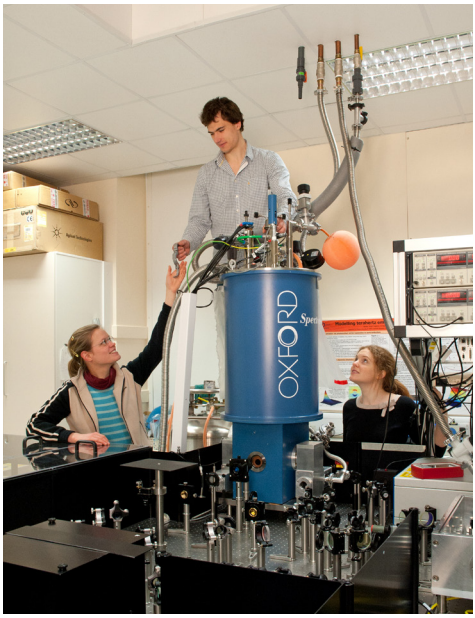
These are exciting times for Physics at Oxford. Drawing on the wide-ranging expertise and remarkable versatility of a large world-leading department, we are pursuing the most important and challenging physics problems of the age through a powerful combination of experimental, observational and theoretical investigation. Below is just a sample of the fascinating physics being done today at Oxford.

Oxford has played a major role in the Large Hadron Collider (LHC) since its inception. Crucial parts of its ATLAS and LHCb detectors were developed and built in Oxford, and many theoretical developments underpinning the LHC physics programme were pioneered here. These efforts are now bearing fruit in a number of important ways. The elusive Higgs boson, the particle central to the structure of matter as predicted by the 'standard model', has been discovered at the LHC. Studies of the asymmetry between particles and their anti-particles are giving us a window into the possibility that there may be physics beyond 'the standard model', holding out the promise of remarkable discoveries and new understandings in the years to come. Oxford physicists will be at the forefront of these exciting developments.



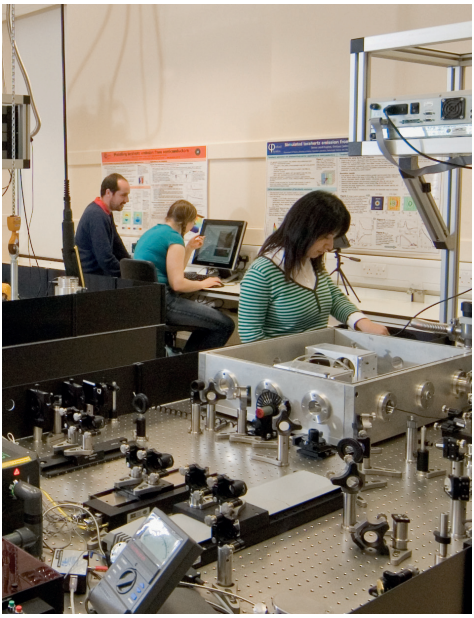
Innovation in Atmospheric Science has been a key theme of Oxford Physics for many years. For example, Oxford's G.M.B. Dobson set up the first systematic global study of the earth's ozone layer in the 1920s and 1930s. In recent times, Oxford developed the first 'citizen science' scheme, enabling huge numbers of climate simulations to be run on personal computers all over the world. We have expanded our study of the physics of climate change, using observational data and sophisticated mathematical models of the oceans and atmosphere. Oxford physicists play a major role in advising national and international bodies on climate science and we collaborate closely with other University departments on many aspects of climate change.

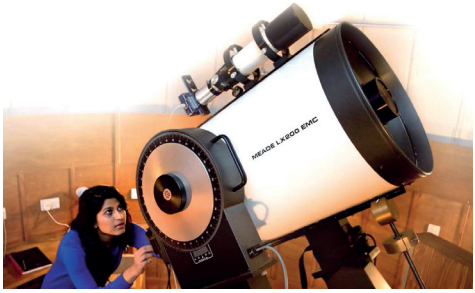
Astrophysics has seen enormous progress in our observational knowledge and theoretical understanding of the universe. Oxford astronomers recently observed the closest supernova explosion to earth for 40 years; such events help us monitor the expansion rate of the universe, which is accelerating. The cause of this acceleration remains a mystery, however, and we are playing a leading role in the *Square Kilometre Array*, the next-generation radio astronomy facility aimed at answering this and other key questions about the universe. We are also combining our expertise in solar planetary atmospheres with traditional astrophysical observation to initiate the study of the atmospheres of exoplanets – planets orbiting other stars – which is crucial to determining whether they are capable of supporting life.



Biophysics in Oxford has grown rapidly into a group conducting world-leading research into the physical mechanisms underlying biological processes. Our work in DNA nanotechnology has produced world firsts in self-assembling systems and molecular machines. A 3D tetrahedron of DNA strands formed in a single-assembly step marked the beginning of rapid developments in efficient nanostructure fabrication, making it possible to explore potential applications of these structures. Our development of a two-footed molecular motor which can 'walk' down a track by catalysing the reaction of a chemical fuel is a seminal step in the science of molecular machines.

Quantum physics is not only one of the great intellectual achievements of mankind – it also has enormous practical importance. Oxford physicists manipulate individual quantum states containing just a few photons and atoms to create fundamentally new physical states where matter and light are entangled, with the ultimate aim of building a quantum computer. We investigate new forms of materials with novel and potentially useful properties. For example, Oxford scientists are contributing to unravelling the mystery of the mechanism that underlies high temperature superconductors. New materials are needed to replace silicon technology and extend the current growth rate in IT capability. Oxford physicists played a leading role in the discovery of spin-ice and topological insulators, both completely novel structures whose potential will be revealed over the next decade.





We have one of the leading groups in the world researching into the interactions of ultra-high power lasers with matter. Optical lasers can be used to subject matter to enormous pressures, and one of the key areas of our research work is the generation and diagnosis of matter at conditions which are similar to those found towards the centre of the giant planets. Our X-ray research programme uses ultra-short X-ray laser pulses to study extreme and unusual states of matter. For example, we recently demonstrated that solid aluminium can be turned transparent by intense X-rays. Our work on laser plasma accelerators offers the prospect of a new generation of accelerators which are so compact that entirely novel applications become economic.

Oxford Physics was the origin of Oxford Instruments, one of the university's first spin-out companies, which commercialised the superconducting magnet technology now found in MRI scanners. Today we work on some of society's most pressing practical problems. Our programme on photovoltaic technology for electricity generation from sunlight has led to many patents and a recent spin-out company, Oxford Photovoltaics. Alternative sources of energy are directly addressed through close collaboration with the nearby national laboratory at Culham on fundamental work in magnetically confined plasma for nuclear fusion reactors. Oxford RF Sensors produces non-contact electromagnetic sensors based on technology developed by the department and used in automotive, aerospace and industrial applications. We are engaged with a wide range of projects with applications across medicine, electronic devices and instrumentation for aircraft engines to name but a few.

Oxford physicists continue to win many national and international prizes – and the Department has bold ambitions to sustain this success and further increase its impact. We are committed to securing provision for the very brightest graduate students, whatever their background or financial circumstances, enabling them to fulfil their academic potential by joining our scientific enterprise. Our developing infrastructure plan will provide world-class facilities to support the cutting-edge work of our researchers, allowing us to compete internationally for the best students and academics in the years to come.

For more information visit: www.physics.ox.ac.uk and www.giving.ox.ac.uk/physics

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