UCL DEPARTMENT OF PHYSICS
AND ASTRONOMY

UCL

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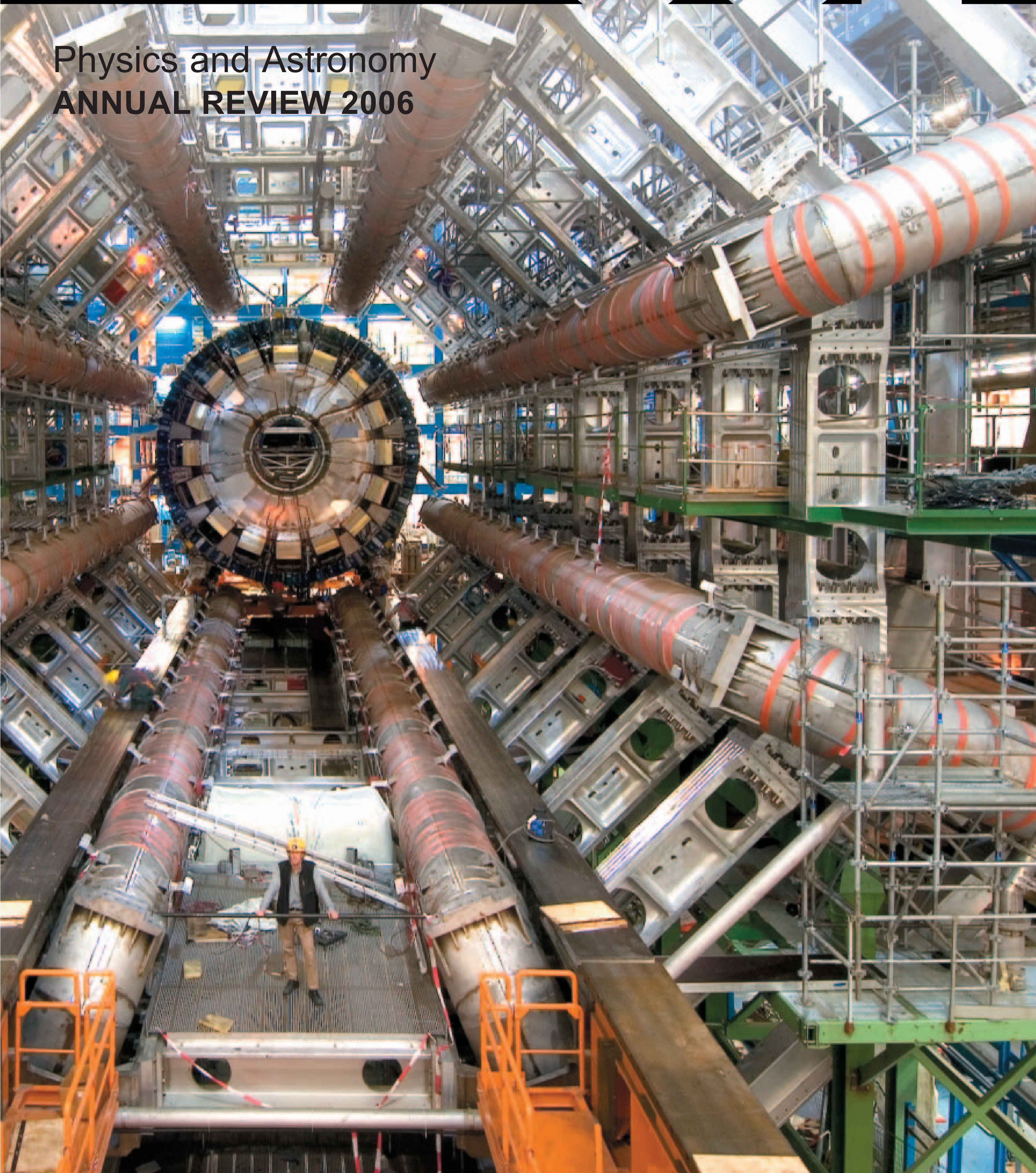

Introduction

2006 saw the many building projects being undertaken in around the Department begin bear fruit. The Condensed Matter and Materials Physics (CMMP) group moved in the London Centre for Nanotechnology (LCN) building in late spring. This building occupies the site between Physics and the Bloomsbury Theatre and, as described on page 4 in this report, it was formally opened in November. Similarly the Astrophysics Group moved into the space formerly occupied by the CMMP group in the Kathleen Lonsdale Building (KLB), meaning that the group members are co-located for the first time. As a result the Department has given up its space in Riding House Street, home of the Atmospheric Physics Laboratory for many years. The KLB opening ceremony is described on page 26 in this report.

In the main Physics Building the refurbishment of the research laboratories is also nearing completion. The Atomic, Molecular, Optical and Positron (AMOP) Physics laboratories on the third floor (the positron group) and ground floor (the atom and laser lab) are now back in action having been brought up-to-date with facilities one would expect in a twenty-first century research lab. Extensive new laboratory space has been made available for AMOP in the basement of the main Physics Building. These will be used for work involving ultracold atoms and biophysical problems. One final refurbishment, an ultrafast laser laboratory on the second floor, should be completed in the first half of 2007. The LCN building and the refurbishment work is all is due generous allocations of money from the government's Strategic Research Initiative Fund (SRIF) of which UCL has been the biggest beneficiary.

One SRIF funded project that remains to be completed is the relocation of the Department's machine room from its location in the "starlink" room on the ground floor of the Physics Building to the machine room in the basement of the KLB previously occupied by the computer centre. The area vacated by this move will be refurbished as offices and the plan is that it will be occupied by CoMPLEX (the Centre for Mathematics and Physics in the Life sciences and EXperimental Biology), an interdisciplinary centre like the LCN.

For the past two years the College has been running a so-called regeneration programme which offered generous early retirement or voluntary severance terms for HEFCE funded members of staff. The result, as can be seen on the following page, is a larger than usual number of

Figure 1. *Jonathan Tennyson tries out an 1820s transit mounted telescope in the Meridian Room at the University of Helsinki Observatory.*

retirements and the consequent loss of a number of senior staff who have worked in the Department for decades, with distinction. They will be hard to replace but fortunately, in large part due to the Department's success in winning a significant number of long-term fellowships, we have been able to balance these retirements with a number of new academic appointments. Besides the new staff listed on pp. 28-29, I anticipate that we will make a further six academic appointments in time for the start of the next academic session. Discussions on how to accommodate everyone are already in progress.

The timing of these appointments is no accident. The end of 2007 will see the census date for the "2008" Research Assessment Exercise (RAE), the last in its current form. Doing well in this exercise is crucial for the future health of the Department. In this context I note with regret the closure of another Physics Department, that at the University of Reading, on financial grounds. It is encouraging to note that the financial position of the Department has improved steadily over the last few years to the point were for the first time, at least in my time in the Department, we are in profit on the College's current financial model. The change in grant funding to so-called full economic costing is an important factor in this.

Our relatively new MSc degrees in Physics and Astrophysics have continued to grow steadily with the interesting result that our Advanced Quantum Mechanics lectures were standing room only! Similarly the number of PhD students admitted continues to grow, something that is particularly noticeable when compared with the 2001 RAE returns. Finally, August of 2007 will see us host the International Conference of Physics Students (ICPS); the first time this conference has been held in the UK. I am sure this will be just one of many events in what is sure to be another interesting and challenging year.

Prof. Jonathan Tennyson
Head of Department

Student Prizes and Events

Each session the Department of Physics and Astronomy awards prizes to students who are deemed to be "outstanding". Although the value of the Prize awarded is not high, it is important for the Department to recognise the high achievement of many of its students. For the recipients it is a recognition of excellence and something they are pleased to be able to include on their CV.

The Department is grateful to those who sponsor prizes. These currently include one given by Wiley Publishers and two given by Tessella for the best use of software in a final year (BSc or MSci) Project. Prizes (including names of recipients) awarded in Session 2005/06 were:
Oliver Lodge Prize (Best performance 1st year Physics): **Yuval Ben-Haim**
Halley Prize (Best performance 1st year Astronomy): **Kalle Juhani Karhunen**
C.A.R. Tayler Prize (Best 2nd Year Essay): **Min Zhou Jonathan Ng**
Wood Prize (Best performance 2nd year Physics): **Sebastjan Meznaric**
Huggins Prize (Best performance 2nd year Astronomy): **Daniel R. Short**
David Ponter Prize (Most improved performance in Department, 2nd year): **Hideki Michael Matsumara**
Corrigan Prize (Best performance in experimental work, 2nd year): **Benjamin J. Richards**
Additional Sessional Prize: **Daniel Went**
Best Performance 3rd Year Physics: **Dara McCutcheon**
Best Performance 3rd Year Astronomy: **Alana Rivera Ingraham**
Best 3rd Year Report: 1st Prize – **Benedict O'Donnell**;
2nd Prize – **Harry Rogers**
Burhop Prize (Best performance 4th year Physics): **Soumaya Mauthoor**
Herschel Prize (Best performance 4th year Astronomy): **Rosemary Willatt**
Brian Duff Memorial Prize (Best project in the department): **David W. Sutton**
William Bragg Prize (Best overall undergraduate): **Khee Ghan Lee**
Tessella Prize for Software (Best use of software in final year Physics/Astronomy projects): **Soumaya Mauthoor, Rachel Porter**
Carey Foster Prize (Postgraduate Research, Physics): **No nominations**
Harrie Massey Prize (Postgraduate Research, Astronomy): **Mark Westmoquette**
Outstanding MSc Performance: **Ole Host**

Faculty Prizes

Faculty Medal:
Martin Luu MSci Mathematics

The following students were placed on the Dean's List for outstanding performance in their final exams:
Ebru Aydemir BSc Mathematics
Helen Margaret Davis MSci Chemistry
Bethan Mary James MSci Environmental Geoscience
Kim Elizabeth Jelfs MSci Chemistry
George Kaoullas BSc Mathematics and Statistics
Khee Gan Lee MSci Physics with Space Science
Soumaya Mauthoor MSci Physics
Paniez Paykari MSci Astrophysics
Rachael Porter MSci Mathematics & Astronomy
Su Lynn Sabrina Tan BSc Mathematics and Physics
Oliver Luke White MSci Planetary Science
Rosemary Clare Willatt MSci Astronomy

Jackson Lewis Scholarship:
Vijay Chudasama MSci Chemistry
Daniel R. Short MSci Astronomy and Physics

Other Prizes

PhD student **Bob Barber** has won the first prize in UCL's 180th anniversary haiku competition with his haiku:
Housman you must weep
The tree that you loved is gone
And we the poorer

Christopher Hadley has been awarded the Valerie Myerscough Prize for 2006 by the University of London, and the money is going to be spent on visiting Prof Vladimir Korepin of the State University of New York at Stony Brook in early 2007.

Jose Reslen (from Colombia) and **Rui Zhang** (from China) have been given Dorothy Hodgkin Postgraduate Awards to perform fully funded PhDs in the Department from October. They are the first successes the Department has had for these very competitive awards.

Dr Christian Ruegg received ETH medal for Ph.D. thesis (ETH Zurich) and Swiss Physical Society Award for General Physics (sponsored by ABB). (The ceremony for the second took place in Lausanne on 13th Feb 2006.)

Stathis Stefanidis got a scholarship from the foundation "Alexander S. Onassis". The scholarship started in October 2005 and will last for 2 years.

Figure 1. *Student Prize Winners with Professor Mike Barlow, Director of Undergraduate Studies (standing left), Professor Jonathan Tennyson, Head of Department (standing centre), Dr Ian Ford, Physics Tutor (standing centre right) and Dr Ian Furniss, Astronomy Tutor (standing right).*

Event Horizon Total Solar Eclipse Trip

Mischa Stocklin, a PhD in the AMOP group, reports on visit to Turkey by students from UCL Physics & Astronomy's Student Society, Event Horizon *(see Fig. 1)*, and Imperial College London to observe the total solar eclipse of Wednesday 29th March 2006. This excursion was organised by a local sub-committee of IAPS (the International Association of Physics Students) at the Middle East Technical University (METU) in Ankara, Turkey. The observation of the eclipse was paired with a conference and social programme at METU.

Figure 1. *The entire UCL Event Horizon group in Mersin. Mischa Stocklin is second from the left.*

A total of 17 students from London and 13 from Bristol University took the opportunity to attend what turned out to be a truly magnificent trip. Sadly all other European groups had cancelled their participation, resulting in the UK students being the only foreign group at the conference. As we were overwhelmed by the Turkish hospitality we encountered there, the absence of other visitors did not do much to diminish the quality of the excursion.

We arrived in Ankara in the small hours of Monday 27th March, after an epic journey via Rome and Istanbul and were glad to get some rest in one of the student residences of the enormous METU campus, which, as we discovered in daylight the next morning, seemed to be about the size of Central London… The first two days of the conference included a series of lectures on atmospheric gravity waves, counting time on Mars and, of course, on solar eclipses, including an inspiring presentation on recent eclipses. The programme also included a tour of the facilities at the nearby Bilkent University's Physics Department, specializing mainly in condensed matter physics.

Figure 2. *The moment of totality.*

Of course there was also ample opportunity for cultural exchange and fostering contacts with our Turkish hosts. On the first evening this included a lovely surprise dinner in Ankara itself, which was located next to an ice rink where the local ice hockey team was busy training for the next match. On the second evening we were treated to some traditional Turkish folk music performed by a number of our hosts on instruments such as the balama (a round body type guitar) and the ney flute, which interestingly most closely replicates the human voice of any instrument in the world.

Finally, on the morning of Wednesday 29th March, a large convoy of buses left Ankara for the small town of Hacibektas in the central Anatolian region of Kapadokya ('Land of Horses'). Our aim was of course to observe what is perhaps the most spectacular astronomical event – the total solar eclipse where the Earth's moon lines up perfectly in between the Earth and the Sun, such that it completely obscures the view of the Sun for a few minutes. This event takes place on average every few years in different locations around the Earth, with partial eclipses (where the Moon doesn't align perfectly) and annular eclipses (where the Moon is too far from the Earth to appear the same size as the Sun and a large ring of sunlight remains around the shadow of the Moon) occurring equally or more frequently. During an eclipse the shadow of the Moon passes over the Earth in a reasonably narrow path of totality where the total solar eclipse can be observed, and luckily for us, the town of Hacibektas and its nearby hill lay almost exactly at the centre of the path of totality.

At 14:02 local time the big moment arrived. We had observed first contact – when the moon first passes into the direct line of sight towards the Sun – over an hour earlier and had steadily observed the waning of the Sun into a small crescent shape, using our special optically thick eclipse glasses. The temperature had begun to drop significantly, winds had started to pick up and a strange almost spot-like light effect had taken place just before the eclipse. When the moment of totality arrived many of us felt like little kids who had just realized that Christmas, Easter and their birthday occurred on the same day this year… When the Moon finally obscures the view of the Sun completely it is safe to take off your eclipse glasses. With the naked eye one witnesses the eerie yet beautiful black disk in the now almost night-time sky, surrounded by the Sun's corona or outer atmosphere, which is only observable without aid during a total solar eclipse *(see Fig. 2)*. Solar flares or 'prominences' (outbursts of magnetic energy from the Sun) can be observed from the corona during the totality. Bright stars were to be seen in the sky and also four of the planets, Mercury, Venus, Mars and most beautifully Saturn, low in the sky. Around the horizon begins a spectacle of what looks like a cross between multiple sunsets in every direction and an enormous ring of fire burning in the distance. The effect was enhanced by the close-by Erciyes Mountain at almost 4000m which could be seen at first in a brilliant white against the horizon and a few minutes later as totality drew towards an end, as a black silhouette against the vivid twilights of the sky.

In ancient times people believed various myths concerning solar eclipses, including, for example, the ancient Chinese who thought a large dragon ate the Sun and had to be chased away to bring back sunlight, and many who had seen an eclipse for the first time in their lives, unaware of what was happening, were convinced the world was coming to an end. In many ways such sentiments were understandable to us, standing there on top of our hill experiencing at 3 minutes 36 seconds what was likely to be the shortest night of our lives so far, with a black sun and red horizon.

At 14:05 local time, the last moment of magic came when the Sun emerged from behind the Moon and the diamond ring effect was seen, with a single brief burst of sunlight. At this time the eclipse glasses are put on again to observe the remaining final stage of the eclipse as the Moon leaves the line of sight once again. When at 15:18 the spectacle was over, many of us suddenly felt that August 1st 2008 when the next total solar eclipse takes place over the Arctic, Siberia and China (during the Olympic Games of Beijing), was a terribly long time away! Those readers who have experienced a solar eclipse themselves will probably be able to share our emotions about this event; to those who have never seen a total eclipse, we can strongly recommend an incredible few minutes of one's life…

LCN Opening

One of the most challenging construction programmes in UCL's history has been completed, with the official opening on 7 November 2006 of the London Centre for Nanotechnology (LCN) building *(Fig. 1)* adjoining the Department and with its main entrance on Gordon Street. The £20 million, eight-storey building was designed to provide the ultra-low vibration environment which is essential to experiments which work at atomic-scale resolution – requirements so sensitive that vibration arising from a person walking nearby, never mind an underground train 50 metres away, would normally destroy the experiment.

Figure 1. *The London Centre for Nanotechnology's new building in Gordon Street.*

Figure 2. *The opening event for the London Centre for Nanotechnology, held in the Bloomsbury Theatre on November 7th 2006.*

The LCN is a joint venture between UCL and Imperial College London which harnesses the world-class expertise of the two institutions across the physical, engineering and biomedical sciences to meet the needs of society and industry – and in particular to improve health care.

The official opening was marked by a symposium *(Fig. 2)* chaired by UCL's President and Provost, Professor Malcolm Grant, at which the future of nanotechnology and its applications were discussed by the Deputy Rector of Imperial College, Professor Sir Leszak Borysiewicz; the Governments Chief Scientific Adviser and Head of the Office of Science and Innovation, Sir David King; the Director of the Wellcome Trust, Dr Mark Walport; and the joint directors of the LCN, Professors Gabriel Aeppli *(Fig. 3)* and Tim Jones.

The majority of the Department's Condensed Matter and Materials Physics group have re-located into the LCN. However Physics and Astronomy is only one of the eight academic departments which are working together on projects which require skill combinations that no individual scientist or even traditional academic department can contribute. Physicists are sitting next to medical doctors, chemists and engineers, paving the way for unique collaborations.

Figure 3. *Professor Gabriel Aeppli, UCL's Director of the newly opened London Centre for Nanotechnology, in one of the state-of-the-art experimental laboratories in the new LCN building.*

Staff News

Promotions

Promotion to Professor:
Jonathan Rawlings
Promotion to Reader: **Sougato Bose, David Bowler, Peter Doel, Nikos Konstantinidis, Ferruccio Renzoni**
Promotion to Senior Lecturer:
Stan Zochowski

Figure 1. *Professors Tegid Jones (left) and David Miller with a sample of the several gifts they received at the end of a special 'Jones and Miller Fest' run in their honour.*

Appointments

The following appointments were made to the permanent academic staff in 2006:
Dr Peter Barker, Senior Lecturer at Heriot – Watt University – Reader in the AMOP group
Dr Robert Thorne, Royal Society University Research Fellow at Cambridge University – Lecturer in the HEP group
Dr Jonathan Underwood, Lecturer at the Open University – Lecturer in the AMOP group (from 01/01/2007)
Dr Nick Achilleos, Senior Research Scientist at Imperial College – Lecturer in the Astrophysics group (from 01/04/2007)

Figure 2. *Prof Allan Willis receives his retirement certificate.*

Retirements

The following stalwarts of the Department all retired this year:
Prof Tegid Jones – previously Admissions Tutor and Head of the High Energy Physics group, fig. 1
Prof Peter Storey – previously Admissions Tutor and Director of Postgraduate Studies
Prof Allan Willis – previously Astronomy Tutor and Chair of the Undergraduate Teaching Committee, fig. 2
John Fordham – after 40 years of offering technical support to almost every area of the Department
Tim Phillips – after many years as Computer programmer then Stores Manager

Alumni Matters

Prof. Tegid Wyn Jones *(see Fig. 1)* writes: in last year's Departmental Annual Review it was announced that I had undertaken responsibility for departmental alumni matters, coinciding with my retirement in September 2006. I was aware that the major task would be to obtain the names and current addresses of under and post graduate students and post doctoral fellows, extending over the past thirty and hopefully more years.

Such a list does not exist – last year's mailing was based on the 1600 names and addresses from the UCL Alumni list, which contains mainly departmental alumni from the past fifteen years or so. A start has been made and I am requesting your help to supply details of any of our graduates or post docs you know, using the form accompanying the Annual Review.

I would like to invite you to a dinner to be held on Friday 27 April 2007 – please respond on the same form if you wish to come. The following people will be coming to share their reminiscences and to contribute to the way ahead for this alumni association:
Dr. Colin Petts – *Petts Consulting Ltd,*
Prof. Mike Charlton – *Head of Psysics at Swansea University,*
Dr. Phil Kaziewicz – *Director and Founding Partner of Global Innovations Partners LLC* and
Prof. Max Pettini – *The Institute of Atronomy, Cambridge University.*

It took the Chemistry department at UCL some ten years to establish a vibrant alumni association. I very much hope that we are at the start of such a process in the Department of Physics and Astronomy.

Careers

Professor W R Newell, Departmental Careers Officer, discusses the increasing demand for Physics graduates and two of our recent ones discuss their subsequent careers.

Physics and Astrophysics deals with the foundations of science and also its applications to cutting edge technologies. As an intellectual path way to the fore front of exploration and understanding of the physical world it is excellent. In addition such a degree in Physics/Astrophysics also opens up many avenues to employment through the skills acquired: these embrace problem solving, the training of a logical and numerate mind, computation skills, modelling and material analysis and the ability to think laterally. These combined with team work, vision and enthusiasm make physics graduates highly desirable members of all dynamic companies.

A brief survey of current UCL Physics undergraduates revealed that the reasons for choosing a physics degree programme was two fold: an interest in the subject coupled with the wide range of careers for which physics provided the gateway.

Physics established careers embrace a broad-band of areas eg. Information Technology, Engineering, Finance, Research and Development, Medicine, Nanotechnology and Photonics. It is no wonder that employers regard a physics degree as a flexible and highly desirable university training. In addition to the primary degree higher degrees, Msc and PhD degrees, are also seen by employers as further evidence of self-motivation, planning ability and more fully developed critical analysis skills.

UCL provides an active Careers Service dedicated to providing effective pathways for our students to enhance their employer-led skills. This is achieved by personnel advice and 'getting acquainted' activities such as the Science and Engineering fair and invited seminars. The success of this is exemplified by the high initial employment rate, 98%, of UCL physics graduates in the immediate period after graduation. There is a growing shortage of physics graduates in the market place for well qualified people. A sample of the diversity of success of our graduates is given by personal profiles of two recent UCL students.

Toby Goodworth

Ph.D. Physics, University College London (1999-2002) MSci Physics, First Class (Hons.), University College London (1995-1999)

Since completing my physics Ph.D. in 2002, I have been working in the financial sector. I started my career as a quantitative analyst working on equity funds, but quickly moved into an area of finance dealing with alternative investments, or hedge funds as they are more commonly known. For the unfamiliar, hedge funds are a form of lightly regulated investment vehicles that aim to generate positive performance irrespective of markets rising or falling. To do this they employ a range of complex investment techniques often involving the use of derivatives or short selling. In my current role as Head of Risk Management at Key Asset Management, one of Europe's oldest hedge fund firms, I oversee research and development of the company's risk models, as well as sitting on the investment committee that controls the firm's $1.6 billion asset base, making sure that we deliver our performance objectives without undue risk.

Figure 1. *Dr Toby Goodworth.*

In meetings, be it with a multi-millionaire private investor over lunch, or a company's board of trustees, I often get asked how I moved from physics to finance. The truth is that this transition is a well trodden path, with investment banks and asset management firms alike actively seeking the rational, methodical and quantitative brains of physics graduates.

Following graduation from my MSci degree, I did not move directly into a financial career as I had initially planned. Instead, I was fortunate enough to be offered a place to study for a Ph.D. within the Atomic, Molecular, Optical and Positron Physics group at UCL under Prof. W R Newell. My doctorate focused on the ultrafast dynamics of atoms and molecules in high intensity laser fields, and, for three years, provided me with an ideal blend of theoretical and experimental physics utilising world-leading femtosecond laser facilities at the Rutherford Appleton Laboratories. Although there is little call for the ability to tune a state-of-the-art laser in modern finance, the theoretical and computational techniques learnt throughout my Ph.D. are crucial to my job. Indeed, advanced financial risk models employ a number of techniques used throughout physics, just with different application. For example Monte Carlo simulations can be used to model molecular fragmentation just as readily as they can be employed to measure risk in an investment portfolio.

Entering finance from a quantitative discipline doesn't necessarily mean being stuck behind an array of screens crunching numbers all day either. In addition to the obvious quantitative side of heading up risk management, my current role also permits me significant portfolio management responsibilities and client facing elements, allowing me to travel all over the world as a conference speaker, meeting fund managers and investors, or giving presentations. In this context, I have found the discipline of undertaking world-class research, and expressing my findings through academic papers and presentations has provided the perfect grounding for such activities.

Finally, first-hand experience has shown me that the financial world is a fast-paced, meritocratic environment where the ideas that shape progress don't necessarily come from the longest-standing, or oldest employee. Quantitative degrees or Ph.D.'s are held in high regard, and as I have found, those with such qualifications can make a significant impact early in their careers.

Kiran Jagpal
(MSci Astrophysics 2006) now a Commercial Graduate with BAE Systems

Towards the end of my degree I, like many other students, was completely clueless about what to do after I finished University. Despite really enjoying Astrophysics, I decided staying in that field was not for me, as I was perhaps not the best Astrophysicist in the world!

Figure 2. *Kiran Jagpal.*

As a result, I started looking at companies which offered graduate training schemes as I felt they would give me a good starting point for whatever career I decide to embark upon. Then I came across the many graduate schemes that BAE Systems offer.

For those of you who don't know much about the company then let me tell you a bit about it. BAE Systems (formerly known as British Aerospace) is Europe's largest and the premier transatlantic defence and aerospace company. They have operations across 5 continents, over 100,000 employees worldwide and customers in 130 countries. They design, manufacture and support military aircraft, surface ships, submarines, radar, avionics, electronic systems, guided weapons and a range of other defence products.

When I first researched the company, I was amazed by how many functions operate amongst all their different projects and how they offered graduate placements in almost all of them. The functions include Project Management, Engineering (Software, Hardware, Systems), Procurement, Commercial, HR and Finance. I have joined the company through the 2 year Graduate Development Framework Programme as a Commercial Graduate, and am currently on a placement with Nimrod MRA4 project.

The other attraction to this company was the way it looks after its employees and how they encourage you to have a life outside of work. There are many graduate programmes that company's offer, for example in investment banking, where you are expected to work long hours and often your efforts will go unrewarded, however at BAE Systems you are never expected to work more than 37 hours per week and if you do work more in order to meet deadlines then you are credited those hours at a later date and are able to take the time off work. Don't get me wrong, the days can be busy and can be quite stressful, but the efforts you put it will certainly not go unnoticed.

So, going from Astrophysics to Commercial Business doesn't seem to link together at all. Well that's what I thought; but now that I'm here I've realised that the skills and knowledge I've learnt at university can be applied in a vast number of situations at work. Within the Commercial activity, there are two distinct but closely related fields – Estimating and Managing Contracts. Estimating requires high numerate skills, involving calculation and modelling, as well as problem solving and an ability to think 'outside the box'. One also needs to identify and mitigate risk, and there is a certain amount of error analysis used to do this. The other part of commercial is to bid for, negotiate, write and manage a contract which requires one to be able to communicate often very complex ideas to the customer. All these skills, as well as many more, I feel I have established to a certain extent at university, whether it be through my final project or weekly visits to University of London Observatory, and am now able to develop them in a way I never imagined. I believe that without having done such an analytical and flexible degree as Astrophysics, I would never have got the job!

Astrophysics

The Astrophysics group at UCL is one of the largest in the UK. Current research activities cover a broad range of studies that include atmospheric physics, circumstellar and interstellar environments, galaxies and cosmology, massive stars and clusters, optical instrumentation, starformation, astrochemistry, and extra-solar planets.

A taste of some of the research conducted during 2006 is provided below, highlighting results from surveys of galaxies, studies of cosmic dust formed by supernovae, and in the Atmospheric Physics Laboratory.

Constructing large 3-d maps of galaxies

UCL astronomers have participated in two international teams that, in 2006, mapped the large scale distribution of galaxies, writes Prof. Ofer Lahav.

The first team is an international collaboration between American, Australian and British researchers, including Prof. Lahav and PhD student Anais Rassat from the UCL Astrophysics Group. In October 2006 they released maps from the largest full-sky, three-dimensional survey of galaxies ever conducted. The maps are based on the observation that, as the universe expands, the colours of galaxies change as their emitted light waves are stretched or ‘redshifted’. By measuring the extent of this redshift, astronomers are able to calculate approximate distances to galaxies.

The new survey, known as the 2MASS Redshift Survey (2MRS), has combined two dimensional positions and colours from the Two Micron All Sky Survey (2MASS), with redshifts of 25,000 galaxies over most of the sky. These redshifts were either measured specifically for the 2MRS or they were obtained from an even deeper survey of the southern sky, the 6dF Galaxy Redshift Survey (6dFGS).

The great advantage of 2MASS is that it detects light in the near-infrared, at wavelengths slightly longer than the visible light. The near-infrared waves are one of the few types of radiation that can penetrate gases and dust and that can be detected on the Earth’s surface. Although the 2MRS does not probe as deeply into space as other recent narrow-angle surveys, it covers the entire sky.

The team provided detailed maps of the cosmos out to 600 million light years, identifying all the major superclusters of galaxies and voids. They were also able to infer the relative motions of the galaxies. According to the team, our galaxy the Milky Way, its sister galaxy Andromeda and other neighbouring galaxies are moving towards a massive supercluster (aptly named the ‘Great Attractor’) at an amazing speed of almost a million kilometres per hour. Furthermore, they were able to establish that the Great Attractor is indeed an isolated supercluster and is not part of the even more massive Shapley Supercluster that lies further away.

In order to map the dark matter probed by the survey, the team used a novel technique borrowed from image processing. The method was partly developed by Prof. Lahav and extended and applied by his former student Dr. Pirin Erdogdu (now at the University of Nottingham), the lead author of the study. It utilises the relationship between galaxy velocities and the total distribution of mass. It is like reconstructing the true street map of London just from a satellite image of the city taken at night. The street lights, like the luminous galaxies, act as beacons of the underlying roads.

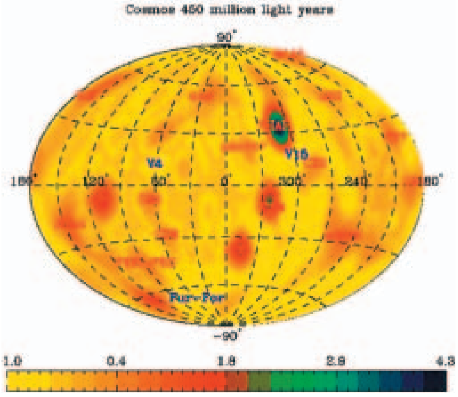

Figure 1. *The reconstructed density field, evaluated on a thin shell at 450 million light years away. The over-dense regions are shown in red, with voids in blue.*

This extraordinarily detailed map of the Milky Way’s cosmic neighbourhood provides a benchmark against which theories for the formation of structure in the universe can be tested. In the near future, the predicted motions derived from this map will be confronted with direct measurements of galaxies velocities obtained by the 6dF Galaxy Survey, providing a new and stringent test of cosmological models.

In the second study, Dr. Chris Blake, Dr. Adrian Collister, Dr. Sarah Bridle and Prof. Lahav (the latter two are members of the UCL Astrophysics Group) announced in May 2006 new results based on the largest map of the Heavens ever constructed. This massive atlas emphatically confirmed recent findings that the Universe is full of dark energy, a mysterious substance that makes up three-quarters of our Universe, and in addition nearly a quarter of dark matter.

Understanding this composition is now one of the most important problems facing the whole of science. It is intriguing that the ordinary matter our bodies are made of and we experience in everyday life only accounts for a few percent of the total cosmic budget.

Our Universe contains billions of galaxies of all shapes and sizes. In recent years astronomers have used increasingly large surveys to map out the positions of these galaxies, stepping their way out into the cosmos. Our research unveiled a three-dimensional atlas of over a million galaxies stretching a distance of more than 5 billion light years. The findings confirm that we live in a Universe filled with mysterious dark matter and dark energy.

The team analysed the patterns in this map and discovered waves of structure over a billion light years in size. These waves were generated billions of years ago and have been vastly stretched in size by the expanding Universe.

Construction of the cosmic atlas was led by co-author Dr. Collister of the University of Cambridge, as part of his PhD work, using a novel Artificial Intelligence technique he developed with his supervisor Prof. Lahav. By using very accurate observations of just 10,000 galaxies to train the computer algorithm they have been able to estimate reasonably good distances for over a million galaxies. The precise observations of the 10,000 galaxies were made as part of an international collaboration between U.S., U.K. and Australian teams using data from the Sloan Digital Sky Survey and the Anglo-Australian Telescope.

By measuring the positions of galaxies, astronomers can unravel the balance of forces that govern our Universe: the force of gravity which pulls everything together, and the competing effect of the expanding Universe which smooths things out. These cosmic forces have arranged the galaxy distribution into a complex network of clusters, filaments and voids. The galaxy map can tell us the amount of ordinary 'baryonic' matter relative to the amount of mysterious dark matter. The cosmic atlas of a million galaxies will shortly be made freely available on the World Wide Web for the benefit of other researchers.

The key problem in mapping the cosmos is determining the distance to each galaxy. Traditionally astronomers have needed to take a "spectrum" of each galaxy to determine this distance, splitting its light into many components to reveal sharp features with which to measure the amount of redshifting. This requires a time-consuming, individual observation of each galaxy. The new cosmic map has been constructed using a novel technique focusing on a special class of galaxy whose intrinsic colour is very well known. For these "Luminous Red Galaxies" researchers can measure the amount of colour distortion, and hence estimate the approximate distance of the galaxy. This is achieved just by looking at digital images of the sky, without the need to obtain a full spectrum. All that is needed to exploit the technique is accurate observations of a small sample of the galaxies. In this case, precise measurements of just 10,000 galaxies were used to produce the atlas of over a million galaxies. These techniques will be very important for future large astronomical projects such as the Dark Energy Survey, scheduled to start in 2010, in which UCL is a key partner.

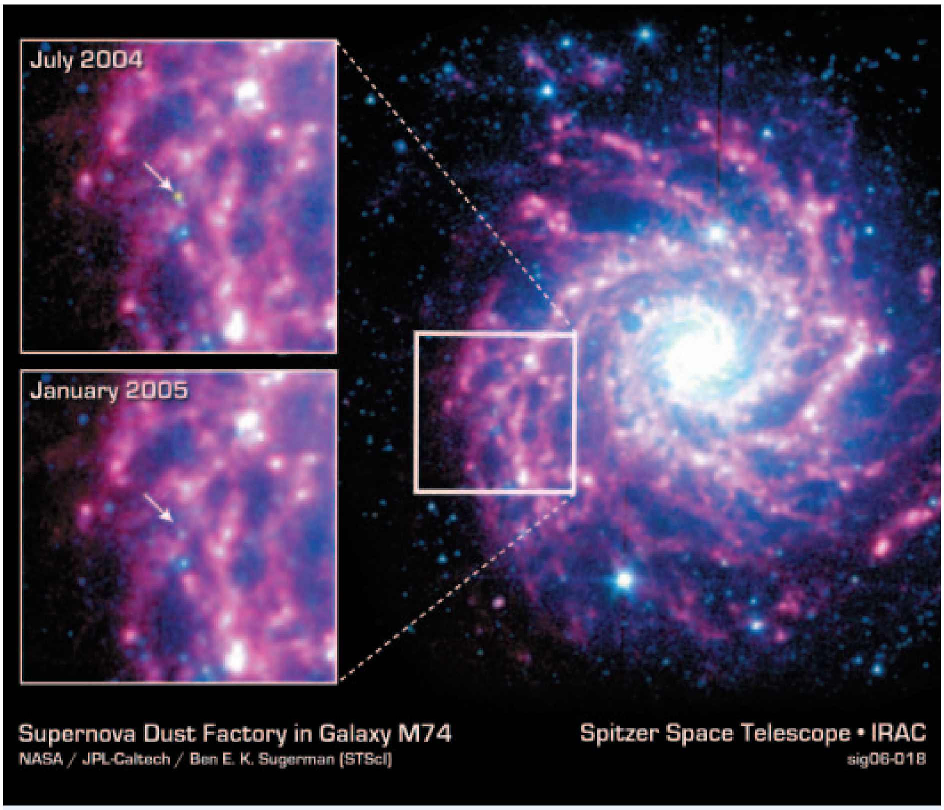

Figure 2. *Supernova SN 2003gd is shown at the center of the two small insets from Spitzer's Infrared Array Camera (IRAC). A white arrow points to its exact location. The yellow-green dot shown in the July 2004 inset (top) shows that the source's temperature is warmer than the surrounding material. This is because newly formed dust within the supernova is just starting to cool. By January 2005, the dust had cooled and completely faded from IRAC's view. The larger image to the right of the insets is the galaxy M 74, as seen by Spitzer's Infrared Array Camera. The white box to the left of the galaxy's center identifies the location of the supernova remnant. In all the images, the blue dots represent hot gas and stars. The galaxy's cool dust is shown in red. The images are false-color, infrared composites, in which 3.6-micron light is blue, 4.5-micron light is green, and 8-micron light is red. (Images due to Sugerman et al.).*

Supernova dust factory

Cosmic dust is an important building block of galaxies, stars, planets, and even life, writes Prof. Michael Barlow. This dust is composed of small particles made of elements such as carbon, silicon, magnesium, iron and oxygen. Until recently, it was thought that this dust was mainly formed by old sun-like stars known as red giants. The problem with this scenario is that it does not explain the large amounts of dust that have recently been found in star-forming galaxies that formed only a few hundred million years after the Big Bang. Supernovae produced by short-lived massive stars have been suspected as the dust factories but they are fairly rare events that only happen approximately once every hundred years in galaxies like our own, making it difficult for researchers to confirm whether dust is formed in their aftermath. However, the great sensitivity to infrared dust emission of NASA's Spitzer Space Telescope, which was launched in 2003, has made it feasible to detect newly formed dust around supernovae in other galaxies.

The Survey for the Evolution of Emission from Dust in Supernovae (SEEDS), a team that includes several UCL astronomers (Prof. Mike Barlow, Dr. Barbara Ercolano, Joanna Fabbri and Dr. Janet Bowey), has acquired and analysed a series of observations of recent supernovae in external galaxies. As dust condenses in the ejecta from a supernova, it should produce three observable phenomena: (1) emission at infrared wavelengths; (2) an increase in obscuration of the supernova's light at visible wavelengths; (3) greater obscuration by the newly formed dust of emission from gas that is expanding away from us, on the far side of the supernova, than from gas expanding towards us, at

the front of the supernova. If all three signatures are detected, this provides strong evidence for the formation of new dust in a supernova's ejecta.
Supernova 2003gd was a supernova whose explosion was discovered in 2003 in the spiral galaxy Messier 74, at a distance of approximately 30 million light-years *(see Fig. 2)*. Spitzer infrared measurements of supernova 2003gd, made 500-700 days after the outburst, revealed emission consistent with newly formed cooling dust.

Detailed modelling of the observed infrared emission and of the measured obscuration at visible wavelengths, taking into account the effects of clumping, implied that solid dust particles equivalent to up to seven thousand earth masses (0.02 solar masses) had formed in the ejecta, corresponding to a sufficiently high heavy element condensation efficiency to account for the observed dust content of high redshift galaxies. Although researchers have detected many supernovae in the past at visible wavelengths, supernova 2003gd is only one of a very small number in the universe that have so far been seen at infrared wavelengths producing dust.

Atmospheric Physics: From the Earth to Extrasolar Planets

The Atmospheric Physics Laboratory (APL) within the Astrophysics group has a history of studying the atmosphere that goes back to the first scientific rocket launches after the second world war, writes Prof Alan Aylward. Nowadays they have expanded their range to studies of other planets' upper atmospheres too, and the tools they use are more sophisticated *(see Fig. 3)*.

For the Earth, large numerical computer models are used at UCL to study what controls the dynamics and composition of the upper atmosphere. For example, how much do changes in solar particle output affect the climate? To study that we have to know how such effects might penetrate through the outer layers of the atmosphere. Recent work has looked at the creation of nitric oxide in the arctic auroral region by particle precipitation, and tracked its transport downwards and equator-wards. It is important because nitric oxide can destroy ozone if it penetrates low enough, and this transport may be important for losses in the mid-latitude ozone layer.

Figure 3. *The two ESR (EISCAT Svalbard Radar) dishes on the island of Spitzbergen in the Svalbard archipelago. The one on the left is a 42-meter fixed dish and the one on the right is a fully-steerable 35-meter dish; each is capable of transmitting 500kW of coded pulses. These powerful radars are used by the APL team in conjunction with the UCL Fabry-Perot Interferometers on Svalbard and, particularly, the new SCANDI (Scanning Doppler Imager) instrument. (Image due to EISCAT).*

Other work has looked at how accurately we can follow the effects of the bright aurorae that result when the Sun ejects what is known as a Coronal Mass Ejection – a bright, hot cloud of dense plasma – towards the earth.

APL also builds instruments to study the Earth's upper atmosphere and they have recently deployed a ground-breaking new wind- and temperature-measuring instrument called a SCANning Doppler Imager (SCANDI) *(see Fig. 4)*. This is important because it allows thermospheric winds and temperatures to be measured over a 500km radius circle simultaneously whereas before a picture had to be built up slowly with many individual point measurements. SCANDI is deployed on an Arctic island only 10 degrees from the north pole, where the wind patterns in the upper atmosphere are particularly complex and linked to the influence of the Sun on the Earth.

Away from the Earth, APL also studies other planetary atmospheres using similar techniques to those it uses on Earth – i.e. modelling and observations. There are models of the Martian upper atmosphere which can be compared to the observations being made by space probes like Mars Express. There are also models of Jupiter and Saturn which can be compared to the group's own telescopic observations of those planets. They specialise in looking at the infra-red emissions from a particular molecular ion in those atmospheres, the exotic H_3^+ ion. This is particularly bright in the auroral regions of these planets: indeed Jupiter and Saturn have aurorae that look similar to those on Earth.

We say "similar" and not "the same" because the APL observations as much as any have been used in recent years to show that the superficial similarity disguises a complexly different set of mechanisms that locates and "lights up" these Gas Giant aurorae compared to Earth's. Making such comparisons tells us something more about the Earth, but also tests our knowledge of plasma physics and some basic chemistry.

The modelling, meanwhile, has lead to some unexpected results. All the Gas Giants have outer atmosphere temperatures much larger than expected from simple energy balance calculations. While trying to investigate this via modelling one of APL's PhD students discovered that "ion drag", one of the mechanisms assumed to contribute to the heating, actually caused a cooling effect in much of the atmosphere because of the way the atmospheric circulation was changed.

One exciting new field that APL is exploring is the modelling of extrasolar planet atmospheres, "Extrasolar planets" are planets going around other stars: the existence of these has only been proven for the last ten years. Early observations have tended to show very large (Jupiter- or bigger sized) planets very close to their "sun" – often well within what would be Mercury's orbit in our system. Having a model of Jupiter to start from, APL have been able to study theoretically what one would see happening to the atmospheres of such bodies, and to show, for example, why the atmospheres remain fairly stable, despite the heat input, to distances as small as 1/10 of the Earth-Sun distance. It neatly rounds off the interests of the group that this stability is due to the same H_3^+ ion they study in the solar system.

Figure 4. *(left-to-right) Eoghan Griffin, Iris Yiu, Andy Charalambous and Ian McWhirter from the Atmospheric Physics Laboratory stand under an auroral display in the Longyearbyen valley on Svalbard (79degs N) where they have been installing the SCANDI (Scanning Doppler Imager) system. This was installed in winter, at a time when the sun does not come above the horizon all day, so this picture is lit by a combination of moonlight, the aurora and lights from the town.*

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Active Grants and Contracts

Observation and modelling of the upper atmospheres of the earth planet
(PPARC) £669,156 PI: A D Aylward
Studies of thermospheres and ionospheres: From the Earth to the Stars
(PPARC) £1,570,463 PI: A D Aylward
Dust contributors to galaxies – supernovae versus evolved star outflows
(PPARC) £164,557 PI: M J Barlow
The dust enrichment of galaxies: supernovae and evolved stars
(PPARC) £184,227 PI: M J Barlow
Analysis of iso/LWS scans of ORION BN/KL (CCLRC) £46,850 PI: M J Barlow
Deep spectroscopy and 3D photoionisation modelling of planetary nebulae
(Royal Society) £12,000 PI: M J Barlow
Stellar duets in theory and observations – Studentship for Rupert Neal
(American Museum of Natural History) £9,504 PI: M J Barlow
Formation of massive star clusters and cluster complexes in galaxies
(PPARC) £250,170 PI: N Bastian
Constraining and testing cosmological models
(Royal Society) £192,224 PI: S L Bridle
Measuring cosmic shear (PPARC) £186,144 PI: S L Bridle
Research on large carbon fibre composite adaptive mirrors for the next generation of Extremely Large Telescopes (PPARC) £145,653 PI: A P Doel
Dark Energy Survey Design Work (University of Chicago) £21,598 PI: A P Doel
Smart X-ray optics (EPSRC) £3,072,090 PI: A P Doel
Bringing the Universe to London Schools (PPARC) £7,200 PI: J Dunkley
Astronomy in the classroom: school and observatory visits
(PPARC) £8,200 PI: M Dworetsky
Astronomy in the classroom: school and observatory visits for KS2, KS3, KS and A-level (PPARC) £5,600 PI: M Dworetsky
Development of a photon counting L3CCD detector for spectroscopic applications
(Royal Society) £6,837 PI: J L A Fordham
Rolling grant support for use of ground-based facilities
(PPARC) £137,648 PI: I D Howarth
Rolling system-management support for the UCL Astronomy Group
(PPARC) £134,217 PI: I D Howarth
System management support for the UCL Astrophysics group
(PPARC) £90,155 PI: I D Howarth
Quantative inference from large galaxy surveys and other cosmic probes
(PPARC) £111,618 PI: O Lahav
Development phase of the Dark Energy Survey instrumentation
(PPARC) £31,454 PI: O Lahav
Cosmology with the new generation of photometric redshift surveys
(PPARC) £186,144 PI: O Lahav
Modelling the Universe: From atomic to large scale structures
(PPARC) £246,804 PI: S Miller
UKIRT observations of the Deep Impact mission (PPARC) £33,489 PI: S Miller
UCL Astronomy short-term visitor programme 2003-2006 (PPARC) £21,799 PI: R Prinja
UCL Astrophysics short-term visitor programme 2006-2009
(PPARC) £25,661 PI: R Prinja
Star formation and its relationship with the interstellar medium
(PPARC) £164,007 PI: J Rawlings
Rolling grant support for use of ground based facilities (PPARC) £46,702 PI: L J Smith
Massive stars, starbursts and feedback into the environmental galaxies
(PPARC) £164,231 PI: L J Smith
PATT linked grant to sponsor use of ground based telescopes
(PPARC) £81,165 PI: L J Smith
Clumpiness in star-forming regions
(PPARC Advanced Fellowship) £204,563 PI: S Viti
The environment around Herbig-Haro objects: clumpiness and star formation
(Royal Society) £5,000 PI: S Viti
Chemistry in galaxies at high redshifts (Leverhulme) £112,381 PI: S Viti
Does UV processing of interstellar ices occur? (Royal Society) £4,412 PI: S Viti
Optical manipulation and metrology (PPARC) £122,617 PI: D D Walker
Automated polishing (Royal Society) £207,356 PI: D D Walker
Studentship agreement (Zeeko Ltd) £13,650 PI: D D Walker
CASE studentship (EPSRC) £44,700 PI: D D Walker
Basic Technology: Ultra precision surfaces (EPSRC) £1,568,731 PI: D D Walker
Studentship agreement (National Physical Laboratory Case) £12,930 PI: D D Walker
On-machine metrology for surface fabrication (PPARC) £298,259 PI: D D Walker
Distinguishing modifications of gravity from Dark Energy
(Nuffield Foundation) £4,800 PI: J Weller
Perinatal events in Astronomy (PPARC) £4,215 PI: D A Williams
Massive star astrophysical fundamental properties (PPARC) £85,293 PI: A J Willis

High Energy Physics

The High Energy Physics group at UCL undertakes world-class research across a broad range of experimental and theoretical areas of particle physics. Dr. Chris Smith describes UCL's involvement with the MINOS Experiment at Fermilab which went live during 2006.

The MINOS experiment (Main Injector Neutrino Oscillation Search), initially conceived over 10 years ago, has this year published its first results on the properties of neutrinos from the NuMI beamline (Neutrinos from the Main Injector). The construction, installation and commissioning of the detectors and beamline finished in April 2005. A rapid understanding and analysis of the data has allowed the collaboration to produce world competitive results based only on the first year of NuMI beam running. UCL physicist Prof Jenny Thomas spearheaded the first MINOS analysis and led the collaboration-wide effort to produce the first publication.

The experiment begins with the NuMI beamline, part of the accelerator complex at Fermilab in the USA, which produces the highest intensity neutrino beam in the world. A beam of 120 GeV protons extracted from Fermilab's Main Injector accelerator are focussed onto a thin graphite target. The resulting interactions produce many secondary particles which are focussed using two magnetic horns and the decay of these particles then produces the neutrino beam. Figure 1 is a photograph of one of the two magnetic horns used to focus the secondary particles from the target.

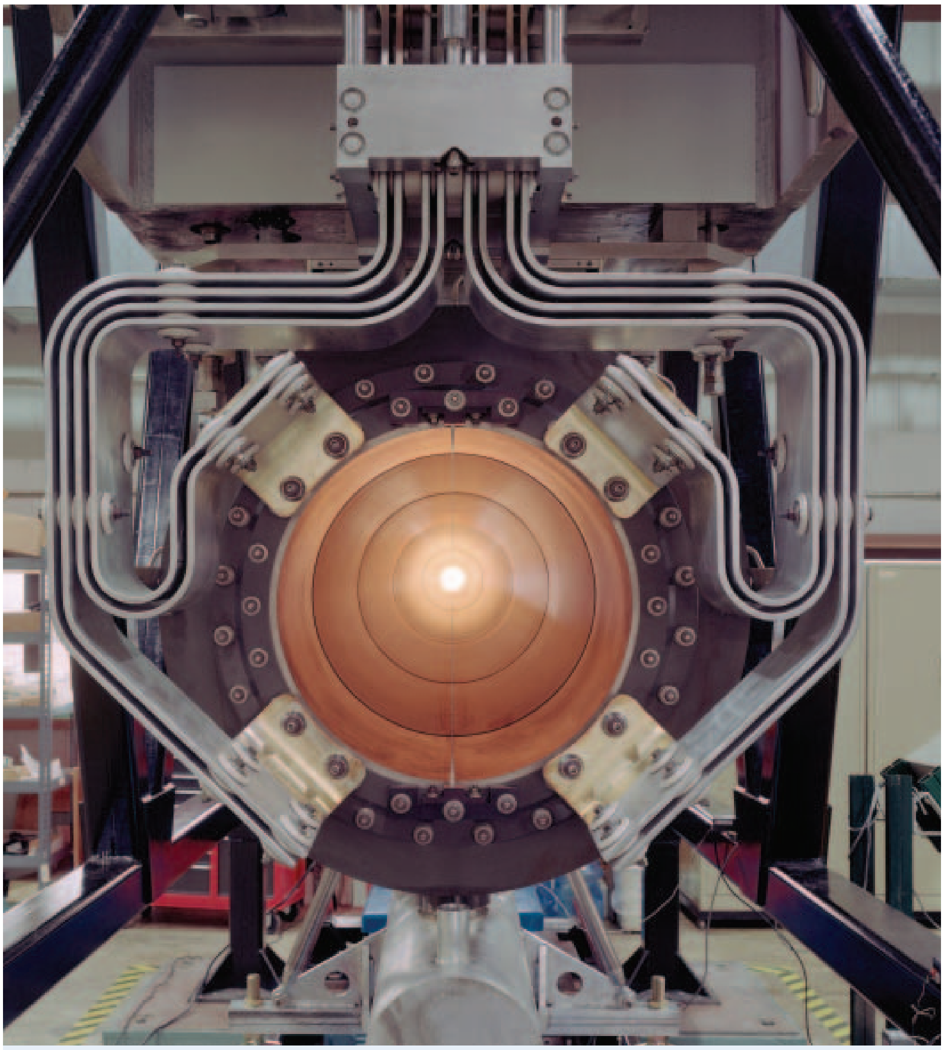

Figure 1. *One of the two magnetic focussing horns used to produce the neutrino beam at the MINOS experiment.*

The MINOS experiment uses two detectors constructed in the line of sight of the beam to measure fundamental properties of the neutrinos. The first detector, the 980 ton Near detector, is located on the Fermilab site at a distance of 1 km from the beam production point. This detector is designed to make precise measurements of the neutrinos just after they have been produced and collects data on thousands of neutrino interactions every day. The 5.4 kton Far detector is located 735 km away in the Soudan Underground Laboratory in Northern Minnesota, USA and is shown in Figure 2. This detector was constructed to probe the curious nature of neutrino oscillations – the ability of a neutrino to change its "flavour" as it propagates. By measuring the neutrino beam at the Far detector and comparing with the measurements made at the Near detector, the MINOS experiment can conclusively say whether or not the neutrinos have indeed changed flavour during their flight.

The primary MINOS measurement makes use of Charged Current (CC) neutrino interactions of the "muon" flavoured neutrinos that dominate the composition of the beam at production. A diagram of a muon neutrino CC interation with a nucleon is shown in Figure 3 (left) and is typified by the exchange of a charged W boson. The final products of the interaction are a spray of hadronic particles from the nucleon and a muon. Muons are easily identifiable in the MINOS detectors and appear as long, narrow "tracks" as can be seen in Figure 3 (right). The spray of hadronic particles can be identified as the cluster of hits at the track vertex. The characteristic long track is only produced in CC interactions of muon neutrinos. If another neutrino flavour interacts (an electron or tau neutrino), a different hit pattern is observed in the detector. Given that the beam is initially dominated by muon neutrinos, a disappearance of this flavour of neutrino at the Far detector relative to the number observed at the Near detector,

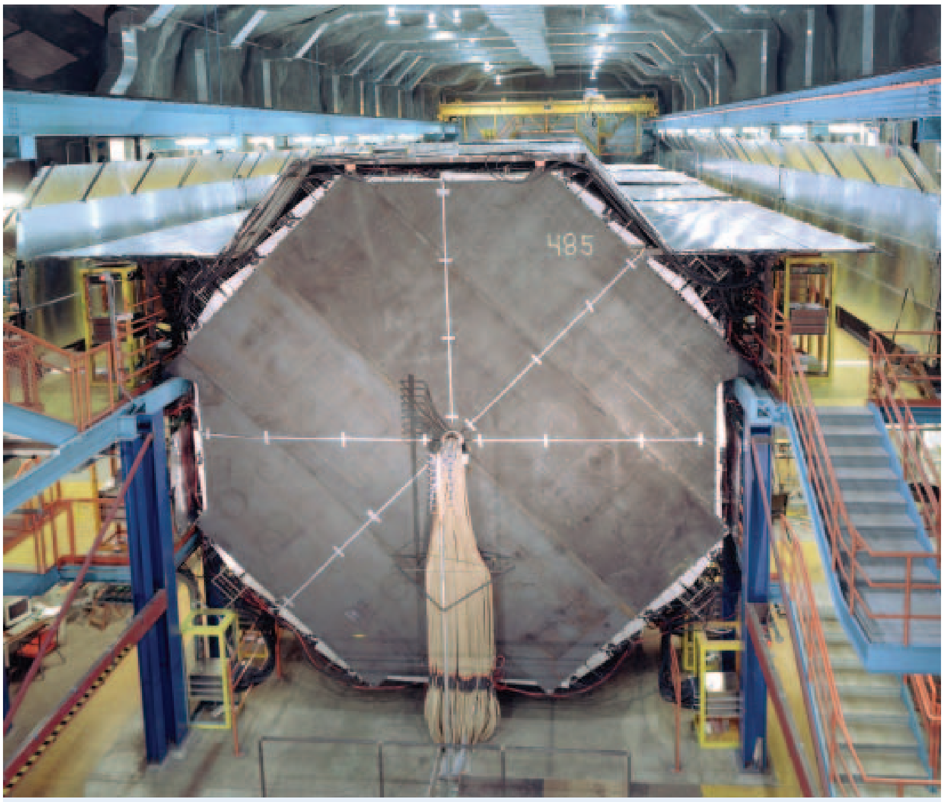

Figure 2. *The MINOS Far Detector located half a mile underground in the Soudan Laboratory, Minnesota, USA.*

would then indicate oscillations. Furthermore, looking at the dependence of muon neutrino disappearance on the energy of the neutrinos allows us to make fundamental measurements of their properties.

However, turning the raw data into measurements of fundamental parameters requires an enormous amount of effort on several fronts and UCL physicists continue to be involved at every stage. From working on the accelerator complex to ensure that the neutrino beam is well controlled and as intense as possible; to striving to fully understand the neutrino composition of the beam at production by studying the Near detector data. From working on the algorithms used reconstruct the hit patterns observed in the raw data in order to identify the final interaction products (as described in Figure 3) and finally to identifying and developing viable analysis techniques for extracting the fundamental oscillation parameters. UCL physicists played important roles in each of these areas for the first analysis and contributed significantly to the resulting paper.

The measurement reported in the paper is summarized in Figure 4 which shows the results from MINOS compared to previous experiments. It shows a range of possible values for two of the fundamental oscillation parameters: $\sin^2 2\theta_{23}$ and $|\Delta m^2_{32}|$. The area enclosed within the lines, or contours, represents the range of values that the experiment considers favourable. This area will reduce with more data and with more experiments, and the favourable region will eventually close in on the true values in nature. Over the next few years, as MINOS continues to collect data, UCL will continue to play a strong role in the oscillation analyses and will also begin making other important measurements with the large amount of neutrino interaction data in the Near detector. The MINOS measurements will soon become the best in the world and will help guide the next generation of experiments seeking to unravel the mysteries of the neutrino.

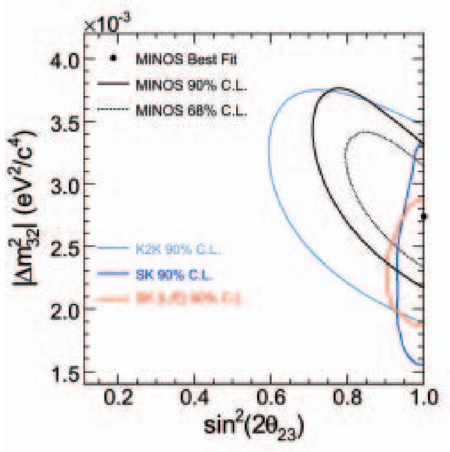

Figure 4. *The final measurement from the first year of MINOS data taking with the NuMI beam. The area within the black contours represents the most favourable values for the oscillation parameters: $\sin^2 2\theta_{23}$ and $|\Delta m^2_{32}|$. The other coloured lines represent the same measurement for previous experiments. MINOS is competitive with these after only 1 year of NuMI beam running.*

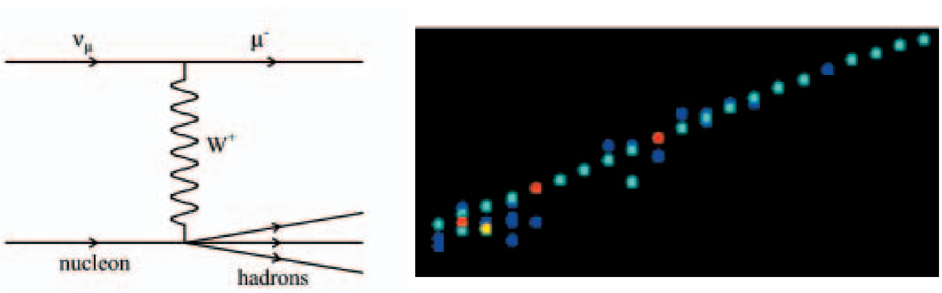

Figure 3. *Left: a Feynman diagram showing the interaction of a muon neutrino with a nucleon. Right: the final products of the interaction are a muon, which is easily identifiable as a long track in the detector; and a spray of hadronic particles, which are observed as a cluster of hits close to the track vertex (at the left end of the track).*

Publications

1. **ACoRNE (a)** Signal processing for acoustic neutrino detection in water, ice and salt, ACoRNE Collaboration, *Int J Mod Phys A 21S1:75-86 (2006)* **(b)** ACoRNE simulation work, ACoRNE Collaboration, *Int J Mod Phys A 21S1:207-211 (2006)*
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3. **CDF (a)** Observation of B0(s) – anti-B0(s) Oscillations, CDF Collaboration, *[hep-ex/0609040] Fermilab-Pub-06-344-E (2006) 9p.* **(b)** Measurement of the t anti-t Production Cross Section in p anti-p collisions at s**(1/2) = 1.96-TeV using Lepton + Jets Events with Jet Probability b-tagging, CDF Collaboration, *[hep-ex/0607035] Fermilab-Pub-06-247-E (2006) 45p.* **(c)** Data processing model for the CDF experiment, CDF – Run II, *[physics/0606042] Fermilab-Pub-06-169-CD-E (2006) 12p.* **(d)** Measurement of the tanti-t Production Cross Section in p anti-ptnipbar Collisions at s**(1/2) = 1.96-TeV, CDF Collaboration, *Phys Rev Lett 97:082004 (2006) [hep-ex/0606017]* **(e)** Search for excited and exotic muons in the mu gamma decay channel in p anti-p collisions at s**(1/2) = 1.96-TeV, CDF Collaboration, *[hep-ex/0606043] Fermilab-Pub-06-186-E (2006) 7p.* **(f)** Measurement of the ratio of branching fractions B(D0 —-> K+ pi–) / B(D0 —-> K– pi+) using the CDF II Detector, CDF 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**(l)** Search for high-mass resonances decaying to e mu in p anti-p collisions at s**(1/2) = 1.96-TeV, CDF Collaboration, *Phys Rev Lett 96:211802 (2006) [hep-ex/0603006]* **(m)** Measurement of the B+(c) meson lifetime using B+(c) —-> J/psi e+ nu(e), CDF Collaboration, *Phys Rev Lett 97:012002 (2006) [hep-ex/0603027]* **(n)** Measurement of the t anti-t production cross section in p anti-p collisions at s**(1/2) = 1.96-TeV using missing E(T) + jets events with secondary vertex b-tagging, CDF Collaboration, *Phys Rev Lett 96:202002 (2006) [hep-ex/0603043]* **(o)** Observation of B0(s) —-> psi(2S)phi and measurement of ratio of branching fractions B(B0(s) —-> psi(2S)phi) / B(B0(s) —-> J/psi phi), CDF Collaboration, *Phys Rev Lett 96:231801 (2006) [hep-ex/0602005]* **(p)** Measurement of the top quark mass using template methods on dilepton events in p anti-p collisions at s**(1/2) = 1.96-TeV, CDF Collaboration, *Phys Rev D 73:112006 (2006) [hep-ex/0602008]* **(q)** Search for Z' —-> e+ e- using dielectron mass and angular distribution, CDF Collaboration, *Phys Rev Lett 96:211801 (2006) [hep-ex/0602045]* **(r)** Measurement of sigma(Lambda(b)0) / sigma(anti-B 0) x B(Lambda0(b) —-> Lambda+(c) pi-) / B(anti-B0 —-> D+ pi-) in p anti-p collisions at S**(1/2) = 1.96-TeV, CDF Collaboration, *[hep-ex/0601003] Fermilab-Pub-05-574-E (2006) 7p.* **(s)** Measurement of the top quark mass with the dynamical likelihood method using lepton plus jets events with b-tags in p anti-p collisions at s**(1/2) = 1.96-TeV, CDF Collaboration, *Phys Rev D 73:092002 (2006) [hep-ex/0512009]* **(t)** Search for H —-> b anti-b produced in association with W bosons in p anti-p collisions at s**(1/2) = 1.96-TeV, CDF Collaboration, *Phys Rev Lett 96:081803 (2006) [hep-ex/0512051]* **(u)** Search for second-generation scalar leptoquarks in p anti-p collisions at s**(1/2) = 1.96-TeV, CDF Collaboration, *Phys Rev D 73:051102 (2006) [hep-ex/0512055]* **(v)** Measurement of the inclusive jet cross section using the k(T) algorithm in p anti-p collisions at s**(1/2) = 1.96-TeV, CDF II Collaboration, *Phys Rev Lett 96:122001 (2006) [hep-ex/0512062]* **(w)** Search for anomalous semileptonic decay of heavy flavor hadrons produced in association with a W boson at CDF II, CDF Collaboration, *Phys Rev D 73:051101 (2006) [hep-ex/0512065]* **(x)** Measurement of mass and width of the excited charmed meson states D0(1) and D*0(2) at CDF, CDF Collaboration, *Phys Rev D 73:051104 (2006) [hep-ex/0512069]* **(y)** Top quark mass measurement from dilepton events at CDF II, CDF Collaboration, *Phys Rev Lett 96:152002 (2006) [hep-ex/0512070]* **(z)** A Search for scalar bottom quarks from gluino decays in anti-p p collisions at s**(1/2) = 1.96-TeV, CDF Collaboration, *Phys Rev Lett 96:171802 (2006) [hep-ex/0512072]* **(aa)** Measurement of the dipion mass spectrum in X(3872) —-> J/psi pi+ pi- decays, CDF Collaboration, *Phys Rev Lett 96:102002 (2006) [hep-ex/0512074]* **(bb)** Measurement of the helicity of W bosons in top-quark decays, CDF-Run II, *Phys Rev D 73:111103 (2006) [hep-ex/0511023* **(cc)** Determination of the jet energy scale at the collider detector at Fermilab, A Bhatti, et al., *Nucl Instrum Meth A 566:375-412 (2006) [hep-ex/0510047]* **(dd)** Top quark mass measurement using the template method in the lepton + jets channel at CDF II, CDF Collaboration, *Phys Rev D 73:032003 (2006) [hep-ex/0510048]* **(ee)** Precision top quark mass measurement in the lepton + jets topology in p anti-p collisions at s**(1/2) = 1.96-TeV, CDF Collaboration, *Phys Rev Lett 96:022004 (2006) [hep-ex/0510049]* **(ff)** A Search for t —-> tau nu q in t anti-t production, CDF Collaboration, *Phys Lett B 639:172 (2006) Phys Lett B 639: 172-178 (2006) [hep-ex/0510063]* **(gg)** Search for charged Higgs bosons from top quark decays in p anti-p collisions at s**(1/2) = 1.96-TeV, CDF Collaboration, *Phys Rev Lett 96:042003 (2006) [hep-ex/0510065]* **(hh)** Direct search for Dirac magnetic monopoles in p anti-p collisions at s**(1/2) = 1.96-TeV, CDF Collaboration, *Phys Rev Lett 96:201801 (2006) [hep-ex/0509015]* **(ii)** Measurement of the ratios of branching fractions B(B(s)0 —-> D(s)- pi+) / B(B0 —-> D- pi+) and B(B+ —-> anti-D0 pi+) / B(B0 —-> D- pi+), CDF Collaboration, *Phys Rev Lett 96:191801 (2006) [hep-ex/0508014]* **(jj)** Measurement of b hadron masses in exclusive J/psi decays with the CDF detector, CDF Collaboration, *Phys Rev Lett 96:202001 (2006) [hep-ex/0508022]* **(kk)** Search for neutral MSSM Higgs bosons decaying to tau pairs in p anti-p collisions at s**(1/2) =1.96-TeV, CDF Collaboration, *Phys Rev Lett 96:011802 (2006) [hep-ex/0508051]* **(ll)** Search for W and Z bosons in the reaction anti-p p —-> 2 jets + gamma at s**(1/2) = 1.8-TeV, CDF Collaboration, *Phys Rev D 73:012001 (2006) [hep-ex/0507051]*
4. **eScience (a)** GridPP: Development of the UK computing Grid for particle physics, GridPP Collaboration, *J Phys G 32:N1-N20 (2006)* **(b)** HepData and JetWeb: HEP data archiving and model validation, A Buckley, et al., *[hep-ph/0605048] (2006) 4p.* **(c)** HepForge: A Lightweight development environment for HEP software, A Buckley, et al., *[hep ph/0605046] (2006) 3p.* **(d)** HZTool and Rivet: Toolkit and Framework for the Comparison of Simulated Final States and Data at Colliders, B M Waugh, et al., *[hep-ph/0605034] (2006) 4p.* **(e)** A Standard format for Les Houches event files, J Butterworth, et al., *[hep-ph/0609017] Fermilab-Pub-06-337-T (2006) 8p.*
5. **Linear Collider (a)** Data acquisition in the EUDET project, M Wing and J Mnich *[physics/0608090] LCWS 2006, Bangalore, March 2006.* **(b)** A scintillator tile hadron calorimeter for the Linear Collider detector, CALICE Collaboration, *Nucl Phys Proc Suppl 150:248-252 (2006)* **(c)** The scintillator tile hadronic calorimeter prototype, CALICE Collaboration, *Nucl Phys Proc Suppl 150:253-256 (2006)* **(d)** Status report on silicon photomultiplier development and its applications, Calice/SiPM Collaboration, *Nucl Instrum Meth A 563:368-376 (2006)*
6. **MINOS (a)** Ramifications of intranuclear re-scattering in MINOS, M Kordosky, *Nucl Phys Proc Suppl 159:223-228 (2006) [hep-ex/0602029]* **(b)** The MINOS calibration detector, P Adamson, et al., *Nucl Instrum Meth A 556:119-133 (2006)* **(c)** First observations of separated atmospheric nu(mu) and anti-nu(mu) events in the MINOS detector, MINOS Collaboration, *Phys Rev D 73:072002 (2006) [hep-ex/0512036]*
7. **NEMO (a)** Measurement of double beta decay of 100Mo to excited states in the NEMO 3 experiment, R Arnold, et al., *[hep-ex/0609058] (2006) 23p.* **(b)** Limits on different Majoron decay modes of Mo-100 and Se-82 for neutrinoless double beta decays in the NEMO-3 experiment, NEMO Collaboration, *Nucl Phys A 765:483-494 (2006) [hep-ex/0601021]*
8. **OPAL (a)** QCD coherence and correlations of particles with restricted momenta in hadronic Z decays, OPAL Collaboration G Abbiendi, *Phys Lett B 638:30-38 (2006) [hep-ex/0604003]* **(b)** Measurement of the Strong Coupling alpha(s) from four-jet observables in e+ e- annihilation, OPAL Collaboration, *Eur Phys J C 47:295-307 (2006) [hep-ex/0601048]* **(c)** Determination of alpha(s) using jet rates at LEP with the OPAL detector, OPAL Collaboration, *Eur Phys J C 45:547-568 (2006) [hep-ex/0507047]* **(d)** Searches for gauge-mediated supersymmetry breaking topologies in e+ e- collisions at LEP2, OPAL Collaboration, *Eur Phys J C 46:307-341 (2006) [hep-ex/0507048]* **(e)** Measurement of the mass and width of the W boson, OPAL Collaboration, Eur Phys J C 45:307-335 (2006) [hep-ex/0508060] **(f)** Colour reconnection in e+ e- —-> W+ W- at s**(1/2) = 189-GeV – 209-GeV, OPAL Collaboration, *Eur Phys J C 45:291-305 (2006) [hep-ex/0508062]* **(g)** Measurement of the running of the QED coupling in small-angle Bhabha scattering at LEP, OPAL Collaboration, *Eur Phys J C 45:1-21 (2006) [hep-ex/0505072]*
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Active Grants and Contracts

Studentship agreement (Argonne Laboratories) £45,500 PI: J Butterworth
Studentship agreement (Argonne Laboratories) £19,718 PI: J Butterworth
CEDAR: Combined eScience data analysis resource for high energy physics (PPARC) £326,408 PI: J Butterworth
Experimental high energy physics research at UCL (PPARC) £3,448,534 PI: J Butterworth
Exploring beyond the standard model Physics with the ATLAS experiment at the LHC (PPARC) £210,218 PI: A Barr
Preparation for and measurement of new physics processes using the ATLAS experiment at the LHC (PPARC) £459,243 PI: C Gwenlan
Core software development for the physics exploitation of the ATLAS detector at the LHC (PPARC) £412,558 PI: N Konstantinidis
Laser interactions with high brightness electron beams (CCLRC Studentship) £12,285 PI: N Konstantinidis
ARTEMIS – Investigation of the electroweak symmetry breaking and the origin of mass using the first data of ATLAS detector at LHC (EU) £228,960 PI: N Konstantinidis
ESLEA: Exploitation of switched lightpaths for Escience applications (EPSRC via Edinburgh University) £134,810 PI: M Lancaster
Experimental high energy particle physics research at UCL (PPARC) £5,724,080 PI: M Lancaster
The linear collider beam delivery system (PPARC) £192,623 PI: D J Miller
Employment of a Research Assistant to work on the Linear Collider ABD programme work package 4BPM/spectrometry (CCLRC) £70,000 PI: D J Miller
Accelerator Science Programme, work package 2.1 (CCLRC) £20,000 PI: D J Miller
European Design Study towards a Global TeV Linear Collider (EUROTeV) (EC) £81,270 PI: D J Miller
Investigating neutrino oscillations with MINOS and neutrino astronomy with ANITA (Royal Society) £262,445 PI: R Nichol
QCD phenomenology at hadron colliders and an improved measurement of the top quark mass (PPARC) £104,556 PI: E Nurse
Measurements of the neutrino mass spectrum with oscillation and double beta decay experiments (PPARC) £236,269 PI: R Saakyan
Design study of the SuperNEMO experiment (PPARC) £753,999 PI: R Saakyan
Studying neutrino oscillations with the MINOS experiment (PPARC) £115,437 PI: C B Smith
Development of the ZEUS global tracking trigger at HERA and the ATLAS level 2 trigger for the LHC (PPARC) £225,125 PI: M Sutton
ILIAS – Integrated large infrastructures for astroparticle science (EC) £12,096 PI: J Thomas
Construction, Calibration and Exploitation of the MINOS experiment (PPARC) £9,426 PI: J Thomas
NEMO III Exploitation (PPARC) £52,741 PI: J Thomas
Establishment of a new HEP/SS facility for construction of large HEP and SS projects (PPARC) £251,152 PI: J Thomas
Global fits for Parton distributions and implications for hadron collider physics (PPARC) £150,676 PI: R Thorne
University research fellowship (Royal Society) £113,952 PI: R Thorne
Electroweak physics and Higgs searches at the CDF experiment (Royal Society University Fellowship) £159,768 PI: D S Waters
GridPP Tier-2 support (PPARC) £42,244 PI: B Waugh
Precise determination of beam energies at a future linear collider (Nuffield Foundation) £5,000 PI: M Wing
CALICE: Calorimetry for the International Linear Collider (PPARC) £138,596 PI: M Wing
Studentship agreement (DESY) £25,151 PI: M Wing
EUDET – Detector Research and Development towards the International Linear Collider (EC) £194,230 PI: M Wing

Physics and Astronomy PhD Degrees Awarded in 2006

Robert Barber A high-accuracy synthetic water line list: computation and applications (Supervisor Prof J Tennyson)
Robert Bastin Recombination processes in ionised plasmas (Supervisor Prof P Storey)
Thomas Bell Photon-Dominated Regions: Development of a time-dependent model and application to astrophysical problems (Supervisor Dr S Viti)
Ben Cooper A Measurement of the Production of Jets in Association with a W Boson in Proton-Antiproton Collisions at the Tevatron using Data Collected with the CDF Experiment (Supervisor Dr D Waters)
Janice Drohan An Investigation of the Higgs Boston Production Channel ttH,H->bb with the ATLAS detector at the LHC (Supervisor Dr N Konstantinidis)
Joseph Gittings Quantifying entanglement of overlapping indistinguishable particles (Supervisor Prof A Fisher)
Gwang Ok Hur Chaotic Hamiltonian ratchets and filters with optical lattices: properties of Floquet states (Supervisor Prof T Monteiro)
Leo Jenner Measurement of Muon dE/dX at the MINOS Calibration Detector and Neutrinoless double beta decay in NEMO-3 (Supervisor Prof J Thomas)
Sarah Kendrew Lightweight deformable optics for ground and space- based imaging systems (Supervisor Dr P Doel)
Yee-Ting Li An investigation into transport protocols and data transport applications over high performance networks (Supervisor Prof P Clarke)
Christopher Lintott Analysis of the early stages of star formation (Supervisor Prof J Rawlings)
Henrik Melin Comparative Aeronomy of the Upper Atmospheres of the Giant Planets (Supervisor Prof S Miller)
James Munro States near dissociation in H_3^+ (Supervisor Prof J Tennyson)
Samantha Searle Spectroscopic analysis of atmospheres and winds of B supergiant stars (Supervisor Dr R Prinja)
Christopher G A Smith Modelling the upper atmospheres of the gas giant planets (Supervisor Prof A Aylward)
Christopher Targett-Adams Dijet Photoproduction and the structure of the proton with the ZEUS detector (Supervisor Prof J Butterworth)
Sarah Watson Femtosecond laser interactions with dilute matter (Supervisor Prof R Newell)

Atomic, Molecular, Optical and Positron Physics

The Atomic, Molecular, Optical and Positron Physics (AMOPP) group explores many different topics in atomic and molecular physics. The group includes theoretical activity on atoms and molecules of astronomical interest, experimental and theoretical studies on scattering of positrons and positronium off atoms and molecules, and experimental studies using high intensity lasers. Ultracold atoms and molecules, and activity at the borderline between physics and life science also forms major research directions of the group. In this review, Dr. Sougato Bose and Prof. Tania Monteiro describe their theoretical research activities in the areas of quantum information and computation, foundations of quantum physics and the coherent control of atoms and spin waves in external fields.

Quantum Information and Computation:

Quantum Computers, when realized, hold the promise of speeding up the solution of certain problems perceived as difficult on a classical computer, and particularly enabling the controlled simulations of the behaviour of complex many-body quantum systems. In the foreseeable future, one expects the size of individual quantum computers to be rather limited due to fundamental obstacles, and identifying viable ways to connect and network such computers to enhance their effective computational power has a high technological incentive. Much work performed in 2006 by the group of Dr. Bose and their collaborators has been driven by this motivation. For example, a new way of accomplishing a quantum logic gate involving atoms trapped in two distant optical cavities have been proposed in which the cavities are simply connected by optical fibers. This can enable networking distant atomic quantum computers. A reversal of the setting, in which the distant computers may be light based (light stored in cavities), while atoms flying between them connect these computers have also been investigated. How a mobile electronic spin in a mesoscopic conductor can aid in networking quantum computers based on distant static spins have also been explored this year. The fiber connected cavity and mobile electronic networking methods are depicted in Fig. 1.

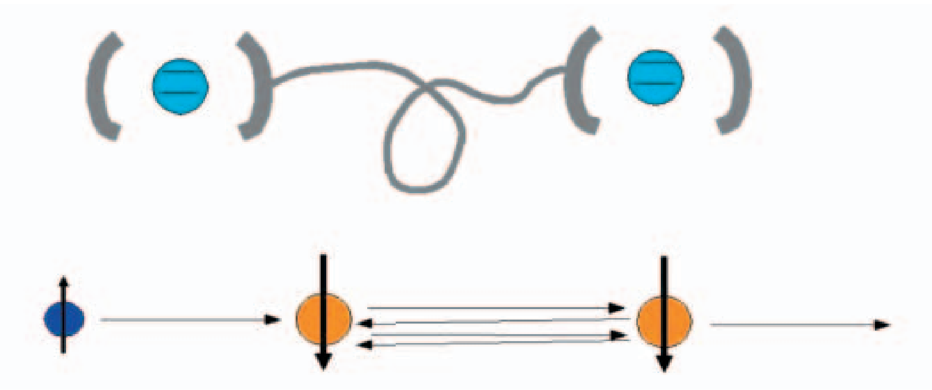

Figure 1. *Two distinct methods of networking separated quantum processors. The first one connects distant atoms by an optical fibre, while the second correlates (or entangles) two static spins in a mesoscopic conductor through the scattering of a mobile electronic spin.*

Another way of networking quantum computers, namely using spin chains as quantum wires, has been a topic of central interest for quite a few years. A spin chain is a permanently coupled 1D system of spins. When one places a quantum state on one end of it, the state will be dynamically transmitted to the other end with some efficiency if the spins are coupled by an exchange interaction. No external modulations or measurements on the body of the chain, except perhaps at the very ends, is required for this purpose. The principal motivation is in connecting quantum registers without resorting to optics. In this context, Dr. Bose and his student Daniel Burgarth explored how an environment of other spins in which such chains will be unavoidably immersed, will affect the quality of networking through such chains. The model studied was solvable using only pen and paper, and yet gave some insight into the delay and destabilization of networking caused by such an environment.

Spin chains can accomplish much more for quantum computing than merely acting as quantum wires. This has become clear this year through a collaboration with Oxford. Particularly, such spin chains can be used as a processor core for a quantum computer (a Quantum CPU or a "Pentium Q" as has been claimed in the coverage of this work in popular media) onto which information needing to be processed are loaded and unloaded for running certain important classes of algorithms. A figure of this architecture for a quantum computer is depicted in Fig. 2.

Foundations of Quantum Mechanics:

One of the fundamentally motivated interests of Dr. Bose's group is in exploring the limits of validity of quantum mechanics. Mesoscopic systems have been shown to behave quantum mechanically in series of audacious experiments elsewhere in the world. Can we do the same for more macroscopic systems? One method, namely by coupling a microscopic and a mesoscopic system to probe the quantum nature of the latter, remains largely unexplored and unexploited. Work by Dr. Bose has now shown how this is possible in at least two distinct settings, namely that of a LCR circuit coupled to a superconducting quantum bit, and the motion of ions coupled to their internal levels, even when the macroscopic system is at a finite temperature. These schemes are depicted in Fig. 3. Another activity in this direction is that of designing a scheme to entangle or quantum mechanically correlate a pair of nano-scale mechanical oscillators and verify this entanglement by a novel "teleportation" of a superconducting quantum bit.

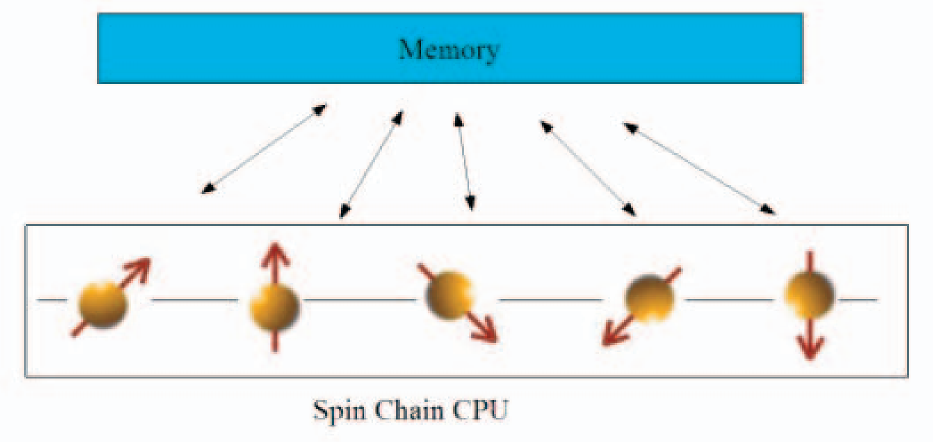

Figure 2. *Architecture of a quantum computer with a spin chain as a CPU (central processing unit).*

Coherent control of cold atoms and spin waves with external fields

The theory of these processes is studied by Prof. Monteiro's group. The dynamics of physical systems subjected to forces which oscillate or vary periodically with time can be different, in unexpected and even counter-intuitive ways, from the behavior encountered if monotonically varying forces are applied. In particular, for time-periodic fields, new types of quantum states (sometimes called Floquet states) determine the quantum dynamics. Their applications in the new fields of cold atom physics and quantum information are largely unexplored.

For example, for cold atoms subjected to periodic pulses from optical lattices, the Floquet states have a similar, distinctive sharply peaked profile as the quantum states of electrons in a disordered conductor (which is known as Anderson localization). The cold atom equivalent involves no randomness or disorder; nevertheless there is a formal mathematical analogy in the equations of motion hence the name "dynamical Anderson localization" applied to the behavior of the driven cold atoms. This has been investigated experimentally by several cold atom groups world-wide. At UCL, a variant of this experiment,driving atoms with pairs of closely-spaced pulses, revealed a novel staircase structure for the quantum states which is shown in Fig. 4. It was also found that the localization length of the states has a fractional power-law scaling (unlike ordinary dynamical localization which has an integer scaling). Together with collaborators in Singapore, the USA and Israel we are currently investigating the origin of this behavior.

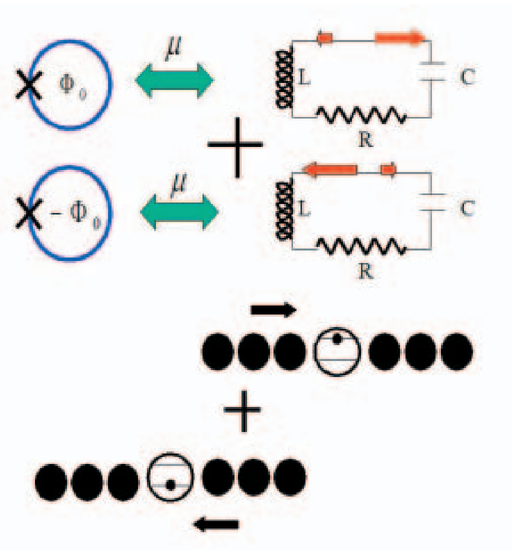

Figure 3. *Two settings in which the validity of quantum mechanics in the macroscopic limit can be explored. In the first, a superconducting qubit is used to explore the quantum nature of a LCR circuit. In the second, the internal levels of a trapped ion is used to explore the quantum nature of the motional state of several trapped ions.*

One effect of the time-dependent driving of the system is to make the corresponding dynamics chaotic. Although a quantum system can only exhibit chaotic behavior for a short time, valuable insights on its dynamics can sometimes be obtained by investigating a hypothetical classical particle exposed to similar forces; typically the quantum behavior (if the classical limit is chaotic) differs sharply from the regular classical limit. Some of these issues are of basic interest within the research area of 'quantum chaos'. They are also of potential practical interest by providing possible new ways of manipulating quantum states.

This year, the quantum dynamics group,in collaboration with the quantum information group has also been exploring possible means of exploiting Floquet states for preparing or transmitting single-flips of a quantum spin along a spin chain. We investigated a well-studied type of spin chain (the Heisenberg ferromagnet) subjected to a periodically pulsed magnetic field which varies quadratically along the length of the chain. It was found that the form of the time evolution operator of the quantum states has a close analogy with cold-atom forms which yields dynamical Anderson localization in the Floquet states. The key insight of the work was that, although a spin-chain is a complex many-body quantum system, its dynamics has a close mathematical

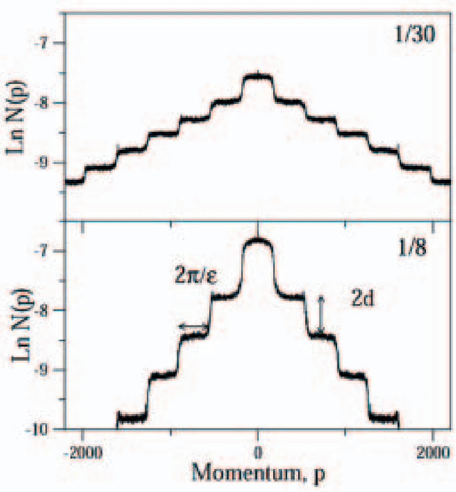

Figure 4. *Quantum states obtained for cold atoms subjected to pairs of closely spaced pulses from an optical lattice. Experiments carried out at UCL observed the first two or so steps.*

correspondence with that of a fictitious 'image' single-particle classical system. Because that image system happens to be a textbook of Hamiltonian dynamics,the "Standard Map" almost every aspect of the spin-flip's evolution is predictable. It was shown, for example, that by tuning the field strength one can convert the spin-flip into a pair of counter-propagating coherent states which hop along the chain without dispersion *(Fig. 5)*.

We are extending this to consider ways of manipulations the propagation of spin-waves in periodically-driven magnetic materials. We investigated this single-flip dynamics in a pulsed parabolic field in the case of spin-ladders (or spin-chains with next-to-nearest neighbour (NNN)

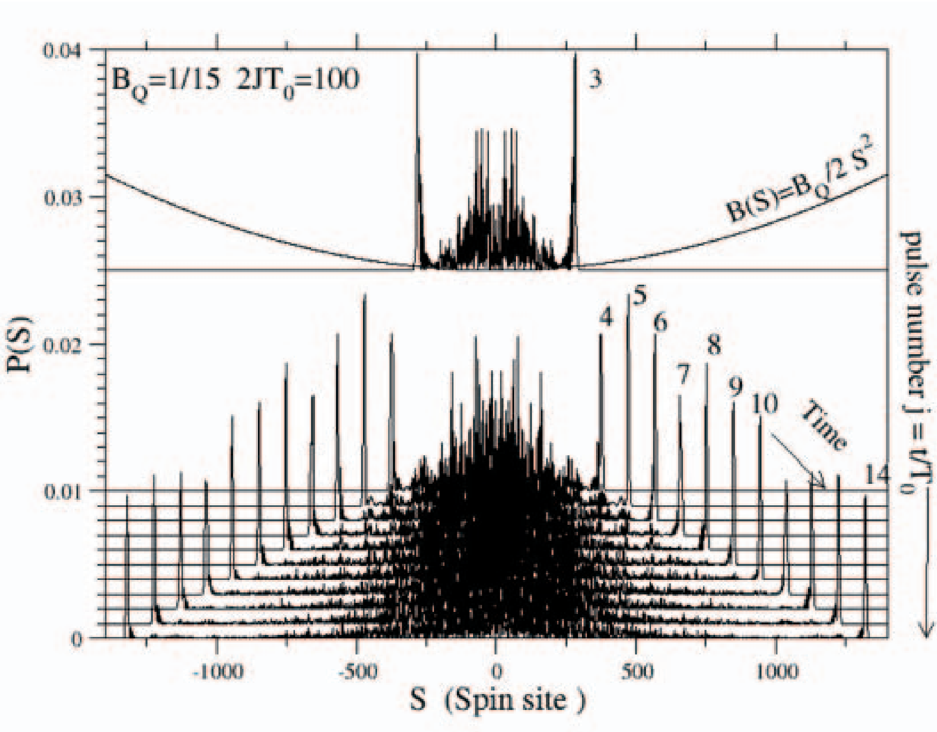

Figure 5. *Dynamics of a Heisenberg spin-chain subjected to short, regularly spaced pulses from a parabolic magnetic field. A single excitation gives rise to a pair of counter-propagating coherent pulses which move with little dispersion along the length of the chain.*

interactions). Fig. 6 shows that, for certain parameters, if the NNN is ferromagnetic, low-energy spin waves would remain trapped near the centre of the chain; if the NNN is anti-ferromagnetic the zero energy point is unstable.

One of the most important recent developments in cold atom physics has been the 2002 experimental observation with cold atoms loaded into an optical lattice, of a 'textbook' quantum phase-transition predicted by condensed matter physics: the Mott Insulator Transition (MIT). It is impossible to overstate the excitement generated by this experiment (its report has received 930 citations in four years). The MIT has been well investigated theoretically within the framework of the Bose-Hubbard Hamiltonian, which parametrizes the dynamics by a tunnelling rate (J) allowing atoms to hop between adjacent wells as well as the interaction energy between pairs of atoms (U). As the ratio J/U of the tunnelling rate between adjacent quantum wells to the on-site energy is varied, the onset of the MIT is observed: atoms localize on individual lattice sites. This permits the preparation of quantum states of much current interest and of potentially great relevance in quantum information.

Rapid experimental advances have opened the exciting possibility for studying the non-equilibrium dynamics of a quantum coherent many-body system. Our recent work investigated the effects of periodic driving on the MIT. In particular, in the lower-frequency (multiphoton) regime, a new regime was identified by us where the Mott transition may be induced by minute changes in experimental parameters. The MIT was found to be modulated by a series of sharp resonances, closely related to near-degeneracies of the underlying Floquet states.

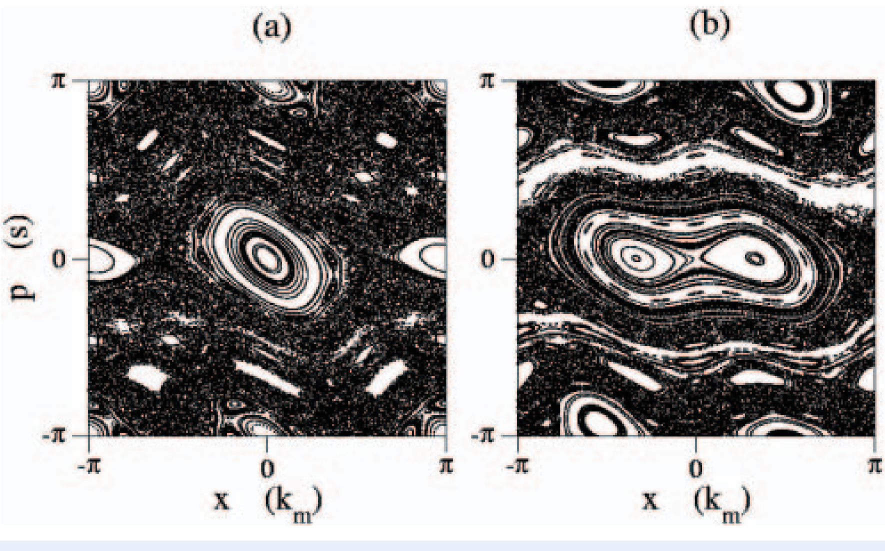

Figure 6. *For a spin-chain or spin-ladder in a pulsed magnetic field, the classical trajectories of an image one-body system can be used to predict the behavior of the spin-waves. Equilibrium points for low energy (low K) spin waves in a spin ladder, in a pulsed parabolic magnetic field. For a ferromagnetic next-to-nearest-neighbor (NNN) interaction, the low energy spin waves should remain localized near the centre of the chain inside the central 'stable island'. For an antiferromagnetic NNN interaction, the zero energy point is unstable.*

Publications

1. **A Serafini, S Mancini, S Bose** Distributed quantum computation via optical fibers, *Phys Rev Lett 96, 010503 (2006)*
2. **J Lee, M Paternostro, C Ogden, Y W Cheong, S Bose, M S Kim** Cross-Kerr-based information transfer processes, *New J Phys 8, 23 (2006)*
3. **A Serafini, M Paternostro, M S Kim, S Bose** Enhanced dynamical entanglement transfer with multiple qubits, *Phys Rev A 73, 022312 (2006)*
4. **S Bose** Qubit assisted probing of coherence between mesoscopic states of an apparatus, *Phys Rev Lett 96, 060402 (2006)*
5. **S Bose, G S Agarwal** Entangling pairs of nano-cantilevers, Cooper-pair boxes and mesoscopic teleportation, *New J Phys 8, 34 (2006)*
6. **D Burgarth, V Giovannetti, S Bose** State Transfer in Permanently Coupled Quantum Chains, *in NATO Science Series, III: Computer and Systems Sciences (Quantum Information Processing – From Theory to Experiment, D G Angelakis et.al. eds), pp 218 – 237 (2006)*
7. **J Lee, M Paternostro, M S Kim, S Bose** Entanglement reciprocation between qubits and continuous variables, *Phys Rev Lett 96, 080501 (2006)*
8. **T Boness, S Bose, T S Monteiro** Entanglement and dynamics of spin chains in periodically pulsed magnetic fields: Accelerator modes, *Phys Rev Lett 96, 187201 (2006)*
9. **M-H Yung, S C Benjamin, S Bose** Processor core model for quantum computing, *Phys Rev Lett 96, 220501 (2006)*
10. **A T Costa, S Bose, Y Omar** Entanglement of two impurities through electron scattering, *Phys Rev Lett 96, 230501 (2006)*
11. **D Burgarth, S Bose** Universal destabilization and slowing of spin-transfer functions by a bath of spins, *Phys Rev A 73, 062321 (2006)*
12. **L Sheridan, N Paunkovic, Y Omar, S Bose** Discrete time quantum walk on a line with two particles, *Int J Quantum Info 4, 573 (2006)*
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14. **M Avellino, A J Fisher, S Bose** Quantum communication in spin systems with long-range interactions, *Phys Rev A 74, 012321 (2006)*
15. **M S Tame, M Paternostro, C Hadley, S Bose, M S Kim** Decoherence-based exploration of d-dimensional one-way quantum computation: Information transfer and basic gates, *Phys Rev A 74, 042330 (2006)*
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22. **R Fulton, A I Bishop, M N Shneider, P F Barker** Creating slow cold molecules by Optical Stark Deceleration, *J Phys B: At Mol Opt Phys 39, S1097-S1109 (2006)*
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29. **H T Bookey, A I Bishop, P F Barker** Narrowband coherent Rayleigh Scattering in a Flame, *Opt Express 14, 3461-3466 (2006)*
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31. **D J Murtagh, C Arcidiacono, Z D Pesic, G Laricchia** Positronium formation from CO_2 and H_2O, *Nuclear Instruments and methods in Physics Research B, 247, 92-97 (2006)*
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33. **D J Murtagh, M Szluinska, J Moxom, P Van Reeth, G Laricchia** Positron-impact ionization and positronium formation from helium, *(vol 38, pg 3857, 2005) J Phys B: At Mol Opt Phys, 39, 1251-1251 (2006)*
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35. **W A Bryan, A J Langley, J H Sanderson, W R Newell** Observation of multiple ionization pathways for OCS in an intense laser field resolved by three dimensional covariance mapping and visualized by hierarchical ionization topology, *Phys Rev A 74, 053409 (2006)*
36. **J McKenna, M Suresh, B Srigengan, I D Williams, W A Bryan, E M L English, S L Stebbings, W R Newell, I C E Turcu, J M Smith, E J Divall, C J Hooker, A J Langley, J L Collier** Rescattering enhanced dissociation of a molecular ion, *Phys Rev A 74, 043409 (2006)*
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Active Grants and Contracts

Excited state photoengineering: Virtual crystallography – A new approach to spectroscopy, molecular dynamics and structure (EPSRC) £625,471 PI: A Bain
Control of the single molecule fluorescence cycle – A feasibility study (EPSRC) £91,927 PI: A Bain
Quantum computation and communication using spin chains and related systems (EPSRC) £97,881 PI: S Bose
Spin chain connectors, entanglement by measurements and mesoscopic quantum coherence (EPSRC) £783,478 PI: S Bose
Microstirring of complex ionic liquids with optical tweezers (Royal Society) £12,000 PI: P Jones
Positron and positronium collisions with atoms and molecules (EPSRC) £418,356 PI: G Laricchia
Theory and application of quantum ratchets in atom optics (EPSRC) £165,609 PI: T Monteiro
Short pulse laser interactions with positive atomic and molecular ions (EPSRC) £206,802 PI: W R Newell
Resonant activation and the ratchet effect in dissipative optical lattices (EPSRC) £125,788 PI: F Renzoni
Levy flights and anomalous diffusion in optical lattices (Royal Society) £6,000 PI: F Renzoni
Studying magnetic phase transitions with ultracold atoms in optical lattices (EPSRC) £57,582 PI: F Renzoni
Cooling of atoms in optical cavities by collective dynamics (EPSRC) £457,631 PI: F Renzoni
Fully three-dimensional modelling of dusty photoionised regions and their environs (PPARC) £152,303 PI: P Storey
The UK RmaX network (PPARC) £10,277 PI: P Storey
ChemReact computing consortium 2002-2005 (EPSRC) £127,902 PI: J Tennyson
Complete spectroscopy of water (INTAS) £6,300 PI: J Tennyson
Very low mass metal-poor stars (PPARC) £121,144 PI: J Tennyson
Absorption by water at near infrared and visible wavelengths (NERC) £113,748 PI: J Tennyson
Quantum states of molecules at dissociation (EPSRC) £233,896 PI: J Tennyson
QUASAAR QUAntitative Spectroscopy for Atmospheric and Astrophysical Research (EU) £123,789 PI: J Tennyson
A theoretical investigation of positron annihilation in molecules (EPSRC) £188,424 PI: J Tennyson
WWLC Weak Water Vapour Lines Contribution to the absorption of atmospheric radiation – Fellowship for Boris Voronin (EU) £102,414 PI: J Tennyson
Dynamic Imaging of Matter at the Attosecond and Angstrom Scale (EPSRC) £101,770 PI: J Tennyson
Electron Drive Processes (Quantemol Studentship) £12,930 PI: J Tennyson
International short visit: Dr Afaf Al Derzi – Graduate level training of Iraqi theorists (Royal Society) £2,570 PI: J Tennyson
Infrared and visible wavelength absorption by water vapour (NERC) £130,616 PI: J Tennyson
Low-mass star formation and evolution in the early universe (PPARC) £118,652 PI: J Tennyson
Pressure effects on the rotation-vibration spectrum of water (Dr Nina Lavrentieva) (Royal Society) £4,162 PI: J Tennyson
Continuum states of carbon monoxide (Dr K Chakrabarti) (Royal Society) £4,162 PI: J Tennyson
An opacity function for ammonia (Leverhulme Trust) £59,480 PI: J Tennyson
Positron scattering from molecules at low energies using R-matrix method (Royal Society) £15,820 PI: J Tennyson
Electron initiated chemistry in biomolecules (EPSRC) £375,728 PI: J Tennyson
Dr Olga Naumenko – Line assignment for water vapour and its isotopic species at visible wavelengths (Royal Society) £4,162 PI: J Tennyson
CAVIAR (NERC) £396,342 PI: J Tennyson

Condensed Matter and Materials Physics

The work of the group covers an enormous range of activities, both experimental and theoretical, in the physics of the condensed phase. Below Dr. Andrew Horsfield describes one project, performed jointly with Prof. Marshall Stoneham, to determine the physical basis of smell, which got extensive coverage in 2006 including an editorial review in Nature.

The basic mystery of smell is the mechanism by which molecules are recognized by the receptors: in other words, how odor character is written into the molecule. There have been for decades two contending theories of odor: one says that it is determined by molecular shape, the other by molecular vibrations. The vibration idea gradually fell out of favour as molecular recognition in biology often relied on lock and key fit, i.e. molecular shape. And more importantly, it was never clear how a receptor protein could act as a vibrational spectroscope. In 1996 Dr. Luca Turin, then at UCL, controversially revived vibration theory, suggesting that olfactory receptor proteins used inelastic electron tunneling spectroscopy (IETS) to probe molecular vibrations. Our fuller theory tests this idea with a simplified model of an idealised receptor protein *(see Fig. 1)*.

In the receptor is a molecular unit that can bind an electron *(D in Fig. 1)*. When no odorant is present, the electron cannot tunnel through the intervening barrier to another molecular unit *(A in Fig. 1)*, largely because energy would not be conserved. The odorant binds to the protein in the physical location of the energy barrier, and the electron then tunnels through the odorant. Though the odorant molecule carries no net charge, the different chemical properties of its constituent atoms give each atom a small partial charge. When the electron sits in either D or A, the electric field it creates deforms the odorant by pulling and pushing on partial atomic charges according to their sign. When the electron tunnels across the odorant from D to A, it does so very quickly compared to atom movements, and the forces acting on the odorant molecule are suddenly released. This is equivalent to the plucking action of a finger on a guitar string. Only if the energy difference between D and A corresponds to the energy of a vibrational mode of the molecule, and only if the deformation caused by the charge matches the atom motions of that mode well enough, the vibration will be excited by the tunneling event and the electron can lose the right amount of energy to the vibration and thus tunnel across. Thus the receptor can detect the molecular vibrations of a bound odorant. This electron transfer actuates the receptor and initiates a signal to the brain. For the mechanism to work, the molecule must fit well enough, but it is the molecular vibrations that determine whether the receptor responds: more like a swipe card than a lock and key.

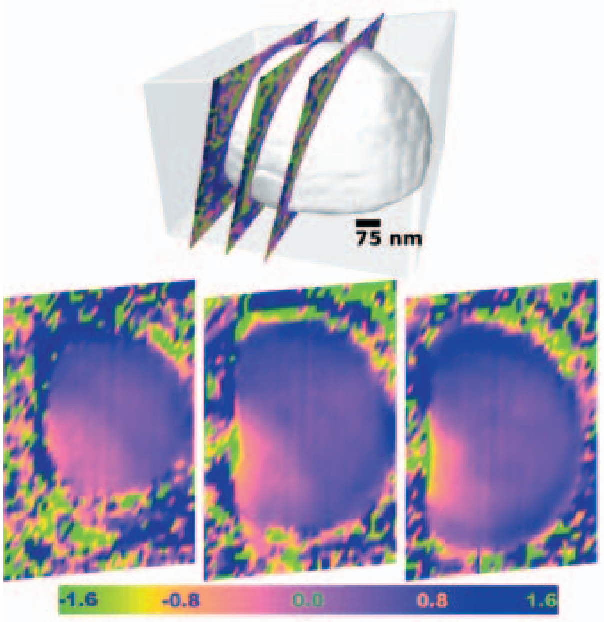

Figure 2. *Slices through the lead nanocrystal coloured according to the phase of the scattering material at each point. The patch of phase at the base of the crystal is caused by internal strain.*

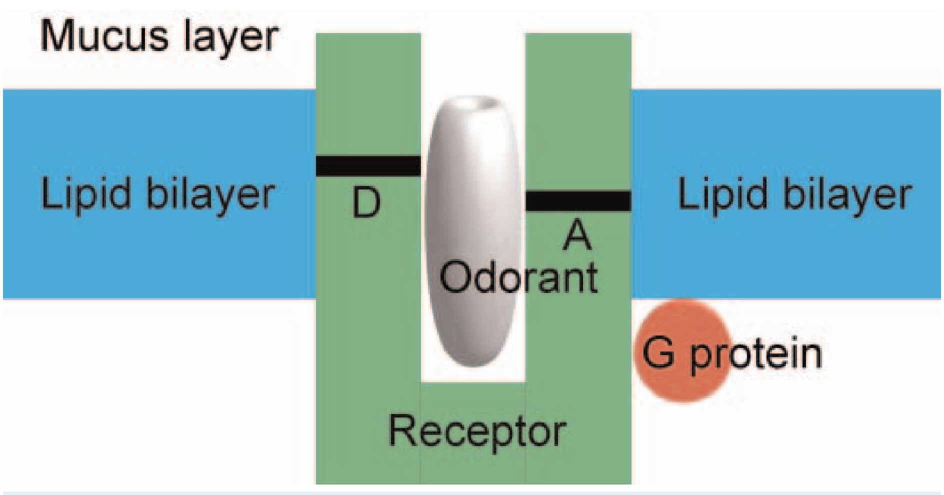

Figure 1. *This figure is a cartoon of the structure of an olfactory receptor containing an odorant molecule. See text for an explanation of its operation.*

Colourful images of nanocrystals

A major breakthrough in coherent X-ray diffraction imaging was published in Nature earlier this year by the group of Professor Ian Robinson. The work was abstracted as a UCL press release and was featured in a dozen or so electronic newsletters in the field of nanotechnology.

The method of phasing of diffraction patterns by "oversampling" has been under development for a number of years and was the foundation for the new development. The general form of the image obtained by inversion of the measured diffraction pattern is a complex three-dimensional function. The novelty of the Nature paper was that the phase of this function could be interpreted as an image of the deformation of the crystal lattice making up the sample. Slices through a nanocrystal of lead are shown in figures. The crystal, which has a diameter of 750 nanometres, was grown in a vacuum chamber attached to the X-ray diffraction instrument where its diffraction pattern was measured.

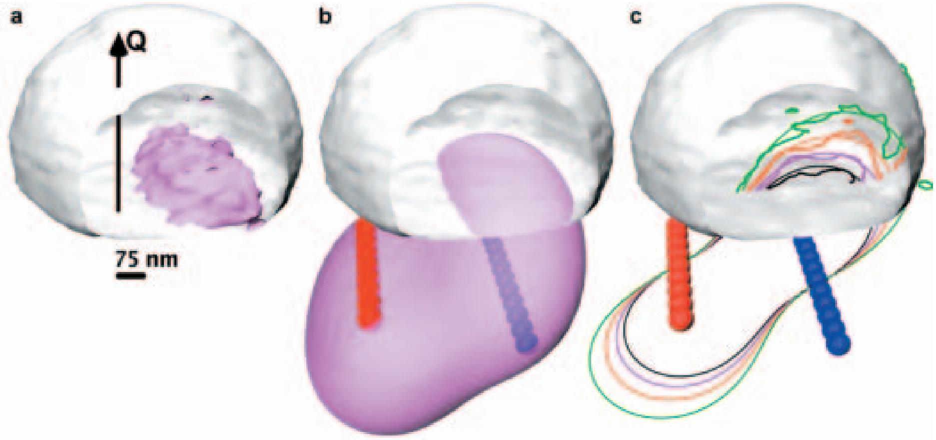

Figure 3. *Fitting of the phase bulge inside the lead nanocrystal using an elasticity model.*

In Fig. 2 the colours indicate the variation of the phase within the 3D image of the nanocrystal, which can be viewed as its internal deformations. In this case the compressive strain arises from pressure from the solid substrate onto the flat base of the hemispherical crystal (left side of figure). The propagation of the strain within the body of the crystal is found to follow the predictions of classical elasticity theory. This is shown three-dimensionally on Fig. 3 as a cut-away image of the nanocrystal with a "surface of equal strain" shown as a pink bulge in part (a). Part (b) is the same bulge predicted by the model and part (c) shows a single section with multiple strain levels. The strain is believed to arise from contact with the flat substrate upon which the crystal was grown.

Publications

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2. **G Aeppli, Q A Pankhurst** Launch of the London Centre for Nanotechnology, *Nanomedicine 1 393 (2006)*

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4. **D Alfe, M J Gillan** The energetics of oxide surfaces by quantum Monte Carlo, *J Phys: Cond Matt 18 L435-L440 (2006)*

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6. **A Ambrosio, O Fenwick, F Cacialli, R Micheletto, Y Kawakami, P G Gucciardi, D-J Kang, M Allegrini** Shape dependent thermal effects in apertured fiber-probes for scanning near-field optical microscopy, *J Appl Phys 99 084303 (2006)*

7. **M Avellino, A J Fisher, S Bose** Quantum Communication in Spin Systems With Long-Range Interactions, *Phys Rev A 74 012321 (2006)*

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9. **K M Beck, M Henyk, C Wang, P E Trevisanutto, P V Sushko, W P Hess, A L Shluger** Site-specific laser modification of MgO nanoclusters: Towards atomic-scale surface structuring, *Phys Rev B 74 045404 (2006)*

10. **G Bersuker, J Gavartin, J Sim, C S Park, C Young, S Nadkarni, R Choi, A Shluger, B H Lee** 2006 Int Symposium on VLSI Technology, Systems, and Applications Taiwan 107-108 (2006)

11. **G Bersuker, B H Lee, H R Huff, J Gavartin, A Shluger** Mechanism of charge trapping reduction in scaled high-k gate stacks Defects in Advanced High-k Dielectric Nano-Electronic Semiconductor Devices ed E Gusev Springer 227-236 (2006)

12. **R I Bewley, R S Eccleston, K A McEwen, S M Hayden, M T Dove, S M Bennington, J R Treadgold, R L S Coleman** MERLIN, a new high count rate spectrometer at ISIS, *Physica B 385-386 1029-1031 (2006)*

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14. **D R Bowler, C F Bird, J H G Owen** 1D semiconducting atomic chain of In and Bi on Si(001), *J Phys: Cond Matt 18 L241-L249 (2006)*

15. **D R Bowler, R Choudhury, M J Gillan, T Miyazaki** Recent progress with large-scale ab initio calculations: the CONQUEST code, *Phys Stat Sol B 243 989 (2006)*

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17. **D T Bowron, J L Finney, A Hallbrucker, I Kohl, T Loerting, E Mayer, A K Soper** The local and intermediate range structures of the five amorphous ices at 80 K and ambient pressure: A Faber-Ziman and Bhatia-Thornton analysis, *J Chem Phys 125 194502 (2006)*

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26. **B Fak, Ch Ruegg, P G Niklowitz, D F McMorrow, P C Canfield, S L Bud'ko, Y Janssen, K Habicht** Magnetic phase diagram of heavy fermion YbAgGe, *Physica B 378-380 669 (2006)*

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29. **R Garcia Calderon, L Fernandez Barquin, N Marcano, G M Kalvius, F E Wagner, O Hartmann, R Wappling, Q A Pankhurst** Local magnetism in the nanoscale granular alloy Fe13Cu10Ag77, *Physica B 374 67 (2006)*

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31. **J L Gavartin, D Munoz-Ramo, A L Shluger, G I Bersuker, B H Lee** Negative oxygen vacancies in HfO_2 as gate electron traps, *Applied Phys Lett 89 082908 (2006)*

32. **M J Gillan, D Alfe, J Brodolt, L Vocadlo, G D Price** First-principles modelling of Earth and planetary materials at high pressures and temperatures, *Rep Prog Phys 69 2365-2441 (2006)*

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34. **J H Harding, D M Duffy** The challenge of biominerals to simulations, *J Mat Chem 16 1105 (2006)*

35. **W A Hofer, A J Fisher** A Reply to the Comment by C Julian, *Phys Rev Lett 96 069702 (2006)*

36. **A P Horsfield, D R Bowler, H Ness, C G Sanchez, T N Todorov, A J Fisher** The

transfer of energy between electrons and ions in solids, *Rep Prog Phys 69 1195 (2006)*
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40. **S Lee, J-G Park, D T Adroja, D Khomskii, S Strelsov, K A McEwen, H Sakai, K Yoshimura, V I Anisomov, D Mori, R Kanno, R Ibberson** Spin gap in $Tl_2Ru_2O_7$ and the possible formation of Haldane chains in three-dimensional crystals, *Nature Materials 5 471 (2006)*
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43. **K A McEwen, H C Walker, P Boulet, E Colineau, F Wastin, S B Wilkins, D Fort** Quadrupolar and magnetic ordering in $(U,Np)Pd_3$, *J Phys Soc Japan 75 Suppl 20 (2006)*
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53. **Q A Pankhurst** Nanomagnetic medical sensors and treatment methodologies, *BT Technology Journal 24 33 (2006)*
54. **M A Pfeifer, G J Williams, I A Vartanyants, R Harder, I K Robinson** Three-dimensional Mapping of a Deformation Field inside a Nanocrystal, *Nature 442 63-66 (2006)*
55. **C Rau, V Crecea, K M Peterson, P R Jemian, C -P Richter, U Neuhsler, G Schneider, X Yu, P V Braun, I K Robinson** A hard X-ray KB-FZP Microscope for Tomography with Sub-100- nm Resolution Developments in Tomography V edited by U Bonse, *Proceedings SPIE 63181G 1-6 (2006)*
56. **C Rau, V Crecea, K M Peterson, P R Jemian, C -P Richter, U Neuhusler, G Schneider, X Yu, P V Braun, I K Robinson** A Full-Field KB-FZP Microscope for Hard X-Ray Imaging with Sub 100 nm Resolution Proceedings of the 8th International Conference on X-ray Microscopyedited by S Aoki, Y Kagoshima,Y Suzuki, *IPAP Conference Series 7 7-8 (2006)*
57. **C Rau, I K Robinson, C-P Richter** Visualizing soft tissue in the mammalian cochlea with partial coherent hard X-rays, *Microscopy Research and Technique 69 660-665 (2006)*
58. **R Riehn, R Stevenson, J J M Halls, D R Richards, D -J Kang, M Blamire, A Downes, F Cacialli** Local probing of photocurrent and photoluminescence in a phase-separated conjugatedpolymer blend by means of near-field excitation, *Advanced Functional Materials 16 469-476 (2006)*
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69. **R P Smith, A Kusmartseva, Y T C Ko, S S Saxena, A Akrap, L Forro, M Laad, T E Weller, M Ellerby, N T Skipper** Pressure dependence of the superconducting transition temperature in C_6Yb and C_6Ca, *Phys Rev B 74 024505 (2006)*
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71. **A M Stoneham** Materials for a life story Review of Robert Cahn The art of belonging: a memoir Book Guild, *Materials Today 9 56 (2006)*
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76. **P V Sushko, A L Shluger, K Hayashi, M Hirano, H Hosono** Role of hydrogen atoms in the photoinduced formation of stable electron centers in H-doped $12CaO*7Al_2O_3$, *Phys Rev B 73 045120 (2006)*
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Active Grants and Contracts

Royal Society research merit award (Royal Society) £162,500 PI: G Aeppli
New tools for Nanometrology (EPSRC) £2,803,814 PI: G Aeppli
Structure and conduction mechanisms of atomic-scale wires on surfaces (Royal Society University Fellowship) £172,260 PI: D Bowler
Computational studies of conduction and local heating (IRC – Cambridge University) £53,078 PI: D Bowler
Modelling charge transport in conducting polymers and biological systems – studentship agreement (IRC-Cambridge University) £51,255 PI: D Bowler
Modelling charge transport in conducting polymers and biological systems – studentship agreement (IRC-Cambridge University) £57,560 PI: D Bowler
New Exploratory Project – Modelling charge transport in conducting polymers and biological systems (IRC-Cambridge University) £127,410 PI: D Bowler
Insulated molecular wires: Supramolecular materials for organic optoelectronics (EPSRC) £266,560 PI: F Cacialli
THREADMILL – Threaded Molecular wires as supramolecularly engineered materials (EC) £310,691 PI: F Cacialli
Vortex phases and vortex pinning in high-temperature superconductors (EPSRC Advanced Fellowship) £96,964 PI: M Dodgson
Molecular modelling of fusion materials – CASE studentship (UKAEA) £18,964 PI: D Duffy
Investigating energy transport and equilibrium under non-equilibrium conditions (EPSRC) £189,649 PI: D Duffy
Synthesis of C6M superconductors using Li-M alloys (M=Ca and Yb) (EPSRC) £44,228 PI: M Ellerby
Exploring new graphitic superconductors: Charge transfer, excitations and dimensionality (EPSRC) £621,904 PI: M Ellerby
Interdisciplinary research collaboration in nanotechnology (EPSRC) £735,534 PI: A J Fisher
Physical limits on implementations of quantum information processing in condensed matter. Studentship for Iain Chapman (EPSRC IRC Cambridge) £42,606 PI: A J Fisher

Interdisciplinary Research Collaboration in Quantum Information Processing (EPSRC IRC Oxford University) £102,087 PI: A J Fisher
Modelling non-adiabatic processes in materials with correlated electron-ion dynamics: The next frontier in quantum modelling of materials (EPSRC) £394,431 PI: A J Fisher
Coherence in low-energy excitations of magnetic systems (EPSRC) £354,536 PI: A J Fisher
Single-molecule vibrational spectroscopy on metal oxides (EPSRC) £117,676 PI: A J Fisher
Structural modelling of the biological interface with materials (EPSRC via Sheffield University) £77,614 PI: M Gillan
First-principles thermodynamics of metals under extreme conditions (EPSRC) £184,560 PI: M Gillan
NANOSAFE2: Safe production and use of nanomaterials (EU) £84,428 PI: A Harker
New method for the growth of magnetic and biocompatible molecular thin films (Royal Society Dorothy Hodgkin Fellowship) £145,183 PI: S Heutz
New exploratory project: Processing of carbon nanotubes dissolved in liquid metals via sequential charging (IRC Cambridge University) £51,011 PI: C Howard
Wolfson Research merit award (Royal Society) £170,000 PI: D McMorrow
Studentship agreement (CCLRC) £19,821 PI: D McMorrow
New routes to optimised multiferroics (EPSRC) £263,699 PI: D McMorrow
Soft x-ray resonant diffraction of charge and orbital ordering in 3D transition metal oxides – Studentship for Tom Forrest (CCLRC) £27,225 PI: D McMorrow
Core-shell exchange pinned magnetic nanoparticles. Studentship for Jalpa Patel (IRC Cambridge University) £13,636 PI: Q Pankhurst
The London-Houston biomagnetometer (DTI) £150,000 PI: Q Pankhurst
CSEL Support for Nanotechnology Business Training Module Development (Centre for Scientific Enterprise) £38,400 PI: Q Pankhurst
Core-shell nanoparticles for next-generation magnetic recording media – Royal Society USA fellowship for Dr D Farrell (Royal Society) £129,000 PI: Q Pankhurst
Multifunctional core-shell nanoparticles for molecular imaging and actuation (Royal Society) £20,000 PI: Q Pankhurst
Magnetic Molecular Imaging (BBSRC) £51,324 PI: Q Pankhurst
Royal Society Wolfson Research Merit Award (Royal Society) £130,000 PI: I Robinson
Exploration of strain fields in crystalline nanowires (EPSRC) £346,253 PI: I Robinson
Modelling of dynamic AFM imaging of bio-molecules in liquids. Studentship for Alexandros Kalampokidis (IRC – Cambridge University) £52,531 PI: A L Shluger
Meeting the materials challenges of nano-CMOS electronics (EPSRC) £439,638 PI: A L Shluger
Laser-materials interactions (SAMPSON) £53,382 PI: A L Shluger
NANOMAN – Control, manipulation and manufacture on the 1-10nm scale using localised forces and excitations (EU) £108,675 PI: A L Shluger
Modelling of charge traps in high-K dielectrics (International Sematech) £130,000 PI: A L Shluger
Structural modelling of the biological interface with materials (EPSRC via Sheffield University) £157,547 PI: A L Shluger
Alliance: Franco-British Partnership Programme 2005 – Study of molecular machines with a dynamic atomic force microscope (AFM) (The British Council) £37,402 PI: A L Shluger
Theoretical calculation on electron states and anion species in nano-porous crystals and on defects in amorphous oxides (JSTA) £70,979 PI: A L Shluger
Hydrogen in nano-crystalline II-VI semiconductors studied μSR (The British Council) £1,000 PI: A L Shluger
PICO-INSIDE: Computing inside a single molecule using atomic scale technologies (EC) £189,000 PI: A L Shluger
Fees for CJEV (EPSRC – IRC Cambridge University) £9,470 PI: A L Shluger
Theoretical calculation on electron states and anion species in nano-porous crystals (JSTA) £78,973 PI: A L Shluger
Structure and dynamics of hydrogen-bonded pore fluids at elevated pressures and temperatures (NERC) £170,001 PI: N T Skipper
Hydrogen in metal-ammonia solutions and carbon based metal ammonia intercalates (CCLRC) £14,400 PI: N T Skipper
CASE studentship for Emily Milner – Ammonia as a solvent for nanotechnology (BOC Ltd) £25,200 PI: N T Skipper
Intramural Fellowship for Helen Thompson ISIS EPSR computer simulation (CCLRC) £53,966 PI: N Skipper
Follow on: A new method for purifying and depositing carbon nanotubes (EPSRC) £88,458 PI: N Skipper
CASE for Tom Headen (Schlumberger Cambridge Research) £6,000 PI: N Skipper
Basic technology – putting the quantum into information technology (EPSRC) £3,672,133 PI: A M Stoneham
A microscopic model of signal transduction in biological systems – Studentship for Jennifer Brookes (IRC Cambridge University) £51,255 PI: A M Stoneham

New space for Astrophysics

As part of the SRIF (Strategy in Research Infrastructure Fund) funded refurbishment of the Department, the Astrophysics group are now located in the Kathleen Lonsdale Building (KLB). This is the first time all the Departmental astronomers have been located together. On 24 March 2006, the Astrophysics Group held an opening ceremony to celebrate their move to the newly refurbished KLB.

Speeches were given by UCL President and Provost, Professor Malcolm Grant, Chief Executive of PPARC, Professor Keith Mason, Head of Department, Professor Jonathan Tennyson and Professor Ofer Lahav, Head of the UCL Astrophysics Group.

Part of UCL Physics and Astronomy, the Astrophysics Group is one of the largest in the country and incorporates the Atmospheric Physics Lab, the Optical Science Lab and staff from the University of London Observatory. Historically, the group was scattered around different areas of UCL.

Professor Lahav said: "The move was divided into two phases. With the first now successfully completed it has already generated an excellent intellectual atmosphere. This move also matches well the recent expansion of the group into new areas such as Cosmology and Astrobiology and an involvement in new cutting edge international projects such as the Dark Energy Survey. With the completion of the second phase soon, almost the entire group will be positioned together in one place."

Figure 1. *From right to left: Professor Jonathan Tennyson, Professor Keith Mason, Professor Malcolm Grant, and Professor Ofer Lahav.*

The KLB has accommodated many distinguished scientists over the years, such as Sir William Ramsay, who won the Nobel Prize in Chemistry 1904, and Kathleen Lonsdale, a well-known chemist and the first woman professor at UCL.

Previously the building was known as 'Old Chemistry' and is familiar to many previous UCL astronomers. It was the place where many of the people involved with the IUE satellite project worked, and where many successful infra-red balloon experiments were built. Over the past ten years the KLB was also used by the CMMP Group.

Professor Lahav, the current holder of the Perren Chair, paid tribute to the three former Perren Professors C W Allen, Sir Robert Wilson and David Williams for their combined contribution to the group over the past 50 years.

He thanked members of staff for their contribution to the refurbishment, in particular Professor Brian Martin, Professor Allan Willis, Hilary Wigmore, and the UCL architects Connor Wilson and Marina Stephanides.

Public Understanding of Science

UCL hosts first Science and Society Fellow in particle physics and astronomy.

University College London is the home of the very first Fellow in Science and Society awarded by the Particle Physics and Astronomy Research Council (PPARC). Dr. Maggie Aderin (Fig. 1), who is also team leader with the space exploration company Astrium, is planning an ambitious programme to engage members of the public with the latest from the world of particle physics and astronomy. And, with the opening of the Large Hadron Collider at the European nuclear physics centre, CERN, in Geneva this coming spring, there is much for Dr. Aderin to be ambitious about.

The aim of PPARC's novel Science and Society Fellowship scheme is to enable scientists with a good track record in outreach activities, as well as excellent "street cred" among the scientific community, to devote a part of their time to innovative schemes of public engagement. Dr. Aderin – who will work on her fellowship 2 days per week – has built up an excellent record in building state-of-the-art astronomical instruments, and was, for five years, a project manager at UCL's Mullard Space Science Laboratory. There she was in charge of building the bench-mounted, High-Resolution Spectrometer, bHROS, on the Gemini telescope.

At the same time, Dr. Aderin – who is of Nigerian descent – has built up her own programme of public outreach activities. In particular, she has concentrated on bringing the excitement of big science to young women and black and ethnic minority communities. But she is not keen on programmes that focus solely on groups who are traditionally under-represented in the physical sciences.

"Through my PPARC fellowship I would like to convey the joy and excitement of science to as many people as possible," said Dr. Aderin. "As scientists we are doing amazing and quite mind-boggling things. I find these advances thrilling and I hope to share this with others. To achieve this, the scientific community needs to make science accessible and in this role I see myself as a translator, removing the jargon and highlighting the wonder."

Figure 2. *The University of London Observatory (ULO) continues to run an extensive outreach programme. The astronomy in the classroom project is funded by the Small Award Scheme from the Particle Physics and Astronomy Research Council (PPARC). It involves visiting lectures to schools and has now extended to the entire London area. Particularly popular is the use of portable telescopes in the school playground. The project was the subject of a feature article entitled "Opening pupils' eyes to the skies" by Fransico Diego in Astronomy and Geophysics, 47, 18 (2006).*

Figure 1. *Dr. Maggie Aderin*

Dr. Aderin is currently working on a project called Monsters of the Universe, which involves bringing the world's largest telescopes as well as the universe as seen by CERN to lay citizens. During the last part of 2006, this has meant visits to the observatories in Chile. And the start of 2007 will see her at CERN.

Later in her fellowship, Dr. Aderin will put together a challenging new programme of outreach activities, African Astronomical Safari, that will highlight the impact that Africa has had on our understanding of the universe, and the new astronomy that is being carried out there today. "I was interested in space from a very early age," Dr. Aderin explains. "You hear about people fighting each other. But – from the perspective of space – it looks like ants squabbling over a leaf."

Throughout her fellowship, Dr. Aderin will be housed by the Department of Science and Technology Studies, and will hold an honorary fellowship in the Astrophysics Group in Physics and Astronomy. PPARC have now awarded one further Science and Society Fellowship, to Dr. Paul Roche of the Faulkes Telescope project.

Departmental Staff

Head of Department

Professor J Tennyson

Deputy Head of Department

Dr A H Harker

Astrophysics

Professors:
A D Aylward, M J Barlow, I D Howarth, O Lahav, S Miller, J Rawlings, A J Willis

Readers and Senior Lecturers:
A P Doel, M M Dworetsky, I Furniss, R K Prinja, L J Smith, D D Walker

Lecturers:
A L Aruliah, S L Bridle, S Viti, J Weller, J Yates

Royal Society Dorothy Hodgkin Fellow:
N Rajguru

PPARC Research Fellow:
N Bastian

Senior Research Fellows:
F Diego, J L A Fordham, G H Millward

Research Fellows:
F B Abdallah, N Bastian, E Bayet, J Bowey, A W Burnley, A Dobbin, B Ercolano, E Griffin, G Hutsi, A M King, E Serra Cypriano, T Spain, T Stallard, S J Thompson, I Tsamis, L Voigt, R Wesson, M Westmoquette, J Yao

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Readers:
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Lecturers:
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C Gwenlan, M Sutton

PPARC Fellows:
E Nurse, C B Smith

Principal Research Fellow:
P Sherwood

Research Fellows:
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Image Processing

Lecturer:
M R B Forshaw

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Professors:
G Aeppli, F Cacialli, J Finney, A J Fisher, M J Gillan, K A McEwen, D F McMorrow, Q A Pankhurst, I K Robinson, A Shluger, N T Skipper

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Lecturer:
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D Farrell

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Principal Teaching Fellow:
M Coupland

Co-ordinator 1st year Undergraduate Lab:
C Bull

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J O'Brien

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Programme Tutors:
I Ford (Physics), I Furniss (Astronomy), A P Doel (MSc students), R K Prinja (Natural Sciences), M Coupland (Part-time Physics), W B Somerville (Astronomy Certificate)

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Manager: P K Thomas
Demonstrators: SJ Boyle, SJ Fossey
Computing and Experimental Officer: T Schlichter
Technical Support: M Pearson
Secretary: V Peerless

MAPS Workshop

Superintendent: R Gollay
Technicians: J Benbow, J Dumper, J F Percival

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Secretary Groups AMOP & HEP: C Johnston
Undergraduate Teaching Co-ordinator: T Saint
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