Assistant/Associate Professorship in Experimental Condensed Matter Physics

Department of Physics

Further Particulars

THE DEPARTMENT

HEAD OF DEPARTMENT: PROFESSOR MALCOLM COOPER

The Physics Department occupies two linked buildings on the central campus close to the Departments of Chemistry, Engineering, the Centre for Scientific Computing, the Library and University House as well as numerous social facilities. Our teaching was awarded 24/24 in the last QAA subject review and is ranked 5A in the 2001 Research Assessment Exercise. There are currently 47 members of academic staff, 32 research fellows, 21 technical staff, plus clerical and administrative support staff. The present postgraduate (PhD) research student population is approximately 73 but will rise rapidly in the next few years as a result of a number of recent initiatives.

The Department supports a broad range of research in addition to its large Condensed Matter Physics, including groups in Observational Astronomy & Astrophysics; Fusion, Space and Astrophysical Plasmas; Elementary Particle Physics; Medical & Biological Physics and Theoretical & Computational Physics. The department typically has received £3M-£4M in research grants each year but in 2006/7 it has won grants with a face value over £10M, notably for an EPSRC Basic Technology project in Magnetic Resonance, an S&I award for creating the Centre for Fusion, Space and Astrophysical Plasmas and a doctoral training centre in Complexity.

THE UNDERGRADUATE COURSES

The annual intake to undergraduate Physics courses at Warwick is 150-170, with average 'A' level scores better than AAB. This total includes students taking the 'Mathematics and Physics' course (about a quarter of the total), which is taught jointly with the Mathematics Department. The Department offers both three-year BSc and four-year MPhys degrees: undergraduates opt for these degrees in approximately equal numbers. We are currently spending £1.5M on the refurbishment of our teaching laboratories.

RESEARCH ACTIVITY

CONDENSED MATTER-MATERIALS PHYSICS AND SPECTROSCOPIES

Research in this large group, which is led overall by Professor Cooper, is concerned with the fundamental understanding of the structure and physical properties of solids, surfaces and interfaces. Materials range from metals, semiconductors and superconductors to ionic and molecular solids and glasses. This activity underpins the development of new structural and functional materials and innovative technologies, for example there are currently three companies within the Department "spun-out" from experimental condensed matter activities. The basic research is supported by a wide range of facilities such as high resolution electron microscopy with EDAX, EELS, and other microscopies such as STM and AFM. Spectroscopies include IR, NMR, EPR, Raman, EXAFS, AES, SIMS, XPS, LEED, etc. In addition there is major activity in X-ray diffraction and scattering, which is carried out in-house as well as at synchrotron sources (ESRF, SRS Daresbury, SPRing8 and, in the future, DIAMOND) and neutron diffraction at national and international facilities (e.g. ISIS, ILL, Oak Ridge). There are comprehensive sample making facilities available including glass melting, ceramic sintering and single crystal growth with image furnaces, plus Molecular Beam Epitaxy and Chemical Vapour Deposition for semiconductor growth (Si, Si/Ge and III-Vs).

Comprehensive analysis and characterisation facilities include optical, electrical, magnetic properties measurements and thermal analysis.

SUPERCONDUCTIVITY AND MAGNETISM (BALAKRISHNAN, LEES, PAUL, PETRENKO)

There is a wide range of research centred on the properties of strongly correlated electron systems. Materials of interest include magnetic and high temperature superconductors, intermetallic heavy fermions, charge-ordered oxides exhibiting collosal magnetoresistance, and frustrated or low dimensional magnets. The group has infra-red image furnaces that are used to grow single crystals. Samples are also prepared using vapour transport and flux growth techniques. These materials are studied in our measurement laboratories whose facilities include a SQUID and a vibrating sample magnetometer, and a range of cryostats (300mK to 1000K) and magnets (0-12T) that are used for transport, (resistivity, Hall effect and thermo-power), magnetic susceptibility and heat capacity measurements. These measurements are often used as a precursor to neutron scattering experiments that are performed at various sources in Europe and the USA. Elastic, inelastic and small angle neutron scattering techniques are used to examine the magnetic and crystallographic structure of materials, investigate phase transitions, probe magnetic and crystal field excitations, and study the morphology of flux lines in superconductors.

FERROELECTRICS AND CRYSTALLOGRAPHY (THOMAS)

Research is carried out on the fundamental physics of a wide range of ferroelectric crystals. These include new-generation relaxor ferroelectrics with "giant" piezoelectric effects, non-linear optical crystals with tailored periodic domains for frequency conversion and novel multiferroic materials that combine ferroelectric and magnetic properties. The aim to understand the physical properties and phase transitions from the basis of structure in the most general sense, i.e. on the average crystallographic, local and "nano" scales. A multi-technique approach is adopted combining synchrotron and laboratory-based high-resolution X-ray diffraction, diffuse scattering and imaging, dielectric and optical measurements, neutron diffraction and NMR.

EPR AND DIAMOND (NEWTON)

This group specialises in the development of Electron Paramagnetic Resonance (EPR) and optical spectroscopic methods, and applies these techniques in the study of diamond and other materials/systems, for which it has high temperature/high pressure growth facilities. EPR is a spectroscopic method employing magnetic fields and microwaves to study materials and molecules with unpaired electrons. EPR provides structural information, details of electron density distributions, and via the interaction of electrons with nuclei is an element-specific probe. The useful properties of materials are often limited by, or dependent on, the presence of defects and impurities. EPR and optical spectroscopic techniques are used to provide an understanding of the nature and incorporation of defects and impurities, which in turn enables the full potential of new materials, such as large synthetic single crystal diamond to be exploited.

SOLID STATE NMR (BROWN, DUPREE, HOWES, SMITH)

NMR is a site and element-specific probe of the local atomic scale structure and dynamics of materials that complements standard characterisation techniques such as scattering, diffraction and microscopy, especially for disordered systems that are otherwise difficult to study. The group has developed the study of many "difficult" quadrupole nuclei and is actively pursuing techniques to provide very high resolution proton spectra from solids. NMR is being applied to a wide range of areas from fundamental a studies of high temperature superconductors and low dimensional magnetically correlated materials, to more materialsoriented problems including the structure of glasses and disordered systems such as sol-gels and electroceramics, the determination of sites responsible for catalytic action in zeolites, oxygen ion conduction, the calcination of clay minerals, biological molecules and supramolecular materials. The group is in receipt of a major award under the EPSRC basic technology programme to develop novel NMR techniques.

STRUCTURAL CERAMICS, GLASSES AND GLASS CERAMICS (DOBEDOE, HOLLAND)

The main emphasis has been on the understanding of microstructural evolution during sintering of "Sialon" (Si3N4-based) ceramics and their high-temperature mechanical and environmental properties, relevant to heat-engine applications. Research emphasis is now changing to ceramic matrix composites with special reference to interface structure and the development of matrix microstructure in glass and ceramic-based systems. A wide range of studies of special glasses and their partially crystallised derivatives is in progress. Projects on mechanical properties, optical properties (optical fibres and anti-reflection coatings), electrical properties and on the production of glass ceramic components for electronic assembly are currently in progress. Thick film fabrication routes for high-Tc glass-ceramic superconductors are being developed. Electron microscopy, the main analytical tool is augmented by a wide range of other techniques which constitute the leading-edge multiprobe approach employed by the laboratory.

X-RAY SCATTERING (COOPER, DUFFY, HASE)

Studies of the electron spin density in ferromagnets are made using X-ray synchrotron sources at the European Synchrotron Radiation Facility (ESRF) in Grenoble, France and a similar large scale facility in Japan (SPring8, Himeji) using techniques pioneered by the Warwick group. Current interest centres on highly correlated electron systems such as those materials exhibiting magnetism and superconductivity. Characterisation of the materials is performed at Warwick in collaboration with the Superconductivity and Magnetism research group. The ESRF in Grenoble also houses the UK materials science X-ray beamline for magnetic and high resolution scattering (XMaS) which is co-directed from Warwick by Cooper. It is comprehensively equipped for diffraction studies of a wide range of materials with unique sample environment facilities. This beam line along with others in Europe is also used by the group for research on magnetic multilayer device materials.

SEMICONDUCTING MATERIALS (GRASBY, LEADLEY, PARKER)

Layer structures grown using molecular beam epitaxy (MBE) and chemical vapour deposition (CVD) techniques have many technological applications. Such thin structures show promise for producing a whole range of new electronic devices. The department has made a major investment in both growth techniques and there are extensive state-of-the-art departmental facilities for growing such devices, for analysing their composition and structure using secondary ion mass spectrometry (SIMS) and high resolution electron microscopy, and for evaluating their novel electronic properties. Currently 2D, 1D and "quantum dot" devices and strained silicon germanium layer devices are being investigated.

SECONDARY ION MASS SPECTROMETRY (DOWSETT)

Continued developments in the semiconductor industry are leading towards smaller and shallower devices on silicon chips. The Advanced SIMS group specialises in all areas of the measurement of dopant profiles by this ion beam technique. The group has been responsible for major breakthroughs in ion gun design that permit ultra-high depth resolution (sub-nanometre) to be obtained, as well as investigating the fundamental processes responsible for the secondary ion signal, and for mathematical analysis techniques. The group has also active interests in the study of electrochemical corrosion of museum artefacts and other heritage objects, which are also pursued by synchrotron-based x-ray diffraction studies.

SURFACE AND INTERFACE SCIENCE (BELL, MCCONVILLE, ROBINSON, WOODRUFF)

The interdisciplinary nature of this field covers both physical and chemical aspects of the topic as well as impinging on materials science. The work is focussed on well-characterised single crystal surfaces studied under ultra-high vacuum conditions using a range of specialised electron, photon and ion scattering techniques (XPS, UPS, HREELS, CAICISS, LEED, etc.) both at Warwick and at national and international central facilities as well as theoretical total energy calculations. Three main themes are pursued (i) structure determination in the reaction of simple molecules with metal (mainly transition metal) and oxide surfaces, motivated by a need to improve our understanding of heterogeneous catalysis; (ii) electronic structure investigations of the near-surface region of semiconductors (especially binary and ternary nitrides) and (iii) understanding fundamental processes in molecular beam epitaxy, especially in the context of magnetic semiconductors.

ULTRASONICS (DIXON)

Ultrasound is a powerful technique in solid state physics, materials science and engineering physics. The ultrasound group is studying magnetic phase changes and related phenomena and developing techniques based on high power pulsed lasers to generate and detect ultrasound without contact. This novel approach finds applications ranging from high-Tc superconductors to industrial non-destructive testing.

ASTRONOMY AND ASTROPHYSICS (GAENSICKE, LEVAN, MARSH, STEEGHS, WHEATELY)

The Astronomy and Astrophysics group at Warwick is one of the two newest additions to the Department of Physics, beginning life in September 2003 with the appointment of Prof Tom Marsh. They are interested in stars and planets, how they live and how they die, and the exotic physical processes (e.g. accretion onto black holes, gamma ray bursts) that they allow us to explore. We are an observational group and make use of a wide range of ground-based telescopes, such as ESO's Very Large Telescope (VLT) in Chile and the Isaac Newton Group of telescopes (ING) in the Canary Islands, as well as space telescopes such as NASA's Chandra and ESA's XMM-Newton X-ray observatories and the Hubble Space Telescope.

The objects studied are dynamic and can change within minutes, seconds and even milli-seconds. The group specialises in the high-speed data acquisition and analysis techniques needed to track them. Members of the group have contributed to the development and exploitation of the ULTRACAM high-speed photometer, and the Wide Angle Search for extra solar planets project (WASP) and various satellite and space mission studies of gamma ray bursts, and are prominent in galactic plane surveys such as IPMAS and UVEX.

CFSA: THE CENTRE FOR FUSION, SPACE AND ASTROPHYSICS (ARBER , CHAPMAN, DENDY, HNAT, GERICKE, NAKARIAKOV, PEETERS, ROWLANDS, VERWICHTE)

Research at CFSA, under the leadership of Professor Sandra Chapman, focuses on plasma physics applied to the grand challenges of fusion power, space physics, solar physics, and astrophysics. Our work spans fundamental theory, observation, and the analysis of experimental data, combined with high performance computing (HPC). The Centre has a strong record of joint work with the fusion research programme at UKAEA Culham, as well as extensive engagement with space plasma and solar observation missions.

Space and astrophysical plasma research was first established at Warwick under the leadership of Professor Sandra Chapman in 1995, and has a strong record of joint work with the fusion plasma theory group at UKAEA Culham, led by Professor Richard Dendy. As part of a major Science and Innovation award to strengthen plasma physics in UK universities, three new academic staff appointments were made during 2006. Some CFSA staff are also core members of Warwick's Centre for Scientific Computing.

ELEMENTARY PARTICLE PHYSICS (BARKER, BOYD, GERSHON, HARRISON, RAMACHERS)

The Elementary Particle Physics group at Warwick was started in January 2004 under the leadership of Prof. Paul Harrison. The group is presently involved in the following experiments. The BABAR experiment, at the Stanford Linear Accelerator Center in California, is studying the delicate asymmetry between matter and anti-matter, known as CP violation. This work could shed light on the paradox that equal amounts of matter and anti-matter were created in the Big Bang, but only matter seems to be present in the Universe today. The COBRA experiment is in a phase of detector research and development, to try to optimise its sensitivity to the very rare neutrino-less double beta decays. If these are observed, it will confirm that the neutrino is its own anti-particle, a so-called Majorana neutrino. It will also measure the absolute neutrino mass. The T2K experiment is being built in Japan, to direct a beam of neutrinos from Tokai, across Japan to Kamioka (hence T2K). By doing this, it is hoped to detect the very rare spontaneous transmutation of muon neutrinos to electron neutrinos via the effect of neutrino oscillations. The group is also involved in preliminary research and development for a possible future neutrino factory, a project which would produce the most intense beam of neutrinos ever, in order to study the matter/anti-matter asymmetry with these particles, and hence to try to understand the fact that the present-day Universe is composed of matter and not anti-matter.

THEORETICAL & COMPUTATIONAL PHYSICS

The theory group, which has a wide range of research interests, is led by Professor Robin Ball who is also the Director of the University's interdisciplinary **Complexity Complex,** recently established, with EPSRC support, to provide doctoral training and foster research.

AB INITIO ELECTRONIC CALCULATIONS (ROBINSON, STAUNTON, WOODRUFF)

The interaction between electrons is both a key source of rich variation in the properties of materials, and a central challenge to the understanding of these materials by theory and by large-scale numerical computation. New extensions and theoretical developments are undertaken to understand magnetic systems. These include magnetic anisotropy and the onset of magnetic order, to describe disordered systems with short range order and the modelling of properties of materials in which strong electron correlation effects are important. Advanced electronic structure calculations are also performed to understand surface structures and X-ray spectra.

QUANTUM TRANSPORT IN DISORDERED SYSTEMS AND QUANTUM DYNAMICS (D'AMBRUMENIL, ROEMER, MOUZYKANTSKII)

The fabrication of semiconductor structures in which one or more dimension is only of the order of the electronic de Broglie wavelength is producing a new branch of physics -low dimensional systems. There are projects on the electrical and thermal conductivity in these low dimensional systems, as well as the quantum Hall effect, quantum size effects and the influence of phonons on electron transport. The dynamics of quantum gates and junctions has prompted our development of new techniques in mathematical and computational physics, with application to a broad range of intrinsically quantum switching problems.

SOFT CONDENSED MATTER AND BIOPHYSICS (BALL, DIXON, ROEMER, TURNER)

Physics can provide a framework on which to build a profound understanding of complex biological and chemical systems. The goal is to understand universal behaviour shared by all similar systems. Techniques drawn from statistical and continuum mechanics are being employed to tackle problems involving both tethered and stacked fluid membranes as well as surface and interfacial phenomena in polymer systems.

NON-LINEARITY AND SELF-ORGANISATION (BALL, CHAPMAN, DENDY, MARSH, ROWLANDS,)

Chaotic behaviour and turbulence are characteristic of systems with non-linear equations of motion, which recent developments, particularly in mathematics, are making increasingly accessible. There is work on the precursor instabilities to full turbulence in convective systems and plasmas, as well as more general time series analysis. This area links in with the large non-linear systems group in the Department of Mathematics.

<u>Molecular Simulation</u> (Allen)

Computer simulations act as a bridge between experiment and theory. In order to understand complex fluid behaviour, an accurate theory is needed but the theoretical predictions also depend on how accurately the molecular interactions can be modelled. Computer simulation helps to test the theory independently of the precise molecular model, establishing the reliability and applicability of the results. Starting from details of the molecular interactions the computer is used to simulate a system of molecules: to calculate bulk properties, structure, and dynamics at the microscopic level. Using Warwick's high-performance computing facilities, as well as national high-end supercomputers, new simulation algorithms, are developed. These activities are intrinsically cross-disciplinary, and there are strong collaborative links with the Department of Chemistry through the Centre for Scientific Computing.

The Department's activities are detailed at www.phys.warwick.ac.uk.

MJ Cooper
February 2007

JOB DESCRIPTION

POST TITLE:	**ASSISTANT PROFESSORSHIP IN CONDENSED MATTER PHYSICS**
DEPARTMENT:	**Physics**
SUB-DEPARTMENT:	
POST RESPONSIBLE TO:	**Professor MJ Cooper**
POST RESPONSIBLE FOR:	
SALARY:	**LEVEL 6**
REFERENCE NUMBER:	**34622-027**
CLOSING DATE:	**31ST MARCH 2007**

JOB PURPOSE:

To carry out internationally competitive research in condensed matter physics (both experimental and theoretical/computational) leading to publications in international journals and to teach physics at undergraduate and postgraduate degree levels, the latter as part of the Midlands Physics Alliance.

DUTIES AND RESPONSIBILITIES:

Research

1. To establish a sound research base within the department in order to pursue independent and collaborative research of high quality in condensed matter physics.
2. To publish the results of this research in appropriate international journals.
3. To seek and secure external funding through research grants or contracts to support a developing research programme.
4. To attend and present research findings and papers at appropriate conferences.
5. To contribute fully to the research plans developed by the Department and the Midlands Physics Alliance, including providing such information as may be required to monitor research progress and to support the department fully in the preparation of material required for the RAE or similar activities.

Teaching

6. To teach and supervise physics at undergraduate and postgraduate degree levels.
7. To co-operate with colleagues in the continuous review and development of the curriculum.
8 To give lectures, seminars, tutorials and other classes as appropriate in support of the required teaching obligations and to supervise laboratory work by undergraduate and postgraduate students.
9. To undertake academic duties (i.e. setting examination questions, marking, invigilation and pastoral support of students) required to sustain the delivery of high quality teaching.

Administration

10. To undertake such specific departmental roles and management functions as may be reasonably required by the Head of Department.
11. To attend departmental meetings and to participate in other committees and working groups within the department, the faculty and the University.
12. To engage in continuous professional development.

PERSON SPECIFICATION

POST TITLE: Assistant Professorship in Condensed Matter Physics

DEPARTMENT: Physics

The Person Specification focuses on the knowledge, skills, experience and qualifications required to undertake the role effectively.

REQUIREMENTS The postholder must be able to demonstrate:	**IS REQUIREMENT ESSENTIAL (E) or DESIRABLE (D)?**	**MEASURED BY:** a) application form b) Test/Exercise c) Interview d) Presentation
Possession of a PhD	E	A
Postdoctoral experience	E	A
A strong record of publications in refereed international journals	E	A
Recent research in an area directly related or overlapping with the interests of the department and the Midlands Physics Alliance.	D	A, C, D
Ability or potential to generate external funding (grants, contracts etc) to support research	E	A
Teaching experience at undergraduate and/or postgraduate level.	D	A, C
Good effective communication skills (oral and written)	E	A, C, D

JOB DESCRIPTION

POST TITLE:	**ASSOCIATE PROFESSORSHIP IN CONDENSED MATTER PHYSICS**
DEPARTMENT:	**Physics**
SUB-DEPARTMENT:	
POST RESPONSIBLE TO:	**Professor MJ Cooper**
POST RESPONSIBLE FOR:	
SALARY:	**LEVEL 7**
REFERENCE NUMBER:	**34621-027**
CLOSING DATE:	**31ST MARCH 2007**

JOB PURPOSE:

To carry out internationally competitive research in condensed matter physics (both experimental and theoretical/computational) leading to publications in international journals and to teach physics at undergraduate and postgraduate degree levels, the latter as part of the Midlands Physics Alliance.

DUTIES AND RESPONSIBILITIES:

Research

1. To establish a sound research base within the department in order to pursue independent and collaborative research of high quality in condensed matter physics.

2. To publish the results of this research in appropriate international journals.

3. To seek and secure external funding through research grants or contracts to support a developing research programme.

4. To attend and present research findings and papers at appropriate conferences.

5. To contribute fully to the research plans developed by the Department and the Midlands Physics Alliance, including providing such information as may be required to monitor research progress and to support the department fully in the preparation of material required for the RAE or similar activities.

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9. To undertake academic duties (i.e. setting examination questions, marking, invigilation and pastoral support of students) required to sustain the delivery of high quality teaching.

Administration

10. To undertake such specific departmental roles and management functions as may be reasonably required by the Head of Department.

11. To attend departmental meetings and to participate in other committees and working groups within the department, the faculty and the University.

12. To engage in continuous professional development.

PERSON SPECIFICATION

POST TITLE: Associate Professorship in Condensed Matter Physics

DEPARTMENT: Physics

The Person Specification focuses on the knowledge, skills, experience and qualifications required to undertake the role effectively.

REQUIREMENTS The postholder must be able to demonstrate:	**IS REQUIREMENT ESSENTIAL (E) or DESIRABLE (D)?**	**MEASURED BY:** a) application form b) Test/Exercise c) Interview d) Presentation
Possession of a PhD	E	A
Postdoctoral experience	E	A
A strong record of publications in refereed international journals	E	A
Recent research in an area directly related or overlapping with the interests of the department and the Midlands Physics Alliance.	D	A, C, D
Ability or potential to generate external funding (grants, contracts etc) to support research	E	A
Evidence of teaching experience at undergraduate and/or postgraduate level.	E	A, C
Good effective communication skills (oral and written)	E	A, C, D