Institution: Royal Holloway, University of London

Unit of Assessment: B9 Physics

a. Overview

The strategic focus of the Department's research centres on groupings with critical mass which are well aligned with national strategic priorities. The research is framed by national strategic partnerships, consortia, joint grants, the SEPnet regional alliance, and is permeated by a broad spectrum of international collaboration. The Royal Holloway **Centre for Particle Physics** is divided into research sub-groups: the John Adams Institute for Accelerator Science (JAI; a Royal Holloway–Oxford joint venture, with IC joining in 2012), the LHC ATLAS experiment, Dark Matter searches and Theory. The experimental programme is supported by laboratories and advanced computing facilities in the Department. All experimental groups work in the context of large international collaborations and make use of facilities at major external laboratories (CERN, KEK, LANL). The Theoretical Particle Physics group has strong collaborations nationally (incl. via SEPnet's NExT Institute) (South East Physics network New connections between Experiment and Theory) and internationally. Dark Matter and Theory are new groups since RAE2008. The **Condensed Matter Physics** theme (sub-groups: Quantum Fluids and Solids; Quantum Matter; Quantum Devices; Bio-diagnostics; Nanophysics and Nanotechnology; Theory) ranges from the fundamental study of quantum matter, both experimental and theoretical, to applied technologies. Research is carried out in modern departmental fabrication facilities and laboratories, centred on in-house facilities of the London Low Temperature Laboratory (a founder member of the European Microkelvin Consortium) and the Nanotechnology Centre, and makes use of national and international large scale facilities such as ISIS, the Diamond Light Source, ESRF and ILL. The Theory of Condensed Matter group, established in the assessment period is a founder member of the Hubbard Theory Consortium (HTC), co-funded by STFC. All activity is permeated by substantive international engagement and collaboration.

We are a founder member (2008) of the HEFCE-funded SEPnet consortium.

b. Research strategy

The Department's research strategy is to continue to deliver a high quality topical research programme, underpinned by excellent individuals, work on world-class facilities, and collaborations internally and with external partners. The assessment period has seen both a consolidation of its research strengths, and major initiatives to diversify its research portfolio into exciting new areas. Some of these developments followed on from our stated aims in the 2007 submission, and some were unforeseen and resulted from seizing opportunities that arose. Since 2008 the Department appointed 12 new academic staff, and carried out a very significant expansion and improvement of its research facilities, with strong institutional, regional and Research Councils backing. Our position is considerably advanced since RAE 2008.

A major development was the establishment of SEPnet, which provided initial funding for 4 Theory appointments. The six partner universities (Royal Holloway, Kent, Queen Mary, Southampton, Surrey and Sussex) have worked together to advance and sustain Physics as a strategically important subject for the UK economy and its science base in the south east region. SEPnet has fostered an increase in regional research collaboration and networking focused around a set of research themes. Three of the four research themes have very strong participation from Royal Holloway, and the HTC is particularly regarded as a major success by the SEPnet Strategic Advisory Panel. SEPnet has also enabled wider contributions to the discipline, aimed at increasing its long-term sustainability, by driving a step-change in public engagement and outreach activity, and coordinating a new Employer Engagement programme.

Major Research Initiatives in 2008-13

Particle Physics: A major initiative, unforeseen in 2007, has been to diversify the experimental Particle Physics theme with the establishment of a new group in 2011 to work on direct searches for dark matter candidates by the appointment of two staff (Monroe, Nikkel), and the creation of the Dark Matter research laboratory in the department, through the award of new space and CIF funding. The group has significant expertise in the development of novel high-sensitivity particle detection techniques and has joined the Radiation Detection & Instrumentation (RDI) theme of SEPnet. The group has expanded rapidly, is already supported by 2 PDRAs and 5 PhD students, and has become a leading player in direct dark matter detection experiments. Monroe won an ERC Starting Grant and PDRA Walding won a Leverhulme EC Fellowship. The Accelerator Science group has expanded its research programme through creation of a new laboratory to support its

research on beam position monitors, in addition to the existing laboratory for laser-wire research. The group has also developed new strong collaborative research links with CERN, including three joint PhD studentships. The appointment of Gibson in 2013 strengthened the links between the JAI activity and the LHC high luminosity upgrades. **Theoretical Physics:** The key strategic aim, stated in our 2007 submission, of developing a strong profile in Theoretical Physics has been achieved in both the Particle Physics (PP) and Condensed Matter (CM) themes, with the initial support of SEPnet and STFC. There is a strong emphasis on promoting interactions between theorists and experimentalists. The new Theoretical Particle Physics group (Kauer, West) forms part of the SEPnet NExT Institute and is strongly aligned with our experimental programme on Dark Matter and LHC Higgs physics. The group has formed a partnership, within SEPnet, with the theoretical physics group at Sussex University, and were successful in their joint bid for STFC funding. The Condensed Matter Theory group was strengthened by several appointments (Coleman, Eschrig, Castelnovo – replaced by Sordi in 2013), establishing the Hubbard Theory Consortium as a partnership with SEPnet institutions, ISIS (which co-funded two of the positions) and the London Centre for Nanotechnology (LCN). Coleman, a leading authority in the field of strongly correlated quantum matter, is the Director of HTC. HTC brings together condensed matter theorists to work closely with experimentalists using world-class facilities in the department, at the Rutherford Appleton Laboratory (RAL; where it has a base) and at the LCN. HTC has rapidly established itself as a hub of excellence to promote interactions with leading theorists and experimentalists from all over the world. This has been achieved through the annual "Condensed Matter in the City" event, and a series of Advanced Working Groups, funded by SEPnet. **Condensed Matter Physics:** Several strong collaborations have been established with LCN and Cambridge, exploiting complementary facilities and core competencies e.g. a programme grant in the EPSRC grand challenge area of Quantum Physics for New Quantum Technologies (Nanoelectronic-based quantum physics: technology and applications). Most recently, Royal Holloway and UCL were partners in a bid for an EPSRC CDT in Condensed Matter, focussing on Quantum Matter, Devices and Technologies. This bid had NPL and Oxford Instruments Omicron Nanoscience as co-creators, featured partnerships with ISIS and Diamond, industry and several leading international laboratories and facilities but was unsuccessful at the full proposal stage.

A formal strategic partnership has been established with NPL (signed Sept. 2011), recognising our expertise in quantum devices and electron-beam lithography. This led to the joint appointment of Astafiev and of Tzalenchuk (0.2), reinforcing the nanotechnology group and the quantum technologies theme. The NPL partnership also reinforces prior collaboration with European National Measurement Institutes, particularly PTB (Germany), and has led to the award of 3 Research Excellence grants to Royal Holloway in different areas by the European Metrology Research Programme. The Quantum Matter theme has seen an expansion of funded activity, developing collaborations with several universities.

Clear vision for the future, from 2013 onwards

Particle Physics Strategy: Our programme will remain fully aligned with the relevant strands of the national and international strategies. Following the current shutdown for LHC upgrades to deliver data at significantly higher centre-of-mass energy and luminosity, the ATLAS group will exploit the new dataset's increased reach and precision, to continue its programme of Higgs and top-quark physics, and exotic particle searches. Work will continue on the upgrades of the triggering and data readout systems necessary for the subsequent LHC luminosity upgrades. The Dark Matter group strategy has two strands: (i) searches with world-leading sensitivity, via collaboration on a series of experiments to push the detection sensitivity frontier (MiniCLEAN, DEAP3600, LZ), supported by continued strong collaboration with RAL through the 5-year joint position proposed by RAL for Nikkel; and (ii) development of new particle detection technology, via activity based on our on-campus laboratory. The Theory group will continue to develop increasingly precise and sensitive techniques to assist in unravelling the properties of the recently discovered Higgs particle, as well as addressing questions on the evolution and composition of the early universe, and the nature of dark matter. This activity will continue to benefit from strong synergy with our experimental programme on ATLAS (Higgs, exotics) and Dark Matter. The Theory group will consolidate and grow by appointing one or two new academics, realigning the group following the departure of Blair. The Accelerator Science group will continue engaging in diagnostics for high power proton accelerators (Front End Test Stand, RAL) and developing novel operation modes of the Diamond Light Source. Internationally, the focus includes the LHC upgrade (beam and

background simulation; diagnostics) and diagnostics for the Linac4 injector. We will apply our world leadership in high energy electron beam diagnostics to a TeV-scale linear collider project, for which there is renewed interest following the Higgs discovery. More generally, we will support and develop our core competences in particle acceleration, particle detection, and triggering and data acquisition, that underpin our participation in current and future experiments, and will continue to engage in SEPnet-wide research collaboration through the NExT Institute and the RDI theme.
Condensed Matter Physics Strategy: We will continue the diversification of the London Low Temperature Laboratory, exploiting our new facilities, within the framework of the continuation of the European Microkelvin Consortium. The focus is the new challenge of quantum behaviour in nanoelectronic and nanomechanical devices cooled into the sub-mK regime, and quantum critical systems at ultralow temperatures. This will involve developing further our international partnerships. A key strategic aim is to develop our research into the priority area of quantum technologies, particularly in superconducting circuits, led by Astafiev, and to develop the partnerships with NPL and Oxford Instruments. We aim to build on the success of the Hubbard Theory Consortium, recognising the crucial strategic importance of a stronger engagement between theorists and experimentalists. The Quantum Matter group will diversify its programme of materials discovery for functional materials, combining in-house laboratory measurements with use of large scale facilities.
SEPnet 2 (expanded to include the Open University and the universities of Hertfordshire and Reading) has been funded by HEFCE over 2013-18, involving significant Royal Holloway investment. This will establish a regional Graduate Network (GRADnet), with primary objectives to develop and deliver an exemplar programme of transferable and leadership skills, promote employer engagement of PhD students through a variety of instruments, enhance research environment diversity by sharing best practice, and enhance impact via a collaborative strategy.

c. People, including:

i. Staffing strategy and staff development

Staffing strategy: In order to ensure the sustainability and vitality of our research programme, appointments of new staff are driven by strategic considerations both to consolidate the research portfolio, as well as expanding it into exciting new directions.
Ten staff left the department: 5 retired, 3 left for another university (Sussex, De Santo; Cambridge, Castelnovo; Lund/ESS, Molloy), 1 left to become Science Programme Director at STFC (Blair) and 1 left physics (McMahon).
The Department has been successful in hiring excellent academic staff from institutions from all over the world: 14 new staff were hired, across all research themes, roughly 1/3 from UK institutions and 2/3 from Europe, North America, Japan. PP theme: Monroe (from MIT, US) and Nikkel (Yale, US) to start the new Dark Matter group, and for the Accelerator Science group, Gibson (CERN, Switzerland) - replacing Molloy (SLAC, US). CM theme: Langford (Oxford) for the Quantum Devices group, Tzalenchuk (NPL; 0.2 FTE) and Astafiev (NEC Research Labs, Japan) for the Nanophysics group. Theoretical Physics theme: Coleman (Rutgers, US; 0.2 FTE), Eschrig (Karlsruhe, Germany), Sordi (ILL, France) - replacing Castelnovo (Oxford) - and Posazhennikova (Karlsruhe; 0.5 FTE); Kauer (Wurzburg, Germany) and West (Oxford). Excellence has continued to be recognised by promotion, with 8 staff promotions across all research themes, including 3 new professorships (Eschrig in Theory, Cowan and Monroe in Particle Physics).
The department is successful in attracting researchers who are awarded personal fellowships: Ho and Casey (EPSRC Advanced Research Fellowship), Ithier and Sharma (Leverhulme Early Career Fellowship), Langford (Marie Curie EU fellowship). Casey, Ho and Ithier became academic staff and Langford became a Senior Research Officer. Two other fellowships were awarded in 2012-13 (Faucci-Giannelli, Marie Curie EU; Walding, Leverhulme ECF), starting early 2014.
The assessment period has seen a large increase in the number of visiting academics, driven by project partnerships on EPSRC grants (eg Parpia, Sauls) and the HTC. Over 2010-13 the HTC attracted 36 leading international theorists through the CM in the City programme, with 100 UK speakers, and a further 44 leading international researchers through 4 Advanced Working Groups, with a total of 99 participants. This is a substantial and intellectually stimulating increase in “traffic”.
The number of PDRAs has seen a significant increase since Sept. 2007 and is now 32.5 (Sept. 2013), an increase of 77%. The fraction of women PDRAs increased from 6% to 20%.
The Department has strong levels of technical support. The well-equipped mechanical workshop supports the experimental work in our laboratories in both thematic areas, used by 4.4 FTE

research technician/instrument makers. There are 5 electrical/electronic/computing engineers, and a technician with responsibility for the helium liquefier. Three Research Officers support infrastructure in low temperature physics, nanotechnology and materials discovery, respectively. The GridPP facility at Royal Holloway is operated and maintained by a full-time Grid Computing Officer.

Staff Development: The University and the Department are strongly committed to the personal and career development of staff at all career stages: from post-doctoral research assistants and early career researchers to more established academic staff. For example, there is mandatory training for all members of selection panels including equal opportunities training, equitable treatment for part-time and fixed-term staff, clear and equitable promotions process. Royal Holloway actively endorses the principles outlined in the *Concordat to Support the Career Development of Researchers* and has policies and practices at both institutional and departmental level designed to facilitate full implementation of these principles. The training and development needs of all research and academic staff are identified via a well-established annual Appraisal scheme. Extensive staff development opportunities are offered, by externally provided courses, or by the institution's "On Track" established programme of workshops, and there is a comprehensive annual equality and diversity data monitoring and review exercise. All academic staff complete a structured Individual Research Plan annually, which is an integral part of the appraisal process. Take up of sabbatical leave is encouraged; since 2008, all requests for sabbatical leave have been granted. The annual workload allocation to staff is the responsibility of the Head of Department, using a quantitative workload model. Newly appointed academic staff have a probation period of three years, during which they have mentoring support and a lighter teaching load, to enable them to set solid foundations for their research career. The success of our diversity strategy is demonstrated by our recent awards of Juno Champion status in Sept. 2011 and Athena SWAN Silver in August 2012. Currently 30% of the academic faculty in the Particle Physics group are women. In 2013 Monroe became the first female Professor of Physics in the department. The department plays an important role in the Women in Science agenda of both the institution and SEPnet through exchange of best practice.

ii. Research students

Studentships are advertised in the departmental web pages as well as in external web sites. A Physics Postgraduate Open Day is organised every year for internal and external prospective students. Recently the Department has been recruiting an average of 13 students a year with diverse sources of funding. Presently STFC, EPSRC and SEPnet fund half of the studentships. Royal Holloway provides significant support for additional studentships, partially offsetting the discontinuation of Project Studentships by EPSRC. Physics has been very successful in obtaining "matched-funding" scholarships, part-funded by an external research partner. These studentships also play an important role in cementing collaborations with strategic external research partners (NPL, CERN, ISIS, Diamond, Harwell and industry). Research collaboration across SEPnet has been enhanced by a number of PhD studentships every year with co-supervisors at Royal Holloway and at another node; this is supplemented by SEPnet EuroMasters PGRs. The latter programme contributes to research training, with many students progressing to a PhD in SEPnet.

As part of Project Juno, the Department has been proactive in its effort to increase the fraction of female PGRs it recruits by, for instance, ensuring photos of researchers on show in the department and its publicity materials include female PhDs and PDRAs. The current PhD cohort has 49 students, an increase of 58% over 2008, and over the last two years the fraction of women in the PGR intake stands at 30%, which we attribute to Juno.

In addition to the research supervisor, every student is assigned an adviser (usually from the same research group as the supervisor) and a moderator (from a different research group). This team conducts the Annual Review of each PGR in the first three years of their studies, based around a viva, the student and supervisor's report and the student training log. The decision to upgrade MPhil students to a PhD registration is taken after the 1st or 2nd year viva. The Department's Postgraduate Forum, meeting termly, is chaired by a postgraduate student, reporting through the Director of Graduate Studies to the Departmental Board.

Royal Holloway has developed and runs a comprehensive Generic Skills Programme, of research training and career development courses/workshops, with the overall aim of helping students develop generic or transferable skills alongside their research skills. The Programme covers all the facets of the Vitae Researcher Development Framework, endorsed by RCUK and HEFCE.

Students can develop their teaching skills by taking the inSTIL programme (Skills of Teaching to Inspire Learning), and can participate in laboratory or problem class teaching. Students also receive training specific to their research area. Students in PP experiments and accelerator science take intensive four month lecture programmes delivered jointly within the University of London or JAI, respectively. PP theory postgraduates take courses delivered within NExT. Both theory and experimental students also attend two-week UK-wide schools (the BUSSTEPP and RAL Summer Schools, respectively) at the end of the 1st year, and normally attend an international school in the 2nd or 3rd year. The Annual NExT PhD Workshop provides additional training. CM postgraduates have access to training in their field, eg courses at Royal Holloway on neutron scattering, low temperature techniques, theory of condensed matter, as well as shared courses through SEPnet. They have attended the EPSRC Condensed Matter Summer School, and the international European Cryoschool. Training in programming for data acquisition is also provided. Since 2012, SEPnet students in both themes also benefited from the Grand Challenges conference.

d. Income, infrastructure and facilities

The Department's research programme is largely funded through UK Research Councils (EPSRC and STFC), but also with a significant and growing contribution (presently above 25%) from EU funding across the whole programme (accelerator science, dark matter searches, nanophysics, low temperature physics). The total research income over this period was in excess of £13.6M. Since 2008, the Department's research income has grown steadily, by 41% overall, from £2.4M/year to £3.4M/year. This is supplemented by annual in-kind contributions which, excluding the CERN subscription, are typically in excess of £0.8M (eg for beam time and use of facilities in ILL Grenoble, and in the UK's ISIS and Diamond Light Source), and have grown by 39% since 2008. Overall, research income from the EU has grown by more than a factor 4 since 2008.

The EPSRC portfolio stands at £3.8M (Sept. 2013) plus participation in the £6.5M UCL/Cambridge/RHUL Programme grant (PI Prof. Sir M Pepper). The Particle Physics group currently holds STFC grants of £2.5M (JAI), £2.1M (PP Consolidated) and £0.4M (ATLAS upgrade, GridPP); an ERC €1.1M grant (Dark Matter); and CERN and EU grants totalling £1.3M (Acc. Science). Institutional investment in equipment and infrastructure has been £2.2M (2008-13).

Since 2008 the Department has benefitted from a dedicated state-of-the-art videoconferencing room funded by SEPnet (£40k). This facility is key to support collaboration across SEPnet and beyond and is extensively used, e.g. for postgraduate training lectures and research seminars.

The establishment of the Dark Matter group and the growth and diversification in Accelerator Science has led to expansion in laboratory space and infrastructure. Furthermore, powerful advanced computing facilities at Royal Holloway, used by the local particle physics group and by the world-wide LHC community, have seen significant investment. The Dark Matter group benefits from shared space in a new laboratory, equipped to support its activity in the DMTPC and DEAP/CLEAN experiments. Infrastructure to support the development of the next-generation DMTPC time projection chamber includes fume cupboard and gas handling with ventilation to the roof. The DEAP/CLEAN activities include the design of the cryogenic system for the Liquid Argon detector, with supporting infrastructure. This was funded by a laboratory refurbishment grant, startup funds (£30k) for Monroe and a LANL LDRD grant agreement (£50k). The JAI is supported by two large multi-purpose laboratories and a laboratory dedicated to the operation of a high power laser. These laboratories are key for the development of accelerator components prior to deployment in beams at international facilities (CERN, DESY, KEK), and were funded with ca. £0.5M CIF and STFC funds. The conversion of existing spaces to provide laboratories adjacent to the Department is a demonstration of strong institutional support. The laboratory for optical and electromagnetic experiments was completed in 2009 and is equipped with low power lasers, optics, opto-mechanics, motion control and laser beam measurement systems. The optical systems have also been routinely used by other groups in the department, in CM and PP. A second, larger, laboratory was completed in 2011 and is sub-divided in two areas: one for the development of radio frequency devices such as accelerating cavities and beam diagnostics devices, the other to study devices for detection of microwave radiation produced by accelerated beams.

The Particle Physics group runs a dedicated computer cluster for data analysis, simulation and modelling. This key research resource for the group is upgraded regularly (£60k STFC funds in last 5 years). The group also operates a very high-performance Grid computer cluster. This is part of

the UK GridPP project, and is integrated into the "LondonGrid" (a collaboration with Brunel, IC, QMUL and UCL) and the distributed worldwide LHC Grid. This powerful facility, primarily for analysis of the very large LHC datasets, is located in a purpose-built state-of-the-art data-centre (an institutional investment of nearly £1M). The cluster has been expanded and upgraded every 3-4 years, with support from CIF (£200k since 2008) and STFC (£260k). Upgrades are planned for 2014 (ca. £300k) and beyond.

The experimental groups in Condensed Matter Physics exploit world class facilities in the London Low Temperature Laboratory at Royal Holloway to explore new states of quantum matter and devices whose operation is governed by quantum principles. The LLTL is a centre for fundamental research in the mK and μK temperature regime and the development of new instrumentation and thermometry, and a founding member of the European Microkelvin Collaboration. It is equipped with three nuclear adiabatic demagnetization cryostats. In the assessment period this attracted CIF investment of £0.8M, with additional support from Oxford Instruments, for a new facility to cool samples to temperatures below 1 mK in magnetic fields up to 9T, supported by a new cryogen-free dilution refrigerator. In addition, there are a further six dilution refrigerators and a modern helium liquefier. Most recently the set-up of Astafiev has been supported by £0.8M for low temperature facilities and equipment for quantum measurement, and investment is also anticipated at NPL. The Centre for Nanophysics and Nanotechnology has pioneered nano-scale devices fabricated by electron beam lithography. The group has expertise in the design, fabrication and measurement of nanostructures and has developed techniques to reliably fabricate small feature sizes in increasingly complex materials (both metals and semiconductors) in order to explore quantum effects at submicron length scales. Facilities include several clean rooms, e-beam lithography, ultra-high vacuum systems, an electron beam evaporator, a reactive ion etching system, pulsed laser deposition. The materials discovery programme is supported by growth facilities essential for growth of novel crystals and development of new nano-devices. The growth of nanostructures using Molecular Beam Epitaxy and Pulsed-Laser Deposition at Royal Holloway enables the production of devices with tailor-made physical properties. Single-crystal oxides are grown using an Image Furnace, supported by CIF investment of £130k in a new X-ray diffractometer.

e. Collaboration and contribution to the discipline or research base

Our research activity is underpinned by strong **national and international collaborations** in all our research themes. All the experimental research activity in PP is carried out in the context of multi-institute national and international collaborations (eg ATLAS; DMUK, DMTPC, DEAP/CLEAN; GridPP; JAI, CLARA, CLIC, ILC, LHC, ATF). In Theoretical PP there is strong collaboration within NExT, and many other collaborations, including with individuals at IPPP Durham; RAL; UCL; the Universities of Glasgow, Oxford, Sheffield, Southampton and Sussex; CERN; FermiLab; Los Alamos; MPI; Paris Institute of Astrophysics; SLAC; UC Berkeley; the Universities of Aachen, Florida, Torino, Wisconsin-Madison. In CM there are collaborations with international (national) project partners on funded EPSRC grants: Cornell, Northwestern, PTB, (UCL) (Casey, B Cowan, Saunders); CEA, PSI, (DLS, ISIS, Johnson-Matthey Technology Centre) (Goff). In addition, there are several EPSRC collaborative grants: (i) programme grant - Nanoelectronic based quantum physics, Cambridge/RHUL/UCL, (Casey, Nicholls, Saunders) with RHUL leading in 2 of 4 work packages; (ii) Cambridge (Niklowitz) (iii) Oxford (Goff) (iv) Bath/St Andrews/Leeds/ISIS (Eschrig). Collaboration with NPL and PTB is supported by 3 EMRP Research Excellence grants (Casey, Meeson, Saunders). The European Microkelvin Consortium (2008-13; Casey, Meeson, Saunders) is a collaboration of 12 leading institutions, with RHUL participating in 4 Joint Research Activities.

Most of our staff **review research grants** for national and international research councils, and other funding agencies. Casey, Coleman, Eschrig, Goff, Ho, Nicholls and Saunders are members of the EPSRC Peer Review College. Eschrig has refereed for the Leverhulme Trust. Boisvert, Cowan, Teixeira-Dias and West review applications for STFC Ernest Rutherford Fellowships, and Monroe is a member of the corresponding Selection Panel. Berry (from 2013) and Teixeira-Dias (2010-12) have served on the STFC Projects Peer-Review Panel. Goff is a member of the Diamond Engineering & Environmental Science Peer Review Panel, the ISIS Facility Access Panel (Large Structures), and the ESRF Beamline Review Panel for ID6 and ID20. Staff have also reviewed grants for US NSF (Coleman, Eschrig, Monroe, Saunders) and DOE (Coleman); Canada NSERC, ERC and Austria FWF (Coleman, Eschrig); France ANR (Coleman, Eschrig, Saunders); Germany DFG, Israel ISF and Netherlands FOM (Eschrig); Japan JSPS (Boogert, Saunders), Poland NSC (Monroe), Portugal FCT (West) and Switzerland SNSF (Sordi).

Coleman and Eschrig/Saunders are on the **Editorial Boards** of Reports on Progress in Physics, and Frontiers in Condensed Matter Physics, respectively. Moore (Emeritus; retired Sept. 2008) is on the Editorial Board of Crystallography Reviews. Most staff also **peer-review articles** for over 40 leading journals in the field, including JHEP, JINST, Nature, Nature Communications/Materials/ Photonics/Physics, NIM A, Phys. Rev. A, B and D, Phys. Rev. Letters, PNAS (USA) and Science.

Invited talks given at national and international meetings. **Particle Physics –** Berry: 1 (EPS2013); Boisvert: 5, including TOP2011, TOP2012, and plenary at IoP HEPP annual meeting 2013; Boogert: 2, incl. International Beam Instrumentation Conference 2013 and Linear Collider Workshop 2008; G Cowan: 8, incl. Rencontres de Physique (La Thuile 2009), and conference summary in PHYSTAT (Geneva 2011); Gibson: 9, including Lepton-Photon 2011, Vertex 2012 and ICHEP 2012. Karataev: 2 (RREPS'09, RREPS'11); Kauer: 18, including Les Houches Physics at TeV Colliders 2013; Monroe: 17 (4 plenary), including plenaries at APS April Meeting 2012 and IoP HEPP Annual meeting 2012; Nikkel: 2; Teixeira-Dias: 3, including UK HEP Forum 2010; West: 4, including plenary at Particle Physics and Cosmology 2011 and Rencontres de Blois 2011. **Condensed Matter Physics –** Antonov: 2, including MSFA2013; Astafiev: 19, including plenaries at Moriond 2008 and ISS2008; Casey: 4, including QFS2010, and LT26; Coleman: 27, including Strongly Correlated Electron Systems 2012 and 2013; Eschrig: 20, including APS March Meeting 2010; Goff: 7, including TEMM2013; Ho: 8; Kay: 1; Lusher: 2; Meeson: 4; Niklowitz: 3; Petrashov: 12, including keynote at 1st Annual Congress of Nano-S&T 2011 and the Sir Nevill Mott Lecture 2011; Saunders: 33, including APS 2008, 2009 (Nyeki) and 2013, German Physical Society 2012, LT25 (half-plenary), LT28 (Levitin, Nyeki), KITP 2011, SCES 2011, and keynote at QFS 2013; Sordi: 7, including APS March Meeting 2011; Tzalenchuk: 23, including Graphene Week 2010 and MSIGN-NT11. Our staff have also been invited lecturers at a number of **national and international schools**: Astafiev (3), Coleman (9), G Cowan (27), Eschrig (3), Goff (1), Karataev (2) and Tzalenchuk (2).

Advisory Board membership/leadership: Berry is an elected member of the ATLAS Collaboration Speakers Committee. She is a member of the UK PP Users Advisory Committee and is the UK representative on CERN's Users' Advisory Committee. Goff chairs the ISIS User Committee and is on STFC's Science Board. Teixeira-Dias is a member of the ATLAS Collaboration Boards (UK, CERN). G Cowan and Teixeira-Dias have been members of the STFC Oversight Committees for the ZEPLIN III project (2008-10) and the Upgrade of the LHC CMS experiment (from 2010), respectively. Meeson chaired the Evaluation Committee for the FP7 Single Cooper Pair Electronics project. Eschrig is on the Board of Governors of the International Institute for Complex Adaptive Matter (I2CAM).

B Cowan is a member of the IoP committees for Degree Accreditation and for Education. He served on the IoP Professional Standards Committee until 2010. Meeson served on the Strategic Advisory Committee for IoP Publishing until 2009. Meeson (up to mid-2008) and Saunders (2011-2014) have chaired the IoP Low Temperature Group, and both were members of the Selection Committee for the International Simon Memorial Prize in Low Temperature Physics (Meeson was Chair in 2008). Saunders is Secretary of the IUPAP Commission on Low Temperature Physics (C5). Goff has influenced policy, giving evidence on scientific infrastructure to the House of Lords Science and Technology Select Committee in 2013. Saunders was a Scientific Advisor to the Academy of Finland (2006-2009). We are fully engaged with the **Women in Physics & Women in Science** agendas: Berry led the successful departmental bids for Juno Champion status and Athena Swan Silver, and is a member of the IoP Project Juno University Assessment Panel. She has been an invited speaker at several project Juno workshops, and at the Women in Physics summer meeting at IoP London. Boisvert is a member of the Royal Holloway Women in Science Steering Group that coordinated the institutional bid for Athena SWAN Bronze and now coordinates the preparation for the Silver award. Monroe is a member of the STFC Women in Science, Engineering and Technology Focus Group.

Our contribution to the vitality of our fields includes taking active roles in the **organisation of national and international conferences and workshops**. **International conferences and workshops** organised include: Workshop on Top Quark Physics TOP2012 (Winchester; Boisvert, Chair); 19th and 20th RD50 Radiation Damage workshops (CERN 2011, Bari 2012), and 1st and 2nd Workshops on Radiation Damage in Silicon Detectors (CERN 2011, 2012), co-organised and chaired by Gibson; Symposium on Radiation from Relativistic Electrons in Periodic Structures -

RREPS (Royal Holloway 2011; Karataev, Chair); Workshop on Theory-Experiment Interplay at the LHC (Royal Holloway 2010; Kauer, Chair); APS Particles and Fields Annual Meeting (Providence 2011; Monroe); Workshop on Advanced Computing and Analysis Techniques in Physics Research (Uxbridge 2011; Teixeira-Dias); 1st and 2nd conferences on Mesoscopic Structures: Fundamentals and Applications (Russia 2010, 2013; Astafiev); Theoretical and Experimental Magnetism Meeting (Abingdon 2013; Eschrig, Chair); Int. Conference on Neutron Scattering (Edinburgh 2013; Goff); ULT2008 – Frontiers of Low Temperature Physics (satellite conference to LT25, RHUL 2008; Saunders, Chair); Materials Research Society Fall Meeting (Boston 2013; Tzalenchuk) and Graphene Conference: from Research to Applications (Teddington 2012; Tzalenchuk). Since the conference series was founded in 2010, members of the CM Theory group (Castelnovo, Coleman, Eschrig (Chair), Ho, Sordi) have led the organisation of all 4 meetings of the Condensed Matter in the City international programme. Membership of **International Conference Advisory Committees** includes Boisvert (TOP2013, Chair), Karataev (RREPS'11, RREPS'13), Coleman (SCES 2010-13), Eschrig (ICTQP2012) and Saunders (LT conference series, and 6 other advisory committees).

We have also participated in the organisation of numerous **national meetings**, including the SEPnet NExT Physics meetings (Royal Holloway hosted 3, in 2008, 2010, 2012) and NExT PhD Students workshops, the SEPnet Grand Challenges Conference 2012, an IoP workshop on Thermoelectric Energy Solutions (2011; Goff), 6th Bio-diagnostics meeting (Royal Holloway 2011; Lusher), IoP LT group meeting (Royal Holloway 2010; Lusher). Casey chairs the Annual IoP Low Temperature Techniques course. We have also taken leading roles in the major national conferences in both our thematic areas: we have co-organised two of the Annual IoP Condensed Matter and Materials Physics conferences (Royal Holloway 2008, Meeson, Chair; Warwick 2009, Meeson), and will be organising and hosting the Annual IoP High Energy and Astro Particle Physics conference in 2014.

The following are partners in **industrial collaborations:** FMB Oxford (Boogert); Andor Technology, Schlumberger (Monroe); NPL (CM group); Optisense Ltd (UK), GN Optics (Russia) (Antonov); Oxford Instruments Nanoscience (Casey, Saunders); Jaguar Land Rover, European Thermodynamics, Johnson Matthey Technology Centre (Goff). Eschrig is a core member and RHUL node leader of the **interdisciplinary project** (EPSRC NetworkPlus) Emergence and Physics far from Equilibrium.

Indicators of Research Esteem: Scientific leadership positions – On the ATLAS experiment G Cowan has convened the Statistics Forum (2009-12), PDRA Gonçalo convened the Higgs bb searches group (2010-12), PDRA George is the Trigger Coordinator (2012-14), and Green is the lead Engineer for the upgrade of the data readout buffers; in the UK, we convened the ATLAS working groups for Higgs searches (Gonçalo, Teixeira-Dias), SUSY/Exotics (Berry) and top-quark physics (Boisvert). Boogert convenes the ICFA and ECFA QCD and top-quark group, and is Deputy Director of JAI. Gibson led the ATLAS SCT tracker alignment system (up to 2010), and manages the Accelerator Diagnostics WP for the RAL Front End Test Stand. Monroe is Spokesperson of DMTPC collaboration since 2011, and was Deputy Chair for DEAP/CLEAN in 2012. Nikkel is on the MiniCLEAN Scientific Board. Meeson is a member of the EMT working group for the National Measurement Office. Sordi is on the Scientific College of ILL. Tzalenchuk is Principal Research Scientist and Knowledge Leader: Time, Quantum & Electromagnetics Division at NPL. **Prizes, Awards and other noteworthy distinctions –** Astafiev was the recipient of the RIKEN Frontier Research System Grand Award (2008) for achievements in research of Single Artificial Atom Maser. Coleman is co-Director of the Institute of Complex Adaptive Matter (ICAM). Coleman wrote Invited Perspective/News and Views for *Science*, *Nature* and *Physics*; Saunders an Invited Perspective for *Science*; Eschrig a feature article in *Physics Today*. G Cowan is the Editor of the Probability, Statistics and Monte Carlo Techniques chapters of the Review of Particle Properties. Langford received the 2012 Australian Optical Society Geoff Opat Early Career Researchers Prize for contributions to the field of optics. Petrashov is a co-founder of the Metallic Nanoelectronics field and supervised many students in this area, including A Geim and K Novoselov (Physics Nobel Prize 2010). Tzalenchuk received the NPL Rayleigh Award (2011) and the Serco Global Pulse Award (2011) for work on graphene, and is a nominator for the Nobel Prize in Physics. His work on the Quantum Hall effect in graphene was cited in the scientific background on the 2010 Nobel Prize.