Institution: University of Sheffield

Unit of Assessment: 9 - Physics

a. Overview

The unit underwent a major renewal over the period of RAE2008, with substantial investments in both staff and physical infrastructure. Over the last 6 years the unit has capitalised on these investments as part of its overall goal of achieving sustained research excellence.

In terms of vitality and sustainability, over the REF2014 period the unit has made strategic staff appointments that strengthen all of its research groups (10 new appointments in total); grant funding has increased by 93% (from £4.3M to £8.3M p.a. in awards between 07/08 and 12/13); and all of the younger members of staff appointed as lecturers in the RAE2008 period have subsequently been promoted through at least one level (Daw, Kok, Wilson), and many through two or more levels (Costanzo, Crowther, de Grijs, Golestanian, Goodwin, Hobbs, Kudryavtsev, Paganis). The unit currently hosts 44 PDRAs/research fellows and 80 research students; its staff delivered more than 200 invited talks at international conferences over the REF2014 period, and published 16 papers in Science or Nature family journals and 22 in Physical Review Letters; they also made leading contributions to the ATLAS Higgs paper and other highly cited LHC papers.

The research portfolio of the unit is broad-based, with a healthy balance between EPSRC- and STFC-funded research activities. It is organised into four main research groups as follows.

Inorganic semi-conductors (IS) group: Burnett, Chekhovich, Cockburn, Fox, Kok, Krizhanovskii, Mowbray, Skolnick (head), Tartakovskii, Whittaker, Wilson. This group is active in nanoscale semi-conductor physics, photonics and the control of interactions between light and matter. Research ranges from single quantum dot and Bose condensation phenomena, to quantum cascade and quantum dot laser device physics.

Soft matter physics (SMP) group: Buckley, Cadby, Clark, Clarke, Geoghegan, Grell, Hawkins, Hobbs, Jones, Lidzey (head). This group uses both experimental and theoretical approaches to investigate the physics and technological applications of polymers, organic semiconductors, biological materials, imaging, photonics and instrumentation. The group is highly interdisciplinary, and works closely with chemists, biologists, biochemists, electronic engineers and social scientists.

Particle physics and particle astrophysics (PPPA) group: Anastopoulos, Booth, Cartwright, Costanzo, Daw, Kudryavtsev, Paganis, Spooner (head), Thompson, Tovey. The PPPA group focusses on four core STFC areas: Particle Physics (ATLAS exploitation), Neutrino Physics, Dark Matter and Underground Science, and Gravitational Waves.

Astronomy and astrophysics (AA) group: Crowther, Dhillon, Goodwin, Littlefair, Mullaney, Tadhunter (head). This group has a burgeoning observational activity focussing on the building blocks of galaxy evolution (Crowther, Mullaney, Tadhunter), and high time resolution astrophysics (Dhillon, Littlefair), underpinned by theoretical work on simulations of star formation and star cluster evolution (Goodwin).

b. Research strategy

The overarching research vision of the unit is to undertake world-leading research in physics and astrophysics, with sufficient breadth and diversity to allow agile responses to emerging research opportunities and a changing funding environment, but sufficient depth and focus to ensure sustained research excellence in all of its main research areas.

Over the last six years the unit's research strategy, consistent with its stated research strategy at the time of RAE2008, has been as follows.

- **To grow sustainably the four research groups in the unit in order to ensure their balance and vitality**. To this end, the unit has made strategic appointments of 10 academic staff members across its research portfolio over the REF2014 period (see below for details). This process has been aided by the introduction (in 2012-13) by the University of its Vice

Chancellor's Fellowship (VCF) scheme that invites excellent candidates from all research disciplines to apply for 3-year (VCF) or 5-year (AVFC) fellowships leading to permanent contracts. There were no subject-specific quotas for this scheme and the unit was disproportionately successful in attracting excellent recruits: candidates for the unit won 3 out of 16 of the VCF/AVCF fellowships awarded, from a total pool of more than 800 applicants.

- **To increase the relative level of theoretical research activity in the unit as a whole** by appointing theorists strategically to complement existing experimental activities, both within the department and across the wider campus. New appointees are integrated into the relevant research groups, rather than a standalone theory group. Over the REF2014 period the unit made new theory appointments at both senior (Clarke) and early career (Hawkins) levels.
- **To further enhance the unit's engagement with knowledge transfer and impact activities**. In response to funder priorities, we have intensified our focus on applied work and its translation to non-academic impact (see REF3a). In particular, the unit has appointed a new lecturer from a commercial background who has a recent track record in technology development and scale-up to manufacture and production (Buckley). Such direct industrial experience is rare in an academic science department, and critically gives the unit an enhanced awareness of the needs of industry – particularly regarding issues such as scale-up and manufacturability – when developing new technology or exploring basic science. Buckley's interest and experience in systems and devices has also opened a number of opportunities for public engagement and participation in research, particularly that involving social scientists. This has been facilitated in part by the investment of the University in the Sheffield Solar Farm. The unit has further expanded its knowledge transfer activities through the engagement of the PPPA group with various external partners; building on its experience in detectors and underground science, the group has seen a major growth of non-STFC, industry, DECC and HMO spin-out research activity (total funding £3M over the REF2014 period).
- **To be responsive to new research opportunities, particularly for cross-disciplinary research**. The cross-disciplinary nature of the unit's research is highlighted by the fact that, over the REF2014 period, members of the unit have been involved as PI or co-I in 24 successful joint grant applications with 14 other academic departments in the University of Sheffield (total Physics grant share: £4.5M). As well as its long-standing cross-disciplinary activities with the departments of Chemistry, Electronic and Electrical Engineering and School of Mathematics & Statistics at Sheffield, the unit has enhanced its links with the biology departments, the Medical School, and the department of Chemical and Biological Engineering in the sphere of biophysics research via the new appointments of Cadby, Clarke and Hawkins, and the transfer of Hobbs' research effort from Chemistry to Physics. On the STFC-funded side of the unit's research activity, collaboration with the University of Durham provides the AA group with access to dedicated facilities for high time resolution astrophysics research on La Palma (0.5m telescope), and a recent agreement between the group and the Thai National Observatory, centred on the Sheffield-built ULTRASPEC instrument, gives the group access to 30 nights per year on the newly-built Thai 2.5m telescope. In addition, the group has joined the LOFAR collaboration, providing access to wide-field, high time resolution radio observations of the cosmos. The collaboration between Daw from the PPPA group (LIGO gravitational wave analysis) and Dhillon from the AA group (high time resolution astrophysics), supported by a joint PhD studentship and access to LOFAR, places the unit in an excellent position to lead the ground-based follow up of the first gravitational wave detections with the upgraded LIGO.

As well as maintaining its existing broad research strategy, beyond REF2014 the unit has the following additional goals for the development of its research.

- **To further enhance the unit's position as a world-leading centre for research by building upon existing strengths**, such as quantum information science (based on III-V semiconductor technology), ultrafast spectroscopy, high time resolution astrophysics, and the next-generation particle physics experiments (e.g. ATLAS upgrade, LBNE).

- **To further enhance cross-disciplinary research activities.** In addition to establishing an international reputation with emerging fields, this will enable the unit to become more responsive to new initiatives, and decrease its reliance on a small number of research funders. For example, the new £0.5M Biophysical Imaging Centre (see section d.) will provide a focus for collaboration between physicists and biologists, and open new funding streams. Thompson's £0.6M DECC- and Premier Oil-funded collaboration with Durham, Bath and Newcastle on muon tomography of carbon sequestration sites is a promising model for future involvement of the unit in interdisciplinary research that tackles global environmental challenges. The unit also plans to further enhance links with the School of Mathematics and Statistics (SOMAS) at the natural interface between the two subjects, in particular to develop links with mathematical biology (Hawkins) and uncertainty modelling (Clarke). The unit will support and nurture all these new activities, with the aim of developing them to the stage where they become platforms for larger funding that supports whole groups, to ensure our research standing beyond 2020.
- **To use EPSRC-funded CDTs to increase the number of PhD students in the department.** Funding has already been approved for a £4M CDT in "New and Sustainable Photovoltaics" with Oxford, Liverpool, Bath, Cambridge, Loughborough and Southampton. This will provide 6 additional studentships over the next 5 years.
- **To appoint at least three University Teachers in the next REF period**. This will enable the unit to continue to deliver a high-quality undergraduate experience, whilst ensuring that academics with both research and teaching responsibilities are able to continue to develop world-leading research programmes. Funding for two such teachers – one in physics and the other in astronomy – has already been approved, and a further position is planned.

c. People:

i. Staffing strategy and staff development

The unit's staffing strategy focuses on recruiting the highest calibre of staff, their support and development, and the provision of an excellent, fair and equal environment in which to flourish. Maintaining the unit's research culture and quality standards ensures a self-motivated, mutually supportive and committed workforce.

Informed by its research strategy, as well as its undergraduate and postgraduate recruitment position and the overall funding environment, the main goal of the unit's staffing strategy has been to make strategic appointments of young academic staff, to ensure vitality, critical mass and sustainability of our four research groups. Over the REF2014 period the unit has succeeded in this goal, with 9/10 of new appointments over the period having ages <40 when they were offered open-ended contracts. Currently, the average age of research-active staff on permanent contracts, or fellowships leading to permanent contracts, in the unit is 45. The unit now has a well-balanced distribution of senior and junior staff, and has the capacity to expand further its research portfolio.

On a group-by-group basis, the unit's staffing strategy over the period of REF2014 has been implemented as follows.

Inorganic semi-conductors (IS) group. The IS group has been strengthened very considerably by the appointments of EPSRC ARFs Tartakovskii and Krizhanovskii to permanent academic positions. These appointments have allowed the group to open up and maintain new, highly productive areas of research in spin phenomena and polariton physics, respectively. Further additional long-term impact will be derived from the recent appointment of Chekhovich to a VCF in the new area of nuclear magnetic resonance in semiconductor nanostructures.

Soft matter physics (SMP) group. The theory aspect of the SMP group has been strengthened by the appointment of Clarke (chair) and Hawkins (lectureship), whose interests lie in polymer physics and cell dynamics, respectively. The promotion of Cadby (organic and biological nanostructures) from an EPSRC ARF to a lectureship has further strengthened the group's activities in biophysics, while the appointment from industry of Buckley (photovoltaic systems and

devices) has advanced the knowledge transfer agenda in both the SMP group and the unit as a whole. Most recently, the appointment of Clark to an AVCF has brought to the group a wealth of experience in ultra-fast optical spectroscopy of organic semiconductors. Clark's expertise will lead to a significant expansion of activity in the study of excited state dynamics in a range of material systems, including high-mobility organic semiconductors and natural and synthetic light harvesting systems.

Particle physics and particle astrophysics (PPPA) group. The recent appointment of Anastopoulos – currently leader of the ATLAS Higgs to 4-lepton analysis working group – to a Leverhulme Fellowship gives the group leadership of one of the highest profile analyses being carried out at the Large Hadron Collider. The Sheffield ATLAS group is already very active in the area of Higgs searches via the work of Paganis and his team of post-docs and students; the appointment of Anastopoulos will further bolster that activity as the focus shifts from searches for the Higgs boson to detailed measurements of its properties.

Astronomy and astrophysics (AA) group. The appointment of Littlefair to a new lectureship following his RCUK fellowship allowed the group to further strengthen its research effort in high time resolution astrophysics, based around the exploitation of the ULTRACAM and ULTRASPEC instruments. The more recent appointment of VCF Mullaney – who works on deep field studies of galaxy evolution and AGN activity – provides an important bridge between studies of galaxy evolution at high redshifts and the existing research of Crowther, Goodwin and Tadhunter on systems in the local Universe. This places the group in a strong position to exploit the new generation of large astronomical facilities such as ALMA, JWST and E-ELT.

Academic staff development. All new academic staff members appointed on permanent contracts have their teaching and administrative duties built up gradually over a period of 3–5 years, in order to allow them to concentrate on developing their research activities; they are also allocated a senior member of staff as a mentor over their three year probationary period, provided with start-up funding, and given priority in the allocation of PhD students. This is part of the unit's strategy of encouraging all academic staff at an early career stage to become research leaders, even if they are members of larger research groups. This strategy has proved successful in the sense that all the younger members of staff appointed to lectureships in RAE2008 have subsequently been promoted through by least one level (to Senior Lecturer), and many through two or more levels (to Reader or Professor); of the 11 staff appointed to lectureships in the RAE2008 period 8 (73%) were promoted to either Reader or Professor in the last 6 years, and two were subsequently appointed to chair positions at other institutes (Golestanian: Oxford; de Grijs: Kavli Institute Beijng).

As part of our commitment to continuing staff development, all academic staff are interviewed annually by senior academics under the auspices of the Staff Development and Review System (SRDS). This is a reflective process that results in a series of targets for individual academics for the following year, in line with the strategic priorities of the unit. The unit also has a system of targeted sabbaticals that allow established staff to extend and diversify their research and impact activities. For example, such sabbaticals allowed Tovey to cement his role as ATLAS UK spokesperson, Thompson to lead a major new project on muon monitoring of carbon sequestration sites, and Dhillon to further develop his astronomical instrumentation programme, culminating in the award of an ERC Advanced Investigator grant to develop a major new instrument (HIPERCAM); in total, 8 established academic staff took sabbaticals over the REF2014 period (Tovey, Crowther, Goodwin, Hobbs, Cockburn, Dhillon, Spooner, Thompson). In addition, three senior members of academic staff (Geoghegan, Clarke, Crowther) have benefited from the Sheffield Leader Programme (senior level), which involves 3x3-day residential courses.

Recruitment and development of staff on fixed-term contracts. In 2012 the University was awarded the *HR Excellence in Research* award by the European Commission and remains committed to applying the 7 principles of the *UK Concordat for the Career Development of Researcher*s. In particular, there is an established University-wide framework for recruitment and

selection which applies to all posts, irrespective of whether they are fixed term or open-ended. Fixed-term contract (FTC) researchers are on the same salary scales as permanent staff, and our salary scales are comparable with other, research-intensive HEIs, so that we can be confident that FTC researchers are treated equally both internally and within the sector. Such equality of treatment also extends to staff development, and all FTC researchers are reviewed annually as part of the SRDS scheme (see above). We note that 12 of our current RAs have been moved to open-ended contracts, reflecting their length of service and enabling them to develop their own research careers by applying for grants. For example, all three of the EPSRC Advanced Fellows hosted by the unit over the REF2014 period have gone on to be appointed to permanent academic posts, and all have won substantial independent research funding as PIs (Cadby: £530k; Krishanovskii: £180k; Tartakovski: £680k), in addition to their major contributions as co-Is to other grants (total share: £3M).

Dedicated support for the professional development of contract research staff is provided under the auspices of the University of Sheffield *'Think Ahead'* programme. This comprises a comprehensive blend of training workshops, career mentoring, and carefully selected work-based opportunities. It aims to ensure that every researcher has a career trajectory and access to tailored development activities, including the flagship SURE (Sheffield Undergraduate Research Experience) scheme for ECR primary supervision of summer student projects. The Faculty of Science has a member of professional development staff dedicated to ensuring that opportunities for professional development are promoted. An exemplar of the professional development activities for FTC researchers is *'The Sheffield Crucible'*. This flagship programme has invested £160k to offer participants 3 intensive residential workshops focussing on**:** (1) the role of researchers and research in society; (2) opportunities for collaboration within research; and (3) the individual skills required to be a more innovative, enterprising and creative researcher.

The success of the unit in developing FTC researchers is reflected in the fact that 10 of the RAs/research fellows working in the unit over the REF2014 period have gone on to be employed as permanent lecturers or senior research scientists in universities and research institutes in the UK and further afield.

Equality and Diversity. The unit is committed to equality and diversity in the recruitment and support of research staff. All chairs of recruitment panels are required to have undergone diversity and equality training. In addition, all recruitment panels for academic staff in the unit have at least one female member. Mowbray – who was HoD for most of the REF2014 period – is also a member of the Faculty of Science and University Diversity and Equality Committees.

The unit is currently strengthening its commitment of diversity and equality through its engagement with the Athena Swan initiative. The University of Sheffield already holds an Athena Swan Bronze Award, and the Department of Physics & Astronomy recently submitted an application for an Athena Swan Bronze Award.

ii. Research students

The unit has a large and vibrant research student community, with more than 80 PhD students from many disciplinary backgrounds working across all areas of the unit's research portfolio.

The Graduate Student Committee – comprising senior academics representing the four research groups, as well as PhD student representatives – is responsible for managing recruitment, allocation of students to academic staff, mentoring, pastoral care, training, oversight of the University Doctoral Development Programme (DDP), and monitoring PhD student progress.

The PhD opportunities in the unit are widely advertised in UK physics departments; we also hold a specific event for Sheffield undergraduate students to advertise the postgraduate research opportunities; and all UK PhD student candidates are interviewed by at least two staff. Proactive recruitment includes our undergraduate summer studentship programme, which is supported by a variety of sources including the University of Sheffield SURE scheme, EPSRC, the Nuffield Foundation, the Institute of Physics and the Royal Astronomical Society. Over the REF2014 period

the unit has hosted more than 50 such studentships (typically 8 each year).

Most PhD students in the unit are funded through our existing EPSRC and STFC PhD DTG quotas (a total of 8–12 students per annum). However, the recent expansion in fully-funded departmental, faculty and university PhD scholarship schemes has allowed the unit greater flexibility in recruiting high-quality UK, EU and overseas students. Typically the unit recruits 2–3 PhD students per year through the latter scholarship schemes; its recruitment of self- and government-funded overseas PhD students also remains buoyant, with typically 3 such students recruited each year.

Along with the subject-specific training provided by the PhD projects, all PhD students participate in the Doctoral Development Programme (DDP) – a pioneering, innovative approach to doctoral training, noted positively by the QAA. The process commences with the student and supervisor carrying out an individually tailored training needs analysis (TNA), from which a bespoke training programme is designed (incorporating mandatory and non-mandatory components). The DDP is a flexible, on-going training plan that is an integral part of a research degree, and is tailored to individual needs. The aim is to provide PhD students with a range of skills and competency-based training opportunities focussed on enhancing their specific study and equipping them with transferable skills that extend their employability. Mandatory training activities include: a literature review in the 1st year; completion of reports at the end of the 1st and 2nd years; and presenting a talk to fellow postgraduate students and academic staff at a departmental mini-conference in the 3rd year. These are supplemented by subject-specific lecture courses, and generic skills training modules, depending on the training needs of the individual student. Examples of generic skills modules include: Communicating Science to the Public; Thesis Writing; Speaking Skills for Research Purposes; and Ideas to Enterprise. PhD students also benefit from access to the rich *Think Ahead* framework of support (described above).

Every student is allocated a second supervisor from the same research group who monitors progress against the TNA. In addition to the second supervisor, each PhD student is allocated a mentor from a different research group who has a more pastoral role, providing general advice on progress and development throughout the period of the PhD. Progress is formally monitored every 6 months. Initially, all students start with a probationary PhD status, with a decision on progression to the full PhD made at the end of the first year of full-time study, on the basis of rigorous assessment of the 1st year report, literature review and a formal interview with the 1st and 2nd supervisors. The success of the unit's PhD training is demonstrated by the fact that, over the period of REF2014, its PhD students have won poster or talk prizes at 9 international conferences; 3 students have won EPSRC Prize Fellowships; 1 has won a prestigious CERN fellowship; and 2 have been appointed to permanent academic posts.

d. Income, infrastructure and facilities

The research grant income of the unit has been buoyant over the last six years, with awards rising by 93%, and grant spend rising by 28%, over the REF2014 period, despite a challenging overall funding environment; compared with the last 5 years of the RAE2008 period, the research grant income has risen by 60% (from £18.9M to £28.3M in spend). The research activities in the department are funded through grants provided by the UK research councils (primarily EPSRC and STFC: 86% of total funding), the EU (7%), and various government departments, charities, industrial and overseas sources (7%).

Notable individual grant awards include two EPSRC programme grants supporting the IS group (PI Skolnick: £2.9M and £4.9M); two ERC Advanced Investigator awards (PI Skolnick: €2.1M; PI Dhillon: €3.5M); a large EPSRC responsive mode grant to support research on organic photovoltaics (PI LIdzey: £0.95M); an EPSRC cross-disciplinary (C-DIP) grant (PI Buckley: £1.3M); STFC particle physics rolling/consolidated grants (PI Spooner: £5.5M in total); an STFC astronomy consolidated grant (PI Tadhunter: £0.9M); and a DECC award with Premier Oil for muon tomography (PI Thompson: £0.6M). Many of these grants extend well beyond the REF2014 period, thus ensuring the long-term stability of the unit.

The unit's experimental research groups are housed in state-of–the-art laboratories in the Hicks building as a result of a 10-year rolling programme of refurbishment. As well as these dedicated facilities, the IS and SMP groups benefit from the close proximity in Sheffield of the £28.5M National Centre for III-V technologies (incl. 3 molecular beam epitaxy (MBE) and 2 metal organic chemical vapour deposition reactors (MOCVD), electron beam lithography, reactive ion and inductively coupled plasma etching, plasma enhanced CVD etc., all housed in 550m^2 clean rooms). The SMP group also has access to the Sheffield Surface Analysis Centre (SSAC), with its facilities for X-ray photoelectron spectroscopy (XPS), secondary ion mass spectrometry (SIMS), atomic force microscopy (AFM), and spectroscopic ellipsometry.

Research capabilities in the unit are further enhanced by a dedicated team of workshop technicians capable of carrying out entire instrument projects in house, from the mechanical design stage all the way to final manufacture, general-purpose clean-room facilities, and the expertise of a specialist cryogenic engineer. All of these facilities were crucial, for example, in the development of the ULTRACAM and ULTRASPEC instruments by the AA group, and the LHC upgrade activities of the PPPA group.

Following the major £6.3M upgrade of the unit's physical infrastructure over the period of RAE2008, including refurbishment of 95% of its research laboratories, the purchase of a helium liquifier and the re-cladding of the Hicks Building, investment in new equipment over the REF2014 period has included the following (total value £2.2M).

- The IS group has purchased a streak camera (UoS: £150k), a vector magnet (EPSRC: £195k) and a new ultrafast laser (EPSRC: £105k).
- The AA group has joined the LOFAR collaboration (UoS: £50k), and has obtained access to dedicated telescope facilities in La Palma (0.5m; UoS: £10k) and Thailand (2.5m; Leverhulme: £65k), which will be used for high time resolution astronomy.
- The SMP group has purchased four AFMs (UoS, EPSRC, Procter & Gamble: £710k), a STORM microscope (BBSRC, DOE: £70k), a spectroscopic ellipsometer (£75k), and a USI Industrial spray-coater system (UoS: £75k), a laser scanning microscope (BBSRC: £100k), and an epi-fluorescent microscope (MRC: £100k); it has also obtained funding for the Sheffield Solar Farm (HEIF: £120k).
- The PPPA group has been awarded £376k for GridPP computer upgrades, including £100k from a digital infrastructure bid (DRI) to increase the data transfer rate of GridPP computing cluster in Sheffield. It has also been awarded £100k by EPSRC for a new DT neutron source for particle physics-related industrial research.

Future plans for infrastructure developments that have already been approved for funding by the University of Sheffield include the building of a new Biophysical Imaging Centre (BIOCEN) in the Hicks Building (PIs Hobbs and Cadby, £500k, starting mid-2014), as well as the purchase of two new AFMs (£450k), and a fluorescence lifetime imaging microscope plus assorted optical equipment to support the SMP group (£250k).

Considering external facility usage, the AA group has continued to be highly successful at winning allocations on heavily over-subscribed international telescope facilities. Over the REF2014 period the observational astronomers in the AA group have been awarded as PI 70 nights on 4m-class telescopes, 31 nights on 8m-class telescopes, 54 orbits on the Hubble Space Telescope, 32 hours on the Spitzer Space Telescope and 38 hours on the Herschel Observatory. This is the financial equivalent of more that £4.5M for the ground-based facilities alone.

Further evidence of multi- and or interdisciplinary developments leading to grant capture. One of the mechanisms used to encourage interdisciplinary research at the University of Sheffield is the establishment of cross-faculty studentship networks. So far, 12 networks funding 38 PhD students, working on separate but linked projects, each with two supervisors based in different faculties, have been awarded. **Photovoltaic Futures** was sponsored by this scheme under the Energy and Environment theme, and the following year the Physics & Astronomy based

coordinator (Buckley) was successfully awarded a £1.3m EPSRC grant under the C-DIP programme. The same group has also used the student network to secure industrial funding and demonstration work. A further PhD network (**Deep Carbon**), involving the departments of Physics, Civil Engineering and Law, led to major DECC funding (£0.6M) for the PPPA group.

e. Collaboration or contribution to the discipline or research base

Over the period of REF2014, individual members of the unit have made substantial and varied contributions to the broader research base at both national and international levels.

Awards, fellowships and international invited talks. **Skolnick:** elected FRS (2009) and foreign member of the Russian Academy of Sciences (2011); **Jones:** IoP Tabor Medal and Prize for Nanoscience (2009); **Dhillon:** Jackson-Gwilt Medal of the Royal Astronomical Society (2013) for innovation in astronomical instrumentation. Members of the unit have delivered more that 200 invited talks and reviews at international conferences (IS group 101, SMP group 51, PPPA group 22, and AA group 36 international invited conference talks/reviews).

Contributions to the national research base. Clarke: Secretary and Treasurer of the IOP Polymer Physics Group (2006-12); IOP Coordination Committee (2012-). **Crowther:** Chair STFC Gemini Time Allocation Committee (2008-09); E-ELT STFC Steering Committee (2009-). **Dhillon:** STFC's Projects Peer Review Panel (2008-10); special panel member on the STFC Particle Physics, Astronomy and Nuclear Physics Science Panel (PPAN) review committee (2011). **Hobbs:** Secretary IOP Biophysics Group. **Jones:** EPSRC Council (2013-); EPSRC Societal Issues Panel (2007-11); EPSRC Strategic Advisory Network (2011-present); Working Group. Royal Society "The Scientific Century" study (2009-10); Working Group, Nuffield Council for Bioethics "Ethics of emerging Biotechnologies" study (2011-12); Steering Group, Technology Strategy Board, Strategic Review of the Micro- and Nano-Technology programme (2008-09). **Skolnick:** Royal Society selection committee to choose new fellows (2010-13); Royal Society URF selection committee (2010-13); Chair IOP Semiconductor group (2008-09). **Tadhunter:** Vice-President of the Royal Astronomical Society (2011-13); Chair of STFC Liverpool Telescope Oversight committee (2009-present); Chair of the RAS awards committee (2012); Royal Society Dorothy Hodgkin selection panel (2007-09). **Tovey:** STFC Science Board (2013-); Chair of STFC national Science Board Dark Matter Strategy sub-group (2012-); STFC PPAN committee (2010-11); Chair of STFC UK CERN Fellowships Panel (2009-12); STFC Particle Physics Advisory Panel (2009-10); STFC Particle Physics Grants Panel (2007-10). **Whittaker:** Chair EPSRC Fellowships Panel (2012).

Contributions to the international research base. Clarke: American Physical Society Division of Polymer Physics Fellowship Committee (2011-13). **Crowther:** Chair of sub-panel for HST Cycle 18 (NASA/ESA 2010); Spitzer Cycle 5 time allocation committee (2008); IAU Commission 29 (Stellar Spectra), Organizing Ctte member (2012-15). **Hobbs:** Programme Chair, Biological Physics Session, CMMP (2010)**. Jones:** Editor in Chief, European Physical Journal (E) Soft Matter (2006-11). **Lidzey**, Editorial Board of Advanced Optical Materials; Co-chair of TOM5 for EOSAM. **Skolnick:** Chair international conference on Quantum Dots (2012). **Spooner:** Gran Sasso Underground Laboratory Scientific Committee (Italy, INFN, 2011-); NSERC (Canada) SNOLAB science review panel (DEAP, SNO+ review panels, 2008-14); NSERC (Canada) Particle and Fields committee (2013-16); invited only non-US citizen on NSF (USA) Committee of Visitors (CoV) science review committee (2011-12); invited non-US citizen on NSF (USA) S4 DUSEL science review committee; international representative on NSF S3 panel that made final selection of Homestake as site for US $500M national underground laboratory DUSEL (2007-2009); NSF (USA) Physics-S4 committee in particle astro Washington (2010-11); DSG (Germany) trans-regio science panel (2007-08). **Tadhunter:** ASTRONET European Telescopes Strategy Review Panel on the future of ground-based 2–4m telescopes (2009-11); main scientific organizer of two international Lorentz Centre workshops in Leiden (2009 and 2013). **Tartakovskii:** Programme Chair international conference on Quantum Dots (2012); Chair Winter School on Few Spin Solid State Nano-Systems (2012).

International collaborations. We further highlight the following initiatives and collaborations as examples of the contribution of members of the unit to the leadership of research projects at an international level.

High time resolution astrophysics. The Sheffield-based ULTRACAM instrument has continued to make a major contribution to the research base in high time resolution astrophysics at an international level. It is routinely operated on three large telescopes: the 4.2m William Herschel Telescope (WHT) on La Palma, on which it saw first light in 2002, the 8.2m Very Large Telescope (VLT) in Chile, and the 3.5m New Technology Telescope (NTT) in Chile. ULTRACAM is operated as a private instrument by Dhillon (PI) and Marsh (Warwick, co-I) on these telescopes, but is also offered for use on a shared-risks, collaborative basis to any astronomer who is able to win time via the competitive peer reviewed time-allocation process for the particular telescope. Since the start of 2008, ULTRACAM has been awarded 220 nights on 4m class telescopes, and astronomers from 26 different institutes in 10 different countries (Chile, UK, Iceland, Germany, Canada, USA, Netherlands, Spain, Belgium, Italy) have been PIs of ULTRACAM proposals.

Particle physics: the ATLAS collaboration. Members of the PPPA group have made a very significant contribution to the scientific leadership of the ATLAS collaboration over the REF2014 period. **Anastopoulos:** editor and analysis coordinator of Higgs to 4-lepton paper, contributing directly to the Higgs boson discovery; ATLAS HSG2 Higgs to 4-lepton sub-group coordinator. **Costanzo:** SUSY Working Group co-convenor (2006-08); Publications Committee (2012-14); coordinator and paper editor of two analyses (2 b-jet direct sbottom search, 3 b-jet gluino mediated stop search), each producing two papers (2010-13); chair of the Editorial Boards for three papers (2012-13); member of the Editorial Boards for four further papers (2010-13), including key Higgs to 4-lepton analysis (contributing to Higgs discovery); software validation coordinator and member of Software Project Management Board to 2010. **Paganis:** coordinator of three analyses (key Higgs to 4-lepton 2006-Oct 2008, key Higgs to Z+photon 2012-13, Z->mumu+photon measurement 2012); chair of the editorial boards for two papers (2010-13); member of the Editorial Boards for eight further papers/CONF notes (2010-13); co-convenor of the Physics Analysis Tools working group (2006-9). **Tovey:** PI/Spokesperson (2010-13) and Deputy Spokesperson (2008-10) of ATLAS UK; National Contact Physicist for ATLAS-UK (2010-13); main editor and sole analysis coordinator for the key jets + MET + 0-lepton SUSY search (2011-12).

International leadership in condensed matter research. Members of the IS and SMP groups have coordinated three major EU-funded networks and an EPSRC/NSF World Network over the REF2014 period, involving a total of 14 European and US universities (Sheffield, Imperial College, Southampton, Munich, Crete, Milan, Pisa, Cambridge, Konstanz, ETH Zurich, Delft, Radboud, Pennsylvania), as well as 6 industrial partners (IBM, Attocube Systems, Leiden Cryogenics, Hitachi Europe, M Squared Lasers, Sensor Sense):

* **ITN ICARUS (2009-13), coordinated and led by Lidzey (€2.38M),** explores the development of optoelectronic devices and photonic structures that combine both organic and inorganic semiconductors, with the aim of developing new types of lasers, light-sources and optoelectronic devices.

*** ITN S3NANO (2012-15), coordinated and led by Tartakovskii (€4.0M),** focuses on spin phenomena in a wide range of semiconductor nanostructures, from III-Vs through to graphene.

*** EU Industry Academia Pathway Partnership Quantatec (2012-15) coordinated and led by Cockburn (€1.02M)**, involves the development of a new generation of instrumentation for ultra-high sensitivity trace gas detection, based on mid-infrared quantum cascade lasers.

* **EPSRC/NSF Materials World Network Program (2009-12: £299k + $480k; 2012-15: £367k + $520k)** is a collaborative programme between Clarke and Professors Winey and Composto in the Department of Materials Science at The University of Pennsylvania, USA, exploring the relationship between structure and dynamics in polymer nanocomposites.