Institution:	**University of Warwick (UoW)**
Unit of Assessment:	**UOA 9 Physics**

a. Overview

Warwick Physics is submitting 54.6 fte academic staff in UOA9, supported by 73 RAs, 20 technical and 12 admin staff. Research is structured across five Groups: *Astronomy & Astrophysics* (A&A), *Experimental Particle Physics* (EPP), *Centre for Fusion, Space & Astrophysics* (CFSA), *Theoretical Physics* (TP), and *Condensed Matter, Materials & Soft Matter Physics* (CMP) which is managed as 3 Research Clusters. Materials Physics is a major theme uniting much of CMP and TP.

A strong interdisciplinary culture enables Physics to interact effectively across UoW, in many cases initiating and leading the activity. Hence, 6.0 fte CMP staff are in UOA15 with their Engineering colleagues. The institutional level Midlands Physics Alliance (MPA) and Birmingham Science City Research Alliance (SCRA) complement extensive individual international research collaborations.

Excellent progress since RAE2008 is evidenced by: 17 new permanent academic appointments to support major strategic activities; 17 external salaried fellowships, incl. 4 ERC awards; over 2500 refereed journal papers; £35 M of University investment in research infrastructure; PhD population grown by 60% to over 160; strong growth in research income (£48 M c.f. 21 M previously); 2012/13 awards of £14 M; very active use of international facilities, equivalent to ~£46 M income in-kind.

b. Research strategy

Warwick Physics has transformed itself within the last decade from a medium-sized department, concentrating on a few areas, to one with an internationally excellent research profile over a broad range of physics and related interdisciplinary science. Key actions in 2008-2013 included:

(i) Investment in major new facilities (see {d}) that equip CMP groups to compete at world level; establishment of a Microscopy group and, following an external review led by Sir Peter Knight, five further strategic appointments (see {b&c}) incl. a new initiative in Biological Physics.

(ii) Supporting expansion in both A&A (est. 2003) and EPP (est. 2004) to establish new research activity across a broad range of frontier areas.
Including CFSA, research in the STFC remit now approaches half of the Dept.'s activity.

(iii) Expanding interdisciplinary and collaborative research, in and beyond Warwick, with emphasis on interaction between theory and experiment under the umbrella of materials physics.

The following sections set out the research strategy by Research Group.[#]

❖ ***Astronomy and Astrophysics (A&A)*** *8.0 fte Staff; 5 PDRAs;10 PhDs;*
453 articles; 8193 citations; £3.1 M grant awards; >£19 M income in-kind; 11 PhDs awarded

A&A is an observational group using a wide range of ground and space based telescopes. Research focuses on *Compact Objects* (**Gänsicke, Marsh, Steeghs**), *Extra-Solar Planets* (**Pollacco, West, Wheatley**), and the *High-Redshift Universe* (**Levan, Stanway**), which all attract significant public interest and lead to high profile publications. The future is bright, with major new international facilities being built or planned that will have impact in all three areas: GAIA is an ESA mission that will transform our knowledge of compact objects in our Galaxy; the next generation survey instrument (NGTS) for extra-solar planets will be built at ESO's premier optical observing site in Chile; the high-redshift Universe is the key science driver behind the major new millimetre wave observatory ALMA, and equally large projects are targeting the discovery of transient objects in the distant Universe. Collaborations are also being pursued for high-speed astrophysics.

A&A's recent strategy has been to grow to critical mass in a small number of areas and secure the leadership that promotes the prospects for funding from national and EU sources. An initiative in 2012 united key members of the Wide Angle Search for Planets (WASP) team that has discovered tens of transiting exo-planets and is the most successful project searching for such objects. These transiting planets are particularly important, being the only systems where the precise mass and radius, and hence composition, of a planet can be determined and the atmospheric composition can be studied directly. In future the group aims to build on its expertise in wide-field time-domain astronomy to search for transient sources, esp. electromagnetic counterparts to gravitational wave inspiral sources. Telescope time awarded within the REF period (see {d}) included over 2 Msec of X-ray and IR satellite time; the largest Hubble Space Telescope allocation to any UK group, incl. a Large Programme Award (PI **Gänsicke**), only five of which are allocated world-wide each year; and two International Time Programme (ITP) awards for exoplanet work (PI **Pollacco).**

[#] *Data: Personnel as of 10/2013; Financial 08/2008-07/2013; Papers published and citations thereon 01/2008-10/2013*

A&A's research has been recognised in each of its cores areas: **Levan** received the 2011 Philip Leverhulme Prize for Astronomy & Astrophysics for his work on gamma-ray bursts; WASP gained the 2010 Royal Astronomical Society Group Achievement Award; and in 2012 **Gänsicke** won an ERC Advanced Grant that recognises his world-leading work in applying spectroscopic surveys, above all the Sloan Digital Sky Survey, to understand rare populations of white dwarfs.

❖ ***Elementary Particle Physics (EPP)*** *9 Staff; 11 PDRAs; 17 PhDs; 688 articles; 11,126 citations; £7.1 M grant awards; >£12 M in-kind; 10 PhDs awarded*

With the Large Hadron Collider (LHC) at CERN now producing scientific results on a broad front, including constraining the Higgs boson, with its luminosity projected to increase significantly, and with a proliferation of new international opportunities in neutrino physics, elementary particle physics is enjoying a particularly fertile period. The EPP Group is fully involved in this international search for new physical phenomena, participating in particle physics experiments judged to have the highest likelihood of success. Since 2008, EPP has considerably broadened its scope, from neutrinos and heavy quarks at the luminosity frontier, to now include discovery searches at the energy frontier. The highly-regarded group has rapidly grown from being the smallest and newest UK EPP group in 2008, to a secure position with STFC rolling/consolidated grants (2009 & 2012). In the early REF Period, significant physics was extracted from existing data sets, BaBar, Belle, & CDF, whilst strongly contributing to building the **T2K** neutrino experiment in Japan (**Barker**, **Boyd**) and joining the **LHCb** beauty quark experiment at CERN (**Gershon**, **Kreps**). The T2K investment paid off with the first indication for $\nu_\mu \rightarrow \nu_e$ conversions in 2011. Since 2011 the EPP Group has diversified its portfolio by taking a significant role in **ATLAS** at CERN (**Farrington, Harrison, Murray**), culminating in the successful discovery of a new Higgs-like boson in 2012. A priority for the group is to take leadership roles where possible – currently Warwick provides the Physics Coordinators for two of the four major CERN experiments: ATLAS (**Murray**) and LHCb (**Gershon**). The neutrino focus has also been consolidated by joining **SuperNEMO**, a double beta decay experiment in France with two future phases. This now positions the EPP Group in four primary international particle physics experiments, which should ensure both an exciting scientific future and an even stronger funding base. Subsidiary activities in detector research, flavour phenomenology and new initiatives towards the NuSTORM, LBNE and Hyper-K experiments, together with ATLAS and LHCb upgrades will develop the group's longer term programme.

❖ ***Centre for Fusion Space and Astrophysics (CFSA)*** *8.2 Staff; 7 PDRAs; 26 PhDs; 251 articles; 2375 citations; £6.3 M grant awards; ~£1 M in-kind; 22 PhDs awarded*

CFSA is one of the largest interdisciplinary plasma physics centres in Europe. Its mission is to address key physics questions that arise from the grand challenges of fusion energy and the solar-terrestrial environment, and that require deep expertise in plasma physics to solve. The twin-track approach of contributing to fundamental physics and mission-led programmes ensures CFSA's activity is relevant to diverse funding sources: EPSRC/STFC, Euratom/ESA, and aligns with the UK's strategic energy and environmental needs. The group has a strong international reputation that is sustained through close partnerships with large facilities and their communities. These incl. Euratom magnetic confinement fusion (JET, MAST) at Culham & LHD, Japan (**Chapman**, **Dendy**, **Hnat**, **McMillan**, **Verwichte**); laser-driven fusion at RAL and AWE (**Arber**, **Gericke**); ground & satellite observatories for the solar corona (**Broomhall**, **Nakariakov**, **Verwichte**) and for the solar wind and Earth's magnetosphere (**Chapman**, **Hnat**). Extensive research partnerships include university level agreements with U. Kyushu and the Mexican Science Research Agency. CFSA plays a major role in providing research training for energy and space environment missions and is a founding member of the European Fusion Education Association (FUSENET). There is a steady flow of overseas PhD students with their own funding for both fusion and solar-terrestrial plasma research and 24 PhD students have been co-supervised with staff at Culham, RAL and AWE.

Solar wind turbulence ranks amongst the most important research topics in plasma astrophysics* and has been identified by international space agencies† as a scientific question to be addressed with future spacecraft. CFSA will continue to lead in the analysis of data from ESA- and NASA-led solar wind missions that span latitude and distance (ULYSSES), cover several solar cycles (WIND, ACE), and are at high cadence (**Chapman** is Co-I on CLUSTER). The Group's novel data analysis methodology means it will be a core science partner in future international missions, incl. Deep

* Princeton WOPA report, 2011

†ESA Cosmic Vision; NRC Decadal Strategy for Solar and Space Physics 2013-2022 (NASA); JAXA Vision 2025

Space Climate Observatory (launch: 2014); ESA Solar Orbiter (2017), and NASA-led Magneto-spheric Multi-Scale and Solar Probe Plus (2018). As an international leader in wave processes in coronal plasmas, **Nakariakov** will use his ERC Advanced Grant SeismoSun to exploit solar MHD seismology data from spacecraft (SDO, Hinode, STEREO) and be in the science teams of future space & ground-based projects (ESA Solar Orbiter, ALMA). With the latest *high-power laser systems* [ELI, Vulcan, HERCULES, LCLS free electron laser] entering new plasma regimes, CFSA are leading theory support for high-energy-density matter experiments (**Gericke**) and at the forefront of world QED-plasma research through development of the EPOCH-QED code (**Arber**).

❖ ***Condensed Matter, Materials and Soft Matter Physics (CMP)*** *22.4 Staff + 6.0 in UOA15**

The physics of materials has been a major research strength of the Dept. since its inception, and has continued along-side more recent diversification, culminating in large strategic investments in equipment and construction in 2010 of a £24 M Materials & Analytical Sciences building. In 2011, the Knight review of CMP specifically noted the excellent facilities for materials physics research, both within the Dept. and via extensive use of world-class Central Facilities, including those for materials modelling, preparation through epitaxy and single crystal growth, analysis of surfaces and bulk materials, and atomic resolution microscopy.

- **Nanoscale Physics Cluster** *7.2 Staff; 11 PDRAs; 28 PhDs; 287 articles; 2349 citations; £7.8 M grant awards; ~£2 M in-kind; 24 PhDs awarded*

Multi-functional materials with material dimensions on the nanoscale, e.g. Si structures, binary and complex oxides, magnetic semiconductors, and graphene, are fabricated and characterised with a range of epitaxial growth facilities, microscopies and spectroscopies. Close collaboration exists with TP on materials modelling and demonstration devices are made with facilities across UoW. Major investments have been made in high resolution electron microscopy and the field/vibration-free, temperature-controlled environment required to optimise their performance. A *Microscopy* group (**Beanland**, Sanchez*, **Sloan**, **Wilson**) has been established that aims to understand new materials and develop new techniques (often concurrently), with interests from graphene and CNT encapsulated ions, to crystal growth, quantum dots and phase transformations. The group is now involved with the majority of CMP projects and collaborates with TP (Quigley, Römer), researchers across UoW and nationally through SuperSTEM. An experimental *Biological Physics* group was created, in 2013, with **Kantsler** and **Polin** focussing around the dynamics of biological assemblies, from cilia to whole cells and more. It is co-located with Microscopy, anticipates strong research collaboration with TP (Turner, Allen, Ball, Alexander), and has research synergy with Warwick Medical School and Engineering's micro-fluidics research. The *Surfaces, Interfaces & Thin Films* group (**Bell**, **McConville, Woodruff FRS**) has long been recognised for interface formation and surface structure determination, esp. with synchrotron radiation techniques, and for studying epitaxy of III-nitrides and transparent conducting oxides (TCO). A new facility for pulsed laser deposition (PLD) of oxides has been established, which is substantially enhanced by Alexe bringing his expertise, a further 2 PLD chambers, AFM capability and oxide device processing capabilities from MPI Halle. New research is being initiated (**Bell**) in spintronic materials (ferromagnet/semiconductor epitaxy and half-metallic ferromagnets) with a dedicated MBE-STM system and collaboration from TP (Staunton) and industry (Toshiba). The *Nano-Silicon* group (Leadley*, Myronov*, Parker*, Whall*) has the UK's only academic wafer scale epitaxy facility for Group IV semiconductors and investigates Si, Ge, Sn heterostructures for applications in electronics, photonics and beyond. A new SiC epitaxy capability is being created via the BIS *Underpinning Power Electronics* initiative - again unique in the UK. *Analytical Science Projects* (Dowsett) is devoted to the invention of novel instrumentation, evolution of techniques, and data processing methods for semiconductor analysis, synchrotron research and now applying materials science expertise to challenges in cultural artefact and art preservation.

- **Magnetic Resonance (MR) Cluster** *6.2 Staff; 9 PDRAs; 15 PhDs; 193 articles; 1730 citations; £3.1 M grant awards; 24 PhDs awarded*

Millburn House Magnetic Resonance Centre was set up between 2007 and 2009, with an £8.5 M investment, as a multi-user laboratory to develop advanced MR spectroscopic techniques and instrumentation, and to use these to solve a diverse range of challenging problems in Physics, Chemistry and Life Sciences. Cross-disciplinary fertilisation of ideas is promoted through Physics staff (**Brown**, **Dupree, Hanna**, **Iuga, Morley, Newton**, **Wedge)** working alongside 3 Chemistry-based members. Since 2010, the Centre has provided the UK 850 MHz Solid State Nuclear

Magnetic Resonance (SS-NMR) Facility {d} and leads multi-university CDTs in *Integrated Magnetic Resonance* (iMR-CDT) and in *Diamond Science and Technology*. The forward strategy is to be at the leading edge of MR technique development and be central to UK provision of high field SS-NMR. MR academics have established a strong international reputation in the following areas, which are supported by many collaborations with leading scientists and companies:

- Application of SS-NMR to problems in materials science, catalysis, supramolecular chemistry, pharmaceuticals, and structure, dynamics and activity of biomolecular systems.
- Development of SS-NMR methodology, incl. new probe technologies, new pulse sequences, and associated computational approaches (involving Quigley from TP).
- Application of EPR and optical techniques to study colour centres in diamond and related materials; development of sensors that exploit diamond's unique combination of properties.
- Novel MR technique development, incl. pulsed EPR at high magnetic fields, high pressure EPR, Dynamic Nuclear Polarization, electrically & optically detected MR.
- Quantum information processing, with coupled electron-nuclear spins in Si and diamond.

- **Materials Physics Cluster** *9 Staff; 11 PDRAs; 21 PhDs; 449 articles; 4377 citations; £7.1 M grant awards; ~£9 M in-kind; 22 PhDs awarded*

This cluster measures material properties on the atomic to mm length scales, with comprehensive facilities for X-ray studies, ultrafast THz spectroscopy, transport, magnetic, and non-contact ultra-sound, with many at low-temperatures, in magnetic fields, and under pressure. It is a leading centre for single crystal growth, esp. using infra-red image furnaces. Interdisciplinary projects with Engineering & Chemistry are flourishing, as are collaborations with > 100 research groups world-wide and industrial partnerships. Cluster members are recognised as scientifically leading users of Central Facilities for neutron scattering, muon spectroscopy, X-ray studies, and high magnetic field measurements, with facility time valued in excess of £2 M p.a awarded at APS, BESSY, Diamond, ESRF, ILL, ISIS, NHFML, NSLS, PSI and Spring8. Warwick co-leads XMaS, which is the UK's flagship X-ray beamline for materials research at the ESRF and an EPSRC Mid-Range Facility.

In *strongly correlated electron systems* (**Balakrishnan**, **Duffy**, **Lees**, **Paul**, **Petrenko**), interesting and topical materials have been identified that can be grown and studied with these techniques e.g. muon spectroscopy & Fermi surface studies of exotic iron-based superconductors; pioneering investigations of the mixed state by small angle neutron scattering; frustrated magnetism in rare-earth and transition metal oxides; bulk and surface properties of topological insulators.

Research on the *structural physics of ferroic crystals* (**Thomas**) has become well known for the NBT and KNN families of lead-free piezo-electrics, and for contributions to understanding the archetypal PZT system. Novel X-ray and neutron diffraction techniques, optical birefringence imaging and SHG measurements have elicited the origins of enhanced piezoelectric properties. Research in non-linear optical materials, esp. lithium niobate-tantalate, led to a 2011 patent application. Extensive Central Facility use includes synchrotron radiation for spatially-coherent X-ray imaging of domains, building on Thomas's original method (*Nature* 1998).

A significant strategic addition, emerging from the 2011 CMP review, has been attracting **Alexe** to focus on the physics and engineering of complex oxide thin films and nanoscale systems. He will address a large spectrum of research topics: quantum phenomena in ferroelectric/multiferroic tunnel junctions, abnormal photovoltaic effect, domain walls electronics. He is well known for closing the loop of structure-functional properties-device research, so close cooperation with Thomas on structure, McConville on surface analysis and Dixon on thin film piezoelectric devices and MEMS is anticipated. He will use his expertise to setup a nanofabrication lab and a nano-characterisation lab based on low temperature scanning probe microscopy. Two further activities were also initiated in 2013: in low-dimensional magnetism in molecular materials & thin-film hetero-structures (**Goddard**); and in *ultrafast THz spectroscopy* as a probe of fundamental excitations in novel functional materials (**Lloyd-Hughes**), e.g. novel spin waves in magnetoelectric multiferroics.

The *Ultrasound* group (Dixon*, Edwards*) focuses on the interaction of ultrasound with defects and on non-contact measurements of single crystals, establishing the UK's only such facility. Materials investigated cover magnetic rare-earths, organic superconductors and magnetocalorics, as well as ferrous metals. The group collaborates with academic institutions through the EPSRC *Research Centre for Non-Destructive Evaluation* and extensively with industry via research projects, a spin-out company (Sonemat Ltd) and by creating the *Centre for Industrial Ultrasonics*.

❖ ***Theoretical Physics (TP)*** *7 Staff; 10 PDRAs; 22 PhDs; 219 articles; 2472 citations; £2.9 M grant awards; £1.1 M in-kind; 20 PhDs awarded*

The main themes of research in TP are *Molecular & Materials Modelling*; *Complexity & Biological Physics*; *Quantum Condensed Matter*. The Group has a breadth of expertise in materials modelling, esp. in molecular dynamics and electronic structure calculations. There is extensive collaboration with experimental groups on both hard condensed matter and bio-/soft matter. Recent strategy has also been to strengthen interdisciplinary links and make full use of high end computing facilities in the *Centre for Scientific Computing* (CSC). The study of complex matter has become an exciting focus for the future, with strong links to Maths, Chemistry, and Life Sciences coming through numerical modelling of crystal growth and phase stability of biological & functional materials (**Quigley**), applications of geometry and topology to liquid crystals (**Alexander**), and modelling of soft and biological condensed matter (**Allen**). The *Complexity Centre* (co-founded in 2007 and DTC directed until 2011 by **Ball**) has developed into a dynamic environment for inter-disciplinary research into emergent behaviour and self-organisation (**Ball**) and for non-equilibrium biophysics systems (**Turner**). TP was a key driver in forming the new Biological Physics group and its interests in non-equilibrium systems overlap very well with the experimental work. The quantum condensed matter activity has been directed increasingly to understanding experimental developments in non-equilibrium phase transitions (Szymanska), magneto-responsive materials and spintronics (**Staunton**), electronic properties of disordered materials & transport in DNA (**Römer**), and quantum statistics in small devices (**d'Ambrumenil**). The strong and developing links with experimental activity (much of it in-house) in electron diffraction, PLD, magnetic resonance, neutron scattering and graphene offer excellent prospects for future development.

c. People: (i) staffing strategy and staff development

The Dept. has been able to expand by making strategic and financial cases at University level, with a balance of senior staff to add leadership and international visibility in key areas and dynamic ECRs for long term sustainability. Since 2008, 17 new permanent academic appointments have been created and 14 fixed term, 7 of which subsequently became permanent. 3 staff have retired and 7 moved to UK and European positions (VC, Chair, Reader, 3 Senior Lecturers). New posts in EPP and A&A provide these relatively new research groups with long term critical mass. Two of these were enabled by the expansion of our Midlands Physics Alliance Graduate School (MPAGS) to STFC areas. In EPP, our presence in ATLAS and the Higgs search is given prominence by the senior appointment of **Murray,** Higgs Search Convener 2009-11 and ATLAS Physics Coordinator from Oct 2013, and of **Farrington**, who leads ~80 people as Convenor of the Higgs to ττ' Group. **Kreps** strengthens our commitment to LHCb, where Gershon is Physics Coordinator. **Blake** and **Janus** join as Royal Society and Marie Curie Fellows on LCHb and ATLAS, respectively. In A&A, the senior appointment of **Pollacco** gives an international lead in exo-planets. By also recruiting **West** a major team (WASP) is united (with Wheatley) in a single institution. Recruiting **Stanway** provides balanced growth on the high-redshift universe. Both CFSA and TP have attracted ECRs, **Alexander, McMillan**, **Broomhall, Foullon,** and **Quigley**, with 3 winning prestigious fellowships.

CMP has been strengthened considerably in two phases: (i) 3 new posts (**Beanland**, **Sanchez, Sloan**) created the Microscopy group together with major facility developments, levered through SCRA and Warwick Centre for Analytical Science. Growth in MR (**Morley** & **Wedge**) was enabled by our leadership of iMR-CDT. (ii) The favourable 2011 review generated 5 posts to capitalise on equipment investments and add new research lines to materials physics: **Kantsler** & **Polin** initiated a new activity in experimental biological physics; **Goddard** & **Lloyd-Hughes** strengthen existing magnetism and spectroscopy areas, bringing new techniques; **Alexe** brings leadership in ferroelectric and complex oxide nano-structures and will collaborate widely across CMP. With >100 papers since 2008 (7 in Science /Nature) having >1400 citations, he won a Royal Society Wolfson Research Merit Award and is a substantial asset to the Dept. CMP research capability has been further enhanced by appointing Facility Managers for each of electron microscopy, X-ray diffraction, XPS, PLD, Si epitaxy, and the UK 850 MHz NMR facilities. These also ease the research management load of professors taking on senior management duties e.g. SCRA Director (Thomas, McConville), Chair of Faculty (Smith, Thomas), PVC/Deputy V-C (Smith).

UoW has been implementing the *Concordat to Support the Career Development of Researchers* since 2009 and was awarded the HR Excellence in Research Award. Staff at all levels have an Annual Review to discuss their activities and aspirations in a constructive dialogue. The academic

staff workload for teaching, administration and outreach is apportioned to ensure time for research. It is tensioned against funded investigator time and includes allowance for PhD supervision. ECRs and probationary staff ramp up from 30% to 80% of the full non-research load over six years. New staff are helped to establish a research group with lab space, financial support, a PhD studentship in their first 2 years, and training in research student and research group management. With this support, all ECRs listed in RAE2008 have been successfully promoted to Associate Prof. In total, 24 academic staff already in post have received 31 promotions, with 9 earning personal Chairs at Warwick. Established academics take advantage of fellowships (see box) to fully concentrate on research and 15 took a strategic study leave to develop international collaborations, new lines of research and associated funding. Senior academics are encouraged to take positions of University responsibility and can follow the Warwick Leadership Programme (10% of staff in period).

17 distinguished fellowships were obtained during the period (* applied from Warwick):
ERC Advanced *Gänsicke (2012/17), *Nakariakov (12/17); *ERC Starting* *Edwards (08/14), *Gershon (09/14). *Royal Society URF* *Bell (01/09), *Morley (11/16), *Blake (13/18). *EPSRC* *Turner (Leadership 10/15), *Szymanska (Early Career 13/18), *Veal (CAF 08/12), *Quigley (CAF 09/14), Lloyd-Hughes (CAF 09/14), Goddard (CAF 09/14), Polin (PDRF 10/13). *STFC Advanced* *Foullon (12/17). *Leverhulme Early Career* *Wells (10/12); *Warwick Global Research Fellowship* Broomhall (12-17).

Fixed-term fellowship holders receive career mentoring and a clear indication of future employment prospects. A full programme of personal development activities tailored to PDRAs covers careers, mentoring and generic skills, with the possible award of a Postgraduate Certificate in Transferable Skills in Science (PGCTSS). Each PDRA has an academic mentor and formal progress meetings every 6 months. In the REF period, 15 PDRAs obtained lecturer/professorships at leading UK, US and European universities. The Dept. has been recognised for promoting gender **equality** among both staff and students. It was (with IC) the first IOP Juno Champion, re-awarded in 2012, and in 2010 received the Athena SWAN Charter Silver Award, with Physics promoting the overall UoW application. The Dept. is internationally diverse: 27% of academic staff, 35% of recent appointees, originate outside the UK; for PDRAs this figure rises to 52%. 100% of staff are actively engaged in intl. research collaborations, conferences and hold intl. appointments such as **Chapman** (MPI, Dresden; Adjunct Prof., U.Tromso), **Dendy** (Hon. Prof., Kyushu U.), **McConville** (Erskine Fellow & Visiting Prof., U. Canterbury, NZ), **Nakariakov** (Intl. Scholar, School of Space Research, Kyung Hee U. Korea), **Quigley** (Adjunct Prof. Curtin; UCSB), **Turner** (Joliot-Curie Prof. ESPCI Paris), **Verwichte** (KU Leuven), **Woodruff** (Fritz Haber Inst. Berlin). The intl. research environment is enhanced by active engagement of 14 Visiting Professors & 26 Associate Fellows. The Institute of Advanced Studies (IAS) has also supported distinguished visitors e.g. 12 months for Kreisel (Materials Science Director, Centre de Recherche Public Gabriel Lippmann).

c. People: (ii) research students

Warwick is a major centre for physics PhD training, with 137 in Physics and 27 in the associated Complexity DTC making this one of the largest UK physics research student populations. Many of these come from our cohort of over 600 physics undergraduates with entry grades now A*AA, of whom 44% go on to postgraduate study, 23% as PhDs. These u/g students also contribute to the Dept's research by being embedded in research groups for their final year projects and for Dept. funded 10 week summer projects. The PhD population has increased by 60% from 88 in 2008, on top of a 50% increase in the previous RAE period. Growth has been supported by strategic activities and individual awards from a wide range of sources e.g. via MPAGS; Complexity DTC; multi-studentship awards – S&I in plasma physics and Basic Technology in MR, which in turn led to the iMR-CDT; joint supervision of students in other UoW DTCs (MOAC, Systems Biology); overseas government and UoW scholarships; industrial collaborations via CASE awards and UoW funding. The Dept. directly supports PhDs in strategically selected areas, for new appointees, underwrites bids for prestigious scholarships, match-funds industrial engagement, and will continue to develop cohort training through CDTs. The annual physics PhD intake is ~30 Home/EU & 4 overseas plus 10 to Complexity, with the majority having a first class MPhys or equivalent degree. A further ~6 p.a. fund themselves though a research Masters, with several continuing to a PhD.

Since 2007, the Midlands Physics Alliance Graduate School (set up by Birmingham, Nottingham & Warwick) has developed over 50 taught modules for PhD students, delivered via video links. In its second phase (awarded by HEFCE, 2010) MPAGS encompasses all areas of Physics, reaches

beyond the original partners to all Midlands Physics Depts., and offers students 3 month industrial placements. All PhD students complete six MPAGS modules or equivalent training within a CDT or from external courses. Warwick staff deliver several such courses e.g. Warwick Week (EPP), EPSRC Physics by the Lake, IoP Group workshops, UKAEA Culham Summer School. Warwick hosted the STFC Advanced Summer Schools in A&A (2010) and in Solar Physics (2012). All PhDs have at least two supervisors, have progress formally monitored every six months, and are targeted to complete within 4 years. The advanced skill set acquired during their PhD research is recognised within the Transferable Skills Certificate (PGCTSS) that Physics helped develop and is now used by the whole Science Faculty. Additional generic training is available via the UoW Research Student Skills Programme. IAS Early Career Fellowships are available to support a transitional period between doctoral and postdoctoral careers. In the 5 year data period, 139 PhDs supervised in the Dept. graduated (appearing as 115 fte in REF4a due to the extensive inter-disciplinary supervision). Of the PhDs graduating between 2008 and 2011, 44% continued in an academic career and a further 39% took physics based jobs.

d. Income, infrastructure and facilities

Warwick Physics has made major strategic infrastructure investments in the REF period. It has significantly expanded into four buildings that house a number of **specialist facilities** used by academics from a range of disciplines and institutions, and by industry. These investments include a 2,500 m^2, £24 M "Materials and Analytical Sciences" building, opened in 2011 and designed to house new aberration corrected electron microscopes and £11 M of materials analysis tools purchased through SCRA. An extensive **materials characterisation** capability of state-of-the-art analytical equipment has been created: A suite of high-resolution diffractometers can accomplish the whole range of laboratory-based X-ray scattering experiments, from structural studies of tiny single crystals to reciprocal space mapping of extended domains and defects. Microscopy has over 130 trained users from across UoW, applying techniques from optical microscopy to imaging and analysis of clusters of a few individual atoms. EPSRC-funded researchers can have access via the Mid-Range Facility for Aberration Corrected Electron Microscopy (SuperSTEM).

Preparation of the highest quality materials enables Warwick to engage in world-class research. Epitaxial **growth facilities**, initially for SiGe, have been extended in a £2.5 M initiative to introduce SiC CVD to UK academia which combined represents a (globally) unique facility for Group IV epitaxy. The SiGe epitaxy facility has supplied over 1000 wafers to 11 UK and 14 EU collaborating groups since 2008. Similarly, high quality single crystals of complex oxide materials are grown in an EPSRC funded image furnace and supplied to 100 different collaborators worldwide. Further SCRA investment of £1.6 M has enabled PLD growth and XPS characterisation of thin film materials, for internal and external users. The arrival of Alexe means there will soon be 4 PLD chambers able to grow a wide range of materials with minimal cross-contamination.

An £8.5 M investment has been made in magnetic resonance, £3.5 M infrastructure and £5 M on capital equipment. Millburn House contains the UK's leading **MR Centre** with 8 solid-state NMR spectrometers, two high field liquid-state NMR spectrometers and two dynamic nuclear polarisation (DNP) spectrometers. There are pulsed and continuous wave EPR systems and a range of optical spectrometers for Raman, PL, UV/VIS/NIR & FTIR absorption. A wide array of probes, low & high temperature stages, and high pressure systems are available along with combination techniques (e.g. optically detected magnetic resonance) and ancillary equipment for the development and implementation of MR techniques. The UK 850MHz solid-state NMR facility (led by **Brown**) was established in 2010 as a world-leading facility to deliver advances in materials science, chemistry, biology, earth science and physics. In its first 3 years of operation 947 days of facility time were allocated on a competitive basis to 35 PIs from 19 different UK institutions.

Physics took a major part in originating and directing CSC as a **high performance computing** capability that includes hardware updates every three years with a 6000 core machine installed in 2011. This was part funded through the UK magnetohydro-dynamics (MHD) consortium to carry out large-scale MHD simulations and expand the UK parallel computing user base by training the next generation of researchers. The facility was enlarged through the £3.5M EPSRC e-Science grant MidPlus award to become a regional Centre of Excellence for massively parallel jobs and complement the fast throughput machine at QMUL and 1PB data storage in Birmingham.

UoW is instituting a model of 'Research Technology Platforms' that will ensure the long-term sustainability of the above facilities, with capital reserved for equipment upgrade/replacement.

Research income (i.e. spend) for 2012/13 was £10.5 M, making £48 M over the 5 year period cf. £21 M in RAE2008, and is planned to increase by £2 M p.a. as recently recruited staff and ECRs ramp up their activity. The current research funding portfolio includes £26 M from EPSRC (4th largest for a UK Physics dept) and £7 M from STFC, with rolling/consolidated grants for all 3 STFC remit groups. European funding covers the 4 ERC Fellows and a number of EU framework grants. New research awards for 2012/13 total £14 M. At £235 k per fte, this assures a sustainable funding portfolio. Research grant activity is regularly monitored by the Research Committee at a Cluster-, rather than individual-, level in recognition of the collaborative nature of activity.

Over £38 M of research **income in-kind** is recorded in REF4c from winning Central Facility time. CMP uses over 300 days of beamtime p.a. of which £7.6 M is recorded, and should be augmented by £2.9 M of international synchrotron time at BESSY (330 days), NSLS, USA (80 days), Spring8, Japan (60 days), & APS, USA (30 days); and use of the National Centre for Electron Spectroscopy & Surface Analysis (77 days, £0.5 M). TP/CMP benefitted from 38 M HECTOR units for computing (£1.1 M). The A&A group were awarded 190 nights of 4 m telescope time, 70 nights of 6-10 m time, over 2 Msec of X-ray and infrared satellite time, 279 GO and 331 snapshot orbits on the Hubble Space Telescope. The latter awards are the largest to any UK group, and include a large programme award (PI **Gänsicke**), only 5 of which are allocated world-wide each year. Two International Time Programme (ITP) awards for the Canary Island telescopes were received for exoplanet work (PI **Pollacco**). To the £18.3 M of telescope time appearing in REF4c should be added Spitzer Space Telescope (15 hr) and radio telescope time on ATCA (261 hr), IRAM (36 hr), & EVLA (29 hr), collectively valued at £1.1 M. CFSA has secured ~10% of the total MAST (Culham) facility time for 2013. EPP's CERN usage was £10.4 M, to which time on T2K in Japan should be added (~£2 M). Hence, total in-kind income is over £46 M.

Commercial access to research equipment raises half the running costs of X-Ray Diffraction (using 100 machine-days p.a.) and XPS, and makes useful contributions to the more expensive NMR and Electron Microscopy operations. Glass Ceramics research, in support of nuclear waste vitrification, proceeds almost entirely in contract mode. Anticipating these commercial returns, especially through SCRA business development activities, was key to enabling our major infrastructure investments to proceed.

e. Collaboration and contribution to the discipline or research base

(i) Developing Research Facilities and Collaborations

All the research groups have extensive networks of UK and overseas collaborators, with several providing international leadership in their areas. In addition to the local facilities mentioned in {d}, Warwick researchers have led the development of a number of facilities that are used extensively by academics from a range of disciplines and institutions.

CMP has considerable involvement with international **Central Facilities**, both as users and with a major development role. Warwick have been responsible for creating four beamlines: X-ray scattering has been made possible for European researchers looking at a range of different classes of materials by building and running the **XmaS** EPSRC Mid-Range Facility at the ESRF synchrotron, with £20 M of EPSRC funding to Warwick and Liverpool from 1994 to 2017. At the Diamond Light Source, **I05** (**McConville**) is for angle-resolved photoemission and **Woodruff's** original (and unusual) design for **I09** has since been reproduced at several other synchrotrons. The ISIS **MAPS** beamline (**Paul)** continues to enable inelastic neutron scattering to map out large areas of reciprocal space and detect features that would otherwise be missed. Future activity will include building the next generation of instrumentation at these high profile international facilities. **Goddard** is playing a major role in upgrading the Nicholas Kurti Magnetic Field Lab., in Oxford, as an open facility for UK users. All of CMP are engaged in extensive research collaborations, e.g. **Thomas** with Virginia Tech., Florida, Vancouver; Grenoble, Darmstadt, Shanghai, Tokyo, Waseda, Sheffield and Oxford; **McConville** with Santa Barbara, Cornell, Tokyo, Kyoto, Canterbury (NZ), Jena, Magdeburg, Madrid, Valencia, CNRS, Liverpool and Oxford; **Balakrishnan** with Boston, Cornell, Harvard, Pacific Northwestern, U. Basel, MPI Dresden and 30 others.

A&A uses telescopes from the Canaries to Chile to Australia and collaborates with groups world-wide e.g. Caltech, Berkeley, UC Santa Cruz, NASA Goddard Space Flight Centre, U. Copenhagen, U. Amsterdam, Geneva Obs., DLR Berlin, Paris Inst. of Astronomy, Armagh Obs. and most leading UK universities. **Pollacco** led the exoplanet science of ESA's PLATO mission and is UK Proposer

of the accepted ESA S mission CHEOPS. NGTS (**Pollacco**, **West**, **Wheatley**) is a Warwick-led project that was initiated with seed funding from Warwick, Leics. & QUB. It will locate bright targets in the South on which to train the European Large Telescope and proposed space missions (ECHO) to diagnose planetary atmospheres. A&A have continued to develop and operate the portable high-speed CCD camera ULTRACAM as an open facility for transient imaging on 4m & 8m-class telescopes (**Marsh**). Since 2008 it has been used for over 250 nights by more than 20 international groups. A recent ERC award, with Sheffield, has enabled a successor HiPERCAM to be developed over the next 5 years. **Gaensicke** was a member of SDSS-II, one of the most influential astronomical survey projects, and is part of the WEAVE Science Team.

In **particle physics**, Warwick supplies the Physics Coordinators of two major EPP experiments – **Murray** for ATLAS (~3000) and **Gershon** for LHCb (~700). In ATLAS, the group plays a key role in developing the L2 trigger which filters all data capture. In LHCb, **Kreps** is part of the intl. Particle Data Group, providing the latest averages of B-physics observables, **Gershon** is on the Heavy Flavours Averaging Group. EPP contributed to development, construction and installation, and led the calibration, of the near detector at the T2K neutrino experiment in Japan. Several PDRAs in the group also have co-ordination roles in international collaborations. The group is now working on generic detector technology for future experiments, e.g. liquid argon and liquid scintillators.

CFSA has longstanding collaborations with national facilities, notably five staff work with CCFE Culham, where **Dendy** is 0.8 fte. **Chapman** & **Hnat**, who is a member of the SOL and Exhaust Physics Task Force, actively collaborate with Culham via the MAST experiment, its next upgrade the Super-X divertor, and in developing ITER-like edge plasma conditions within JET. The group collaborates with two of the leading teams (Los Alamos, U. Delaware) in large scale kinetic simulations of turbulence and reconnection. CFSA are part of the EU MC network "Turboplasmas" for solar wind research; **Chapman** is a Cluster Co-I. **Nakariakov** leads the EU MC IRSES network "RadioSun" coordinating research of 7 teams on solar radiophysics in the EU, China and Russia. He also leads two of the four International Space Science Institute Teams that CFSA have been invited into. A main aim of NASA's SDO/AIA (launch 2010, **Nakariakov** Guest Investigator) and Hi-C (2012) instruments is to exploit the group's novel method of plasma diagnostics by MHD waves. **Chapman** participates in several climate science networks: e.g. CLIMATHnet and is international partner on a new NORKLIMA. **Arber** chairs the Collaborative Computational Project in Plasma Physics that encompasses some 50 UK plasma physics groups, all of which, and some 150 researchers from Europe, USA, India and China, now use the EPOCH code he developed with Oxford and Imperial. **Hnat** co-ordinates the EPSRC NetworkPlus: *Emergence and Physics far from Equilibrium* which aims to highlight key problems in non-equilibrium systems for UK activity.

Within **Theory**, **Staunton** was invited to join a Japanese initiative on new permanent magnets with Tsukuba that has resulted in several visitor exchanges, as has her EPSRC funded magneto-calorics project that works with the rare earth group at Ames Lab., Iowa. **Roemer** leads the *Protein Biology and Biophysics* network with participants in five UoW Depts.

The Dept. takes the initiative in fostering new collaborations and funds **Physics Days** (~5 p.a.) where selected leading academics discuss a particular topic in a sandpit environment, such as *Creating a liquid scintillator TPC for future neutrino physics*, *Silicon Quantum Information Processing*, *Ferroelectric Photovoltaics*, *Magnetic Monopoles in Spin Ice*, *Complex Oxide Thin Films.* These events have stimulated several new collaborations, e.g. a new research project with Halle and CNRS to investigate photovoltaic effects in $BiFeO_3$ using X-rays at Diamond and XmaS.

(iii) Interdisciplinary Research: UoW strongly embraces interdisciplinary research and has set ten Global Research Priorities (GRP) to highlight its research strengths and encourage cross disciplinary activity, of these Physics engages strongly with Energy (solar cells to fusion) and co-leads Materials. Physics has played a major part in establishing UoW interdisciplinary Centres: Complexity [3 Physics staff, Ball as DTC Director], Scientific Computing (CSC) [6, Römer Director], Magnetic Resonance iMR-CDT [5, Newton], Analytical Science [3, Sloan], and Centre for Industrial Ultrasonics (CIU) [2, Dixon]. Physics has strong interactions with **Chemistry** through joint MR activity; shared facilities in the MAS building; solar energy programmes in soft and hard materials; joint activity on diamond sensors; complementary activity in scientific computing; and analytical sciences as a training route for PhD students. **Engineering** links incl. growth of the CIU; joint research in power electronics, esp. installation of SiC CVD; in biomedical engineering; provision of high resolution microscopy and through the GRPs. Connections with **Life Sciences** come from

our biophysics expertise: experimental SS-NMR, advanced modelling, and the recent experimental biological physics group. **TP** activity in CMP theory and materials modelling are supported by and foster strong links with Maths, incl. Complexity and other DTCs that are in turn important PhD recruiting grounds for theoretical physicists. CSC promotes collaboration across fields, between theory & experiment, and spawns new interdisciplinary initiatives, e.g. computational biology. CFSA's research program transfers knowledge, techniques, and researchers between sub-fields of plasma physics and from other branches of physics, to which mission-led large facilities may have less access, to plasma physics. Although these examples focus on Warwick, research groups have similar interdisciplinary interactions with many world-leading partners.

(iv) Interactions with Research Users: Beyond the mainly academic interactions of {e}(i), the Dept. has on-going mutually influential relationships with several companies.

The **Science City Research Alliance** (SCRA) was set up as a regional initiative, between UoW and U. Birmingham with support from the European Regional Development Fund and Advantage West Midlands, to encourage growth and support of science and technology in the region. Physics plays a central role in the Advanced Materials Theme that gives companies access to state-of-the-art analytical equipment and expertise, specifically in SS-NMR, XRD, TEM and XPS. The need to provide external Users with an efficient service, and easy access to equipment/researchers led to UoW creating Warwick Scientific Services. As a result of some 200 business interactions, many research projects have been initiated or steered to satisfy the requirements of the companies e.g. product improvement for Sandvik Hard Materials via an XPS study of tungsten carbide powders. Industrial engagement in Microscopy ranges from work with intl. companies (e.g. Sharp Europe, Japan Electron Optics, JDSU, IQE) to local SMEs based on UoW's Science Park and across the West Midlands. These activities not only match our research interests but also provide new tools and techniques to microscopists world-wide, and hence new collaborations. **JEOL** has used Warwick expertise to develop and supply magnetic field measurement and control systems that allow materials to be examined under field-free conditions in their microscopes. **Agar Scientific** have an agreement to develop highly electron trans-parent graphene oxide support films for examining nano-particles using a Warwick protocol and PhD student placements in their labs. In the science and applications of diamond, Warwick has a long running special relationship with the **de Beers** group (incl. **Element 6**), who have supported a succession of projects developed in areas of mutual interest. A current project on diamond sensors with the Warwick electrochemistry group and has led to sales for Element 6. **Newton** hosts the Diamond Research Conference that brings all the de Beers supported UK researchers annual together in Warwick. This interaction directly led to Warwick's leadership of the 8 university CDT in Diamond Science and Technology. **Elster plc** identified Warwick as key partner for Ultrasound Research: the Dept. is prominent in ultrasonics of solids and Elster were keen to broaden this to flow analysis. An Elster Chair has been established jointly in Physics and Engineering as well as the CIU with a broad and increasing capability informed by industrial focus groups embracing 25 companies. Work on the EPOCH (see {e}(i)) code's optimization for HPC systems has made it one of the core codes used by **AWE** for benchmarking new computing systems and novel architectures as part of their rolling program of HPC procurement. The code also required the development of novel data formats and visualization tools that proved to be of generic application. These are now used extensively by FGE Ltd, a high tech SME, in their commercial operation.

(v) Academic Leadership and Esteem

Awards & prizes: **Alexe:** Wolfson Research Merit Award 2013. **Arber:** RAS Group Achievement Award 2013 for UK MHD consortium. **Ball:** IoP Rayleigh Medal & Prize 2009; Ig Nobel Prize 2012 for clustered fibres (ponytail physics). **Levan**: Philip Leverhulme Prize 2011. **Pollacco**: RAS Group Achievement Award 2010 for Super-WASP. **Stanway**: RAS Winton Capital Astrophysics Prize 2010. **Woodruff** (FRS): IoP/DPG Max Born Prize & Medal 2011, IOP TFS Group have named a "Woodruff Prize" for best PhD thesis. 17 Distinguished Fellowships (listed on p6).

National/Intl. advisory boards: **Allen:** DFG Special Priority Prog. 1296; **Arber:** EPSRC HEC Consortium in Plasma Physics (Chair). **Chapman:** Intl. Evaluation Ctte for Research Council of Norway - Review of Basic Physics Research 2009, Centres of Excellence 2012. **Dendy:** Nuclear Research Advisory Council; Marshall Aid Commemoration Commission. **Harrison**: Intl. EuroNu Stakeholders Board; UK Neutrino Factory Stakeholders Board (Chair). **Murray:** Advisory Boards for Beijing Symposium on Higgs Physics & Aspen Higgs Quo Vadis. **Pollacco:** NASA Senior

Review of Astrophysics (setting the science policy for NASA); NASA Origins Panel (Chair); UKSpA Projects Review Panel; Isaac Newton Group of Telescopes Science Advisory Ctte (Chair); Liverpool Telescope Oversight Ctte (Chair). **Staunton:** Scientific Advisory Board, Hierachic Eng. of Industrial Materials, KTH, Sweden; **Woodruff:** Scientific Advisory Ctte. MAX IV Lab., Sweden.

Leadership roles in industry, Research Councils, learned societies: **Ball:** EPS StatPhys Board. **Barker, Boyd**: STFC Grants Panel; **Chapman:** AGU Non-linear section, EGU Alfven medal ctte. (Chair). **Dendy:** Head (1996-2011) Theoretical Plasma Physics, Euratom/CCFE Fusion Assoc.; EPSRC Physical Sciences Strategy Advisory Team; EPS Plasma Physics Division (Vice-Chair). **Dixon:** EPSRC National Research Centre for NDE (Academic Chair). **Gänsicke**: STFC Near Universe Advisory Panel. **Gershon:** STFC Particle Physics Advisory Panel. **Marsh**: STFC Astronomy Grants Panel - Astro Obs (Chair). **Murray**: Director, Rutherford High Energy Physics Summer School, 2008 & 09. Represented all 4 LHC expts to LHC committee 2011 and LHC Higgs to European Cttee for Future Accelerators 2013. **Nakariakov**: President, EPS Solar Physics Division; UK Solar Physics (Chair). **Pollacco**: STFC Advisory Panels for Astronomy, Exoplanet Strategy & Near Universe; STFC Ground Based Facilities Review, STFC Project Peer Review Panel (Astro. Core Rep.). **Thomas**: STFC Science Board. **8 staff:** Fellowships selection panels. *IoP/RSC Group Chairs:* **Allen** Liquids & Complex Fluids; **Ball** TCM; **Brown** BRSG; **Newton** ESR. *Resource allocation panels:* **Arber** National Nuclear Security Administration (US) grant review panel; INCITE access for US leadership-class computer systems. **Barker**: CERN LHC Resources Scrutiny Board. **Farrington**: STFC CERN Fellowships Cttee (Chair). **Gericke**: PHELIX beam time allocation, GSI Helmholtzzentrum. **Hase**: ISIS Facility Access; ESRF Access; Intl. Beamline Advisory Team for CSX-2 at NSLS II. **Levan:** Swift/XMM-Newton oversight cttee; Hubble Space Telescope, Cycle 21 review. **Paul**: FAP6 ISIS (Chair), NMI3 board European Access to Neutron and Muon Facilities. **Roemer:** EPSRC HECToR allocation; EPSRC DECI/PRACE prioritisation. **Woodruff** ESRF Surfaces and Interfaces Beamtime (Chair to 2009). **Levan**, **Stanway**, **Gänsicke**, **Steeghs** & **Wheatley:** ESO OPC, JCMT, LT, XMM, Chandra and HST time assignment panels.

Journal editors: **Brown**: Solid State NMR. **Dendy:** (Editor-in-Chief) Plasma Physics & Controlled Fusion. **Dixon:** (Editor-in-Chief) Non-destructive Testing & Evaluation Insight, NDT&E Intl. **Gänsicke**: Advances in Astronomy. **Gericke**: Laser & Particle Beams. **McConville**: Appl. Surface Science. **Newton:** Diamond & Related Materials. **Roemer:** Euro. Phys. Lett; Scientific Reports.

Conferences: Physics staff have organised and/or hosted established meetings *at Warwick*, with Dept. admin. support and benefitting from the excellent Warwick conference facilities (voted Best Academic Venue 18 times in the M&IT awards' 25 year history). Examples (with Chair) include: IoP CMMP (2009 & '10); European Conf. on Complex Systems (2009, ~400 delegates); IoP TCM Group (**d'Ambrumenil** 2008-12); 10th Biennial Conf. on High Resolution X-Ray Diffraction & Imaging (**Thomas** 2010); CKM 2010 (**Gershon**); 18th Interdisciplinary Surface Science Conf. (**McConville** 2011) largest ever ISSC meeting, over 190 attendees; Neutrino Interactions Conf. (**Boyd** 2012 & '13); Silicon Quantum Information Processing Meeting (co-created by **Morley** 2012); CCP5/MDNet conf. on molecular dynamics (**Quigley** 2012); European Crystallography Meeting: Centenary of W.L. & W.H. Braggs' Nobel-prize winning research (**Thomas** 2013); Diamond Conference (**Newton** annually). Computation meets Experiment (**Staunton** 2013).

Conferences chaired elsewhere include: Physics of High Energy Density in Matter (Hirschegg, 2009, **Gericke**); Disordered Systems (Mexico 2010, Spain 2012, **Römer**); Emergent Order in Biology (Corsica, 2012, **Turner**); Computational Materials Design in Heterogeneous Systems (MRS 2012 **Quigley**); 39th Physics & Chemistry of Semiconductor Interfaces (Santa Fe, 2012 **McConville**); Intl. Symp. on Crystalline Organic Metals (Montreal, 2013 **Goddard**).

Keynote lectures include: **Chapman:** invited review at EPS Conf. on Plasma Physics (Sofia, 2009); and at EGU 2010, '12, & '13. **Gänsicke**: 10 keynote talks at intl. meetings, e.g. "Planets around stellar remnants" (2012), "Evolution of Cataclysmic and Compact Binaries" (2010). **Gershon**: 8 invited plenary talks at intl. meetings e.g. Lepton Photon 2011. **Harrison**: "Heavy Flavours" summary talk at Workshop on the Standard Model at the LHC (2011). **Levan**: Invited reviews "GRB progenitors" IAU 279 (2012); "High redshift GRBs" COSPAR (2012). **McConville**: 18 invited talks at intl. meetings, e.g. Fall MRS 2009, SPIE 2010, EuroMBE-2013. **Pollacco**: 48 invited talks. **Staunton:** Special invited lecture Japan Inst. of Metals Annual Meeting (Tokyo, 2013). **Thomas:** 10 major invites in last 2 years, keynote at European Crystallographic Meeting (Darmstadt, 2012).