Institution: University of York

Unit of Assessment: 9 - Physics

a. Overview

Since RAE2008 the Physics Department at York has invested significantly to expand research activity with resultant significant increases in research income, and post-graduate and post-doctoral numbers. We have concentrated research activity in three key areas in order to achieve critical mass: Condensed Matter Physics (CMP), Plasma Physics and Fusion (PPF) and Nuclear Physics (NP). We have appointed 14 new REF-submitted academic staff since RAE2008, acquired > £4 M of new equipment and expanded into a new 400 m^2 plasma laboratory building and 1300 m^2 of additional office accommodation. All three research groups comprise a critical mass and have a balance of experienced, mid-career and early career staff.

b. Research strategy

We have met our strategic aim set out in RAE2008 to concentrate research activity in key areas in order to achieve critical mass and establish a higher profile of our research and leadership in our chosen fields. Highlights of our success during the REF period include:

- Establishment of the York Plasma Institute (YPI) with an international reputation for fundamental plasma science and related technology undertaking new research in low temperature plasmas with industrial and biological relevance, and expansion of research in magnetic and inertial confinement fusion energy and high energy density physics.
- Full operation of the York-JEOL Nanocentre and development of 0.1-nm-resolution electron microscopy, with novel provision for samples in gas and liquid environment and for electron beams with orbital angular momentum; enabling biological and catalysis studies and providing capability for nanomaterial, thin film and electron vortex research.
- Establishment of research in photonics, with facilities for the manufacture of photonic structures with a state-of-the-art (resolution 8 nm) electron beam lithography tool and clean room facilities.
- Significant expansion of research in magnetic nanostructures and quantum information.
- Expansion of biophysics research across all research groups leading to the strategic appointment of a joint Anniversary Chair in Biophysics with Biology and the creation of the cross-campus Biological Physical Sciences Institute (BPSI).
- Expansion of nuclear physics research into research on fission with relevance to nuclear power generation and strengthening of the nuclear astrophysics area.
- Development of significant external collaborations which are increasing the impact of our research and our profile e.g. Culham CCFE, Diamond Light Source, AWE and Seagate.
- Increased research income: average with (and without) in-kind contributions has increased from £2.1M (£1.44M) p.a. over the RAE2008 period to £9.6M (£2.3M) p.a. in the REF period.
- Through a strengthened research group structure and leadership created an environment which encourages higher impact research outputs and leadership in our chosen fields.

To continue to deliver our research expansion in the next REF period we have a recruitment strategy with the University which will increase academic staff from 40 to > 50, aiming:

- To expand the internationally leading cross-disciplinary YPI to develop further its world-class reputation for research and training in fundamental plasma science and related technologies. We plan growth in low temperature plasma chemistry and high energy density plasmas.
- To enhance collaborations with national and international laboratories as well as industries, e.g. international laser facilities including NIF will be exploited to access extreme states of matter.
- Recent appointments and the development of YPI facilities will lead to an enhanced emphasis on plasma-materials interaction issues relevant to fusion, including a widening collaboration with Culham exploiting a new Culham materials centre.
- The CMP group will build on intragroup experimental and theoretical synergy and inter-disciplinary links to enhance materials physics research and cross-disciplinary research in medicine, biology, chemistry, archaeology and environmental sciences. This will be enabled by both the Nanocentre and the Group's suite of growth and nanoscale characterisation facilities, further enhanced by expanding the use of external large scale facilities such as synchrotrons.
- Physics will lead a university expansion in Quantum Information with new appointments.
- Nuclear Physics strategy is to enhance nuclear structure, astrophysics and fission research and

to expand into theory, alongside developing new nuclear physics related applications (e.g. nuclear data for fission and fusion reactor programmes) and furthering industrial links.
- Extend photonics research into more interdisciplinary areas, exploiting new fabrication facilities.
- Building on the early successes of the YPI Industry Officer, there will be enhanced collaboration and potential further equipment provision from industrial users of physics-based technology, for example; by expanding our low temperature plasma capability, the industrial applications of laser-plasmas, work on magnetic nanostructures and biophysics.
- The BPSI will stimulate and nurture cross-disciplinary research in biophysics, expanding it from the baseline of research undertaken in the CMP and PPF groups on e.g. coral, magnetic hyperthermia and plasma treatments (sterilisation and cancer therapy, for example).

c. People, including:

i. Staffing strategy and staff development

As we have expanded, we have taken care to make strategic staff appointments to both enhance existing research strengths and to expand into new, but related, areas where we have the potential to make a significant impact. We strive to attract, recruit and retain researchers of the highest quality and then to ensure that they operate effectively.

Condensed Matter Physics: A new Chair *Krauss* has created a new research area of photonics in York, with considerable collaborative potential with UoAs Electronics, Chemistry and Biology. This was supported by a £1.5M university investment in e-beam lithography and Clean Room facilities. Two additional lectureships will establish critical mass, the first (*Wilson-Rae*) is a quantum theorist who will also interact very strongly with the growing cross-campus activity in quantum information. New Chair *Leake* (Biology/Physics) was a strategic initiative to coordinate the growing biophysical science research in York and in Physics in particular; and is supported by a £0.5M University investment to set up new biophysics laboratories. An additional lectureship has also been created. *Lazarov* has brought functional materials expertise and strengthened our electron microscopy expertise. Seagate Lecturer in Magnetic Materials *Vallejo-Fernandez* is a joint appointment with Seagate to strengthen our strong links with the magnetic recording industry. Two further lectureships have been made to establish a coherent nanomaterials research capability including *Cavill,* a joint appointment with the Diamond Light Source, which will provide opportunities to develop our synchrotron based research. A lecturer specialising in electron spectroscopy starts in 2014. Two theoretical physicists (*McKenna* and *Hancock*) were appointed to strengthen the link between fundamental condensed matter theory and experiment.

Nuclear Physics: A new Chair *Andreyev* brings to the York Group expertise in nuclear fission and laser-assisted nuclear and atomic spectroscopy. Expanding the nuclear fission work of the Group will open up opportunities in energy related research in the ESPRC domain. New lecturer *Diget* is a nuclear astrophysicist whose appointment optimises the UoA critical mass in this research.

Plasma Physics and Fusion: *Gans*, *O'Connell* and *Wagenaars* were appointed to establish the low temperature plasma physics strand of the YPI. *Dudson* brings leadership of the development of the BOUT++ plasma simulation code to York, now widely used internationally. Two recent appointments in magnetic confinement fusion provide an international lead for experimental tokamak physics, particularly tokamak exhaust physics, and are a joint venture with Culham CCFE: *Lipschultz* (recruited from MIT) is an international leader in his field. A new research lecturer *Ridgers* is an expert in theoretical laser plasmas and brings a strong theoretical component to existing work on Inertial Confinement Fusion and new areas in the emerging field of dense QED plasmas.

We have a transparent workload model for teaching and administration in order to ensure that staff have sufficient time for research. Administrative and teaching roles, balanced with research resources, are allocated with University promotion criteria in mind, to support career development. Three full time permanent teaching fellows have been appointed to balance our Departmental activities more effectively. To formally monitor staff development, all academic staff have annual reviews with the Head of Department (HoD) where issues can be directly discussed and addressed. Objectives from the previous year are reviewed and set for the next year. The HoD also meets with each research group once per term.

Early-career staff initially have lighter teaching and administrative loads, typically <30%, ramping up to a full load over 3 years. Early-career staff have preferential access to departmental funds, and are allocated a PhD student within their first 1–2 years. They often benefit from the policy to allocate department funds to pump-prime future research-council funding through the

purchase of equipment, consumables, and travel. New staff have an experienced mentor to give advice on research and other aspects of the Department. Early-career staff attend university-wide training, achieving a Post-Graduate Certificate of Academic Practice. Staff also receive assistance from their research group in developing their research programme in tandem with the group's overall strategy, with particular guidance provided on grant applications. An additional termly meeting with the HoD provides all early-career staff with the opportunity to discuss any issues of relevance to them.

There are 35 post-doctoral researchers in post in 2013, a significant increase from 2008. Post-doctoral researchers have an academic staff member closely associated with their work as their line manager, with a formal Annual Performance Review, and probationary reviews at 3, 6 and 9 months after appointment. Professional development courses are available to all staff within the University, and post-doctoral researchers normally attend an international conference at least once per year. The University and Department have fully implemented the seven principles of the Concordat to Support the Career Development of Researchers as listed by RCUK. In particular, the University has rigorous recruitment policies to ensure the fair selection of staff, fair assessment procedures post and opportunities for training and promotion.

In the REF period, we have had two Advanced Fellows (Kay – STFC Advanced Fellow and Lazarov – RAEng Senior Research Fellow), two EPSRC Career Acceleration Fellows (O'Connell and McKenna), a European Fusion Development Agreement Fellow (Imada) and a Royal Society University Research Fellow (Professor Leake). In York Physics, we have succeeded in appointing all Fellows to academic posts at the end of their Fellowship, providing the security to develop substantial research programmes.

In addition to the regular departmental colloquia programme and research group seminar series, over 100 visitors stayed in the Department for a period of more than a day over the REF period. Professor Kieron Burke, University of California Irvine, visited for 2 days in 2010; one of his papers on density-functional theory is one of the most highly-cited papers in physics with over 32,000 citations. Other high-profile visitors included the Director of the Dutch Institute for Fundamental Energy Research (2012), the Vice-President for Research of Keio University (2012), and Nobel Laureate Professor Peter Grünberg (Jülich 2008). Visitors to the YPI include Sir John Beddington (former Chief Scientific Advisor to the Government), Dame Julia King (board member BIS), Dame Sue Ion (Chair EU Euratom Science and Technology Committee), Sir Chris Llewellyn Smith (former head UKAEA-Culham and CERN) and David Delpy (Chief Executive EPSRC). Nobel Laureate Sir Harold Kroto (Florida State University) and the Director of Culham Laboratory Steve Cowley have been both appointed Visiting Professors.

Approximately half of York Physics academic staff received formal education outside the UK. Those submitted for the REF include six with degrees from non-UK EU countries and nine from outside the EU. Many staff also have strong research connections to places of previous employment, for example in the US, Germany and China.

The Department of Physics at York has won two national awards for its procedures and actions in promoting wider participation of women in science. A Silver Athena Swan award in 2012 and Institute of Physics (IOP) Juno Champion status awarded in 2011 both recognise that, in addition to institution-wide policies, the department has a significant record of activity and achievement in supporting the careers of female scientists and has demonstrated the impact of this activity. This proactive support of gender equality benefits all. As a mark of external recognition, staff member Professor Brian Fulton now Chairs the IOP Juno award panel.

The Departmental Management Team, led by the HoD and including the Chair of the Research Committee, formulates strategy and manages the Department. A larger Physics Advisory Group, including early-career staff, provides input to the strategy. An External Advisory Board drawn from a range of backgrounds (academic, industrial, and senior research-council management) annually review the departmental activities, providing an independent view of strategy within the Department. Research in the Department is formally overseen by a Research Committee (chaired by Dr Irene D'Amico). The Departmental Research Committee meets termly and reviews research strategy, monitors grant applications and makes decisions on the allocation of Departmental research funds, research leave and on research student allocations. There is, in addition, an allocation of Departmental funds to research groups (£5-10k p.a. per group) and to individual staff (£1.2k p.a.) for ad-hoc research purchases and travel.

ii. Research students

Research students are a critical of component of our research effort. We offer internationally significant research projects with supervision by experts and access to state-of-the-art equipment. Many students have opportunities for travel to undertake experiments at major facilities, and opportunities exist for extended research periods at international facilities to learn new techniques and develop contacts. In Nuclear Physics, extended student visits are funded via STFC long term attachment awards, while in magnetic confinement fusion, EURATOM funds extended international research visits. We ensure that all students have the opportunity to attend international conferences. During the REF period, the number of registered research students in York Physics has increased from 50 in 2007 to 99 now (with 17/24/25/33 starting in 2009/10/11/12). This growth reflects both a general increase in research activity and also the establishment of an EPSRC-funded Centre for Doctoral Training (initially DTN) in Fusion Energy led by York Physics. During the REF period we have received funding for student fees and stipends from several non-traditional sources including AWE Plc (£210k), Culham Centre for Fusion Energy (£1M including the EPSRC allocation to Culham and CASE top-up), Rutherford Appleton Laboratory (£70k), TRIUMF laboratory (£40k), Intel (£150k) and the magnetic storage company Seagate (£280k).

We advertise PhD places widely online and in specialist magazines such as Physics World and host our own Postgraduate Open Day. We take part in student recruitment fairs and jointly organise an Open Day for prospective PhD students in plasma physics at Culham Centre for Fusion Energy each year in November with typical attendance of 100 seeking research PhDs. A dedicated administrator deals with graduate-student applications. Students are recruited via online application and are interviewed competitively following our Human Resources guidelines

The interests of research students are overseen by a department Graduate Studies Committee. To monitor and support the training and supervision of postgraduates, Thesis Advisory Panels comprising the supervisor and another staff member meet with each student at 6-monthly intervals to review progress and supervision. In order to broaden the training of postgraduates and to better equip them for research during and after their PhDs, they are required to take assessed taught specialist courses within a range of 200-1000 hours of work. Specialist postgraduate courses are run at York, some with engagement outside York such as courses taken by Fusion CDT students and the IOP Magnetism school held in 2011 and 2012. A range of skills activities comprising 60 hours is taken annually (consistent with the Roberts' recommendations in the Concordat to Support the Career Development of Researchers). Many students receive significant formal training at national and international facilities.

The Doctoral Training Network (DTN) in Fusion Energy was initially established in 2009 as a DTN-lite (with EPSRC funding for administration) involving the Universities of Durham, Liverpool, Manchester, York and Oxford Materials. York was the lead institution, providing and supervising 50-60% of the students. Total student intake was ~10 students p.a. with funding coming from the universities' DTA allowances plus support from Culham Centre for Fusion Energy, the Central Laser Facility, AMEC (industry) and AWE. As a result of strong independent reviews, EPSRC increased funding in 2012 to a fully funded, £2.4M Centre for Doctoral Training providing two intakes, each of 10 students for 2012 and 2013, with other sources of funding providing an additional 10 studentships. York is again the lead institution and supervises ~60% of students. DTN students undertake 1000 hours of coursework across a broad range of plasma physics and related topics in their first year of study before completing a major piece of research, taking 3 years, which incorporates a collaborative mini-project. End user organisations (e.g. ITER, CLF, AWE, CCFE, Fusion for Energy) provide expert staff for many guest lectures during the programme. The DTN employs two administrators to support the student learning activities. The Fusion DTN provides an internationally-recognised PhD training programme embedded in our plasma research group. The strategy is to ensure that the UK retains and further builds upon its leadership position in fusion energy in the approach to the first demonstration of fusion power plants, in both magnetic and inertial fusion. The DTN programme is aimed at helping to provide the UK with sufficient expertise to be influential and competitive in winning time on international fusion facilities such as the ITER tokamak and the US laser-based NIF facility over the next 10-20 years. On the 20 year timescale, knowledge gained by DTN students will feed into the design, construction and operation of the DEMO tokamak (designed to be a prototype commercial fusion reactor), and into commercial fusion power plants later. Expertise in high energy density physics

gained by DTN students aligns with the national security needs of AWE.

d. Income, infrastructure and facilities

The Department has two centres of specialist research: the interdisciplinary "York-JEOL Nanocentre" and the "York Plasma Institute" (YPI). The Nanocentre entered full operation in the REF period with significant external investment. The Nanocentre has a leading position in sub-Angstrom-resolution imaging in the gas and liquid environment and in thin film characterisation. The facility supports world-leading chemical catalysis studies, plus novel work on biophysics and interfaces in magnetic and spintronic materials. York is now leading a new area of functionalised electron microscopy in using electron beams with angular momentum ('vortex beams') to develop new chiral specific spectroscopy and for nanomanipulation of nanomaterials. This enhanced capability has been supported by the Wolfson Foundation.

The York Plasma Institute was established at a cost of £3.8M in 2012 with funding from EPSRC and the University. The YPI runs an MSc in Fusion Energy, an EPSRC-funded Centre for Doctoral Training in Fusion Energy and the research of the PPF group across tokamaks, low-temperature industrial plasmas and high energy density physics. There is a range of equipment associated with the YPI research, including a £1.5M plasma etching device supplied by Intel.

Experimental CMP research comprises activities in electron microscopy, nanoscale magnetic materials of relevance to advanced particulate recording media, spintronics, surface physics and photonics. The Department has had research pursuits for many years in advanced characterisation and microscopy techniques such as scanning tunnelling and atomic force and pioneering metastable helium de-excitation spectroscopy. The recent appointment of a joint lecturer with the Diamond Light Source is stimulating synchrotron based activities. Equipment in the Nanocentre has enhanced considerably the work of the CMP group and includes (i) a JEOL FS2200 double aberration corrected Transmission Electron Microscope giving sub-Angstrom resolution, (ii) a JEOL 7000 Fabrika dual column Focussed Ion Beam, (iii) a multifunctional JEOL 5200 Scanning Probe Microscope, (iv) a JEOL 2010 TEM, (iv) a FEI SEM with electron beam lithography capability. A major £1.5M photonics laboratory has been established, including a Raith electron beam lithography systems for the fabrication of photonic structures with resolution <8 nm, and a purpose-built laboratory with Clean Room and preparation area. New biophysics laboratories in both Physics and Biology have been established at a cost of £0.5M. There are several computer cluster systems within the York UoA used by the theoretical CMP researchers for parallel computing and the group lead work using national supercomputers such as HECToR.

The PPF group has new office space and a new purpose-built laboratory. To optimise the commercialisation of plasma research, a YPI Industry Officer (Dr Lancaster) has been appointed with support from Culham Centre for Fusion Energy (CCFE). To help run experiments and to ensure continuity of research, a full-time Research Officer (Dr Niemi) has been appointed. The YPI has strong links to CCFE where many experiments are jointly on the MAST and JET tokamaks and new diagnostics have been jointly developed (for example, a world-leading £2M Thomson scatter temperature diagnostic and microwave imaging system on MAST). Links to international tokamak facilities such as the KSTAR tokamak, Korea are strong with staff involved in experimental programmes. Experimental work in the group is supported by theory and modelling, with an in-house cluster as well as access to state-of-the-art high performance computers such as HECToR and HELIOS (Japan). The low temperature plasma researchers interact closely with Intel Ireland on plasma etching, ELEMENT 6 on diamond coating and Oxford Instruments. Other collaborators include Biology at York and medical researchers in Dublin. The laser plasma staff work with major laser laboratories including the Central Laser Facility, Orion at AWE, Ecole Polytechnique, the TATA Institute in India, Osaka University and the US NIF facility; the last significantly augmented in 2013 by the award of EPSRC grants under the 'Physics of ignition: collaboration with NIF' call where Dr Lancaster has a key role in an EPSRC network and Dr Woolsey is funded to study 'mix' between pellet and fuel on NIF.

Nuclear physics staff play leading roles in the development of experimental programmes at the main current and planned radioactive beam facilities worldwide. For example, at ISAC (TRIUMF, Canada) for low-energy nuclear astrophysics and at the REX-ISOLDE facility (CERN) for nuclear structure with co-ordination of future programmes for facilities under development (HIE_ISOLDE at CERN, SPIRAL2 at GANIL, France and FAIR at GSI, Germany). At all these facilities, and other radioactive ion-beam facilities such as RIKEN (Japan) and NSCL (USA) plus the many stable-beam facilities, the group have access to beamtime through competitive peer-

review. York's strong beamtime allocation (of in-kind value £16m (non-CERN) in the REF period) reflects the international level of our research. In addition, a major detector array was developed by the York NP group and installed at TRIUMF using £600k funding from STFC. It is now used by nine international groups. The NP group has growing industrial links with companies such as NUVIA (UK) and Kromek and is a member of the neutron time-of-flight collaboration at CERN, where data relevant to the operation of future fission reactors is obtained.

Direct research investment from Research Councils, other Government Agencies, industries and charities to the Department ranges from £2 – 2.6M per year implying income averaging at £70k per academic per year. However, this figure is significantly smaller than the true amount benefitting research within the UoA as approximately half of our staff undertake most of their research at national or international facilities, and including the in-kind funding for these facilities increases the UoA annual expenditure to £9.5M which is £280k per academic p.a.

The direct research income from Research Councils, the EU, other Government Agencies, industries and charities for the UoA are approximately equally split between the three research groups averaging £0.85M for CMP, £0.88M for NP and £0.95M for PPF p.a. during the REF period. The total UoA spend including RCUK supplied in-kind contributions is £5.9M p.a., but in the REF period £16M of nuclear physics in-kind contributions to York, not included in RCUK-supplied figures, has also been awarded in beam time at laboratories such as TRIUMF, GSI, and ISOLDE. Central University support not included in the figures via 36 small grants of total value £250k for 2008–13 has been provided to pump-prime research facilities and international collaborations. Larger sums have been provided from the University to establish, for example, the York Plasma Institute (£3.8M together with EPSRC), a new photonics laboratory (£1.5M) and new biophysics laboratories (£0.5M). The Department also manages a budget (≈ £150k) to spend on research, primarily on equipment, pump-priming and access to Nanocentre facilities. Expansion of impact generating research fields will increase industrial interaction, so our funding profile in the next REF-period should be less based on RCUK sources with more from industry. Our success in the present REF-period in obtaining industrial support for equipment indicates that equipment renewal will increasingly be in partnership with industry.

Research is also supported by other income not included in the HEFCE figures. For example, in the REF period, we have obtained funding from UK Atomic Energy Authority (£250k) and STFC (£90k) to fund the academic appointments in the PPF group of Gibson and Pasley. Similarly, the magnetic hard drive manufacturer Seagate funded half the salary costs of Chantrell, and co-funded a post for a new lecturer. The YPI Industry Officer (Lancaster) is funded 30% by CCFE for 5 years to assist UK industry in bidding for ITER contracts (construction cost €16Bn+) and to link our research to industry. Magnetics research is also supported by Seagate with significant in-kind support through provision of samples and technical help. Some facility costs are not captured in the RCUK in-kind expenditure as we are significantly involved with UK facilities that are not readily costed (e.g. the MAST and JET tokamaks at Culham Science Centre, and international laser facilities). A postdoc (Buxton) was funded by the company Tokamak Solutions for 8 months in 2012, and this led to a successful grant proposal for a Knowledge Transfer Partnership funded by Technology Strategy Board in fusion energy.

Approximately half of all staff and students in the UoA have been provided with new office space in the REF period, either in the YPI building of floor area 800 m^2 renovated to high standard in 2011 or a new 2-storey accommodation block of area 500 m^2 next to the main Physics building finished in 2013. A purpose-built laboratory for the YPI of 400m^2 completed in 2012 houses all plasma equipment, including the £1.5M Intel plasma etching device. Future infrastructure plans include a £1.5M new building to house and provide training facilities for Centres for Doctoral Training students adjacent to the YPI building. Within the next REF period the University plans to build a new purpose-built physics building to house all our activities.

Physics staff provide consultancy to Culham Science Centre which supports 40% of the salary costs of Professor Wilson and 40% of the costs of a new Chair in Experimental Tokamak Physics (Lipschultz). Professor Chantrell provides consultancy to Seagate (50% of salary). Professor O'Grady provides consultancy to a company (Liquids Research Ltd) founded by him and employing eight people and to hard drive manufacturers (Seagate and Western Digital).

Research is conducted most effectively when aided by professional and expert support staff and systems, and hence care has been taken to expand technical support in line with our academic staff. Comprehensive internal research web pages inform research activities and

research grant application procedures. The University has a European Liaison Office to advise and help in obtaining EU funding and a Research and Enterprise Office for locating research funding, negotiating contracts and to deal with the financial aspects of research grants. We have a dedicated Research Support Officer in the Department who advises on the financial procedures for research grant applications and ensures that researchers are aware of funding opportunities. Three other staff provide financial advice and maintain financial records. Technical support is provided by a Mechanical Workshop (including an advanced CNC milling machine and 3 staff), Computing and Electronic Workshop (5 staff), Research Services with 4 staff to provide technical support and one specialist staff member in each of the Nanocentre and YPI laboratories. We operate a Store joint with Electronics (two staff) for dispensing consumables and making small purchases. Eleven administrative staff support both teaching and research releasing academic-staff time for research, strategic-level administration and teaching.

e. Collaboration or contribution to the discipline or research base

(1) **Collaboration** outside of the UoA is high throughout Physics at York:

- The plasma physics and nuclear groups utilise collaborative tokamak, laser and accelerator facilities for most of their research activities.
- The York Nanocentre is a collaborative centre, engaging with chemists working on catalysis and electronic engineers working on nanomaterials and devices.
- Low temperature plasma work and magnetic nanostructures research is undertaken in close collaboration with industry (Intel and Seagate respectively).
- Collaborations on biophysics involving PPF and CMP staff (principally O'Connell and Kroeger) are active, with one joint physics/biology staff member returned in the biology REF (Leake).

(2) **More detailed examples of collaboration** outside the UoA include:

- A European network in theoretical spectroscopy has been led by York co-ordinator (Professor Godby) from 2005 until 2012; €8.8M EU grants established the European Theoretical Spectroscopy Facility as a 250-scientist research collaboration.
- A €1.8M EU funded project on ferromagnetic and antiferromagnetic thin films (HARFIR) between EU Universities, Tohoku University and the KEK X-ray and neutron diffraction facility in Japan started in 2013 co-ordinated at York (Professor O'Grady and Dr Hirohata (Electronics)).
- Collaborative high performance computing is a strong research field crossing research groups from CMP development of ab initio quantum mechanical solutions for many-atom problems (Probert), to PPF work involving laser-plasma and tokamak simulations (Ridgers, Dudson, Vann and Wilson). In all cases, collaboratively developed codes have been generated – CASTEP (with Cambridge) in CMP, BOUT++ (with LLNL, US) and ELITE (with General Atomics, US) in tokamak simulations and EPOCH (with Warwick) in laser-plasma simulations.
- Dr Probert leads a national network on computational materials modelling (the UKCP consortium) which supports the use of the supercomputer HECToR for > 100 researchers in physics, chemistry, materials and engineering research.
- Professor O'Grady leads York involvement in a £2.7M EPSRC critical mass project to work with engineers in University of Leeds and York to implement ultra-high resolution electron beam lithography for nanotechnology (from 2012).
- The Nuclear Physics group are members of EuroGENESIS (a EuroCORES programme) of the international NuGRID collaboration with research programmes at ten international accelerator facilities and collaborations with around 20 groups across Europe, North America and Japan.
- York is a leading partner in the EURATOM-funded EU fusion education consortium: Prof Gibson serves on its Governing Board and Prof Wilson serves on its Academic Council.

(3) **Examples of interdisciplinary research** include:

- Research in biophysics with physics staff member Leake returned in the biology REF, and electron microscope work in the Nanocentre on coral (Kroeger) and plasma work on, for example, the killing of biofilms and novel cancer treatments using plasmas (O'Connell).
- O'Grady and Vallejo-Fernandez have pioneered work in understanding the physics in the use of magnetic nanoparticle in enabling localised heating for medical treatments.
- Strong cross-overs to electronics in work on spintronics and magnetic nanostructures.
- Work by the NPG in the measurement of nuclear reaction rates relevant to astrophysics (particularly multi-dimensional stellar models) and collaboration with CERN on nuclear data relevant to fission reactor energy programmes.

(4) **Research collaboration has driven several strategic aspects** of research at York:

- The York Plasma Institute has been set up to exploit synergies between plasma work in the fields of magnetic confinement fusion, high energy density physics and low temperature physics.
- The York Nanocentre has founded a research niche based on collaborative research between developers of advanced concepts in electron microscopy such as wet and gas phase sample cells, and chemists and other users of such concepts. This is being further extended into the development of novel electron beam techniques using electron vortices (electrons with orbital angular momentum), exploiting synergies with theoretical research in optical vortices.
- A Biophysical Sciences Institute has been set up by Physics Professor Leake to stimulate and coordinate campus-wide biophysics activity, bringing together 50 academics (with five in Physics).
- NPG work has led measurements of nuclear cross-sections using facilities at AWE & Culham.
- Collaboration with industry via provision of research equipment has led to research in low-temperature plasma etching using an Intel silicon-wafer plasma-etch device.
- Collaboration with the manufacturers of hard drive storage equipment (Seagate, Western Digital) has driven much of our research in magnetic nanostructures.

(5) There are many **exemplars of leadership** at York:

- (i) ***Membership of Editorial boards and activities in scientific publishing***:

◊ Professor Chantrell is Editor of the Journal of Magnetism and Magnetic Materials and founding Editor of the Journal of Spin.
◊ Dr D'Amico is a non-executive Director of IoP Publishing.
◊ Professor O'Grady was the Magnetism sub-editor of the IoP journal J. Phys. D (1995-2012).
◊ Professor Gans is an Editorial Board Member of Plasma Sources Science & Technology (IoP).
◊ Professor Fulton served as an Editor of the European Journal of Physics A (2008-13) and as member of the Editorial Board of Nuclear Physics News (2008-9).
◊ Professor Wilson was a co-editor for Europhysics Letters 2008-2012 and is a member of the Editorial Board of the IAEA journal Nuclear Fusion (2013-present).

- (ii) ***UK Review panels.*** Twelve staff are members of the EPSRC College. Membership of longer-term RCUK committees and panels are as follows:

◊ Professor Tallents is a member of the STFC High Power Laser prioritisation panel for the Central Laser Facility and the EPSRC Strategic Advisory Team for large facilities. In 2013 he served as a member of the EPSRC Review panel of the Research Complex at Harwell.
◊ Professor Thompson is a member of the EPSRC Physics Strategic Advisory Team.
◊ Professor Wadsworth was appointed to the Nuclear Physics Grants Panel of STFC from 2007 to 2010 and is currently a member of the STFC Nuclear Physics Advisory Panel and Chairs the STFC Nuclear Physics Cross-Community Posts Panel.
◊ Professor Fulton was a member of the PPAN committee (responsible for particle and nuclear physics project expenditure) of STFC.
◊ Professor Bentley was a member of the STFC Project Peer Review panel until 2011 and has recently been appointed to the STFC Nuclear Physics Grants Panel.
◊ Professor Gibson (2008-10) and Professor Wilson (2010 - present) served as members of the tokamak facility MAST Steering Committee providing strategic focus for the scientific programme

- (iii) ***International review panels.*** Examples of leading roles include:

◊ Professor O'Grady was Chair of the Members and Fellows Nominations Committee in 2008/9 of the IEEE Magnetics Society and Chair of the Intermag Administrative Committee in 2011.
◊ Professor Chantrell was a member of the IEEE Magnetics Society AdCom where he coordinated the Distinguished Lecturer programme until 2010.
◊ York staff have chaired two of the seven groups co-ordinating the international collaboration of fusion research on ITER. Professor Wilson chaired the International Tokamak Physics Assessment 'pedestal and edge physics' group, while Professor Lipschultz chaired the equivalent 'divertor/edge' group, both in the period 2008-12.
◊ Professor Tallents was the sole plasma reviewer of the programme of the German Helmholtz Centre for Heavy Ion Research (GSI) at Darmstadt in 2011.
◊ Professor Fulton chaired the review group for the European Science Foundation (ESF) review of the EUROCORES project EuroGENESIS (2009), the working group which produced a nuclear astrophysics chapter for the NuPECC Long Range Plan for Nuclear Physics (2011) for the ESF, a

review of the Helmholtz Centre for Heavy Ion Research for the German Helmholtz Association (2009) and was a member of two review panels for the German DFG Funding Agency - Hadrons and Nuclei (2009) and The Excellence Cluster P2 (2010). He has reviewed the Quality of Research in nuclear astrophysics (2012-13) for the Italian Research Agency and was a member of the Department of Energy panel reviewing Nuclear Physics groups in the USA (May 2013).

◊ Professor Andreyev acts as an advisory Head of the "Research Group for Heavy Nuclei" in the Advanced Science Research Centre of the Japanese Atomic Energy Agency (Tokai).

◊ Professor Wadsworth chairs the international EXOGAM gamma ray array Steering committee.

◊ Professor Wilson served on an international review panel for the Helmholtz Fusion Programme (2009) and jointly with Steve Cowley (head CCFE) represents the UK in advising the European Commission on Fusion policy (2013 onward).

◊ Professor Gans: Secretary, International Union for Vacuum Science, Technique & Applications.

- (iv) ***Conference committees and organisation.*** Many staff serve on conference Programme committees. We list some more significant conference organisation roles:

◊ Professor O'Grady was General Chair of the MMM-Intermag conference in 2010 (1960 participants), Chair of the European Intermag Committee up to 2008 and Programme Co-chair in 2008 (Madrid). He acted as Chair of the Nominations Committee of the IEEE Magnetics Society Conference in 2008 and 2009 and Chair of the MMM Administrative Committee in 2011.

◊ Professor Krauss was organiser and Chair of the inaugural meetings of "Nanostructures for Photovoltaics" (Karlsruhe 2010, Austin 2011, Eindhoven 2012), which aims to explore photonic crystal concepts and diffractive optics for solar cells.

◊ Dr Probert is co-founder of the Theory, Modelling and Computational Methods for Semiconductors conference series (Manchester 2008, York 2010, Leeds 2012, Salford 2014).

◊ Professor Gibson chaired the local organising committee for the International Atomic Energy Agency (IAEA) Spherical Tokamak Workshop 2013 held in York and Professor Wilson chaired the IAEA Technical Committee Meeting on Theory of Plasma Instabilities, Vienna (2013).

◊ Professor Tallents was co-chair of the SPIE conference on x-ray Lasers (San Diego, 2009).

◊ Professor Gans was chair of the organising committee for the International Conference on Phenomena in Ionized Gases (ICPIG 2011). He is vice-chair of the International Scientific Committee for the Workshop on Microplasmas (from 2013).

◊ Professor Andreyev organised several international workshops: "Perspectives in Fission" (2012) and "Decay spectroscopy" (2013) in Tokai, "Shape Coexistence across the Chart of Nuclides" (2013) in York, "Fission and heavy ion fusion" (2012) in Seattle.

◊ Dr Jenkins and Dr Woolsey respectively organised the IoP Nuclear Physics and Plasma Physics conferences held in York in 2013.

◊ Professor Babiker served as co-chair of the International Conference on Optical Angular Momentum (ICOAM) held in York (March 2010).

◊ Professor Boyes ran the international Electron Microscopy EMAG conference at York in 2013.

- (v) ***Invited talks.*** Staff have given more than 200 invited and keynote lectures in the REF period. As an example, we cite Professor O'Grady who was elected an IEEE Magnetics Society Distinguished Lecturer in 2010, which resulted in him giving invited research-level lectures about his recent breakthroughs on exchange bias 57 times.
- (vi) The following ***prizes and honours*** have been won by staff:

◊ Professor Howard Wilson was awarded the American Physical Society John Dawson award for excellence in plasma physics research in 2013.

◊ Professor Andrei Andreyev, Professor Howard Wilson and Professor Bruce Lipschultz were awarded Royal Society Wolfson Research Merit Awards in 2011, 2012, 2013 respectively.

◊ Professor Timo Gans won the Plasma Sources Science and Technology Hershkowitz Early Career Award (2010) and the International Union of Pure and Applied Physics (IUPAP) Young Plasma Physicist Award and Medal (2009).

◊ Dr David Jenkins awarded a University of Strasbourg Institute for Advanced Study Fellowship.

◊ Professor Pratibha Gai (Chemistry UoA) was appointed Laureate for Europe in the L'Oreal-UNESCO Women in Science Awards for 2013.

◊ Our Head of Department, Professor Sarah Thompson was awarded an MBE (member British Empire) for services to Higher Education in the 2013 New Year Honours list.