Institution: University of York

Unit of Assessment: 9, Physics

a. Context

Research in Physics at York is carried out in three areas: The **condensed matter physics** group has industry links in six main research themes: magnetic materials, electron microscopy, nanophysics, photonics, software development, and quantum information. The **Plasma Physics and Fusion** group has industry links in five research themes: manufacturing industries, society and the economy associated with fusion energy, national security, healthcare technologies and outreach. The **Nuclear Physics** group has an industry-linked programme to generate impact in medical imaging, nuclear data for fission and detector development for radiation monitoring.

b. Approach to impact

The York Physics approach to impact is to use our research excellence and industrial links to enable impact opportunities which are driven and facilitated by a Departmental Industry Officer and by the University Research Innovation Office.

Condensed Matter Physics

The magnetic recording industry (Seagate Technologies and Western Digital Corporation) has a close working collaboration with magnetic materials research in the department by co-sponsoring PhD studentships, co-funding an industrial lectureship (**Vallejo-Fernandez**) and co-funding the salary of Professor Roy **Chantrell** (appointed to York from the post of Director of Research, Seagate Inc.). Links to SMEs include well-established collaboration with Liquid Research Ltd, a company founded by Professor Kevin **O'Grady**. Electron microscopy and nanophysics impact stems from the establishment of the York-JEOL Nanocentre with a state-of-the-art 0.8 Å resolution electron microscope. The centre is a part of Nanofactory which aims to commercialise emerging technologies in the Yorkshire Region with users of research, from SMEs (Liquids Research Limited), to large multinationals (BP and Shell). A dedicated Experimental Officer (Dr Leonardo **Lari**) has been appointed to facilitate access for industrial Nanocentre users. Theoretical research in solid state and quantum physics has led to collaboration with Hewlett Packard (with a joint PhD student); the co-development of the CASTEP code (with the department providing student provision and parallel computing facilities), and the European Theoretical Spectroscopy Facility (led by Professor Rex **Godby)** which develops commercially-relevant quantum mechanical material evaluations. The CASTEP code development is one of our impact case studies.

Plasma Physics and Fusion

Impact criteria have (i) determined the appointment of staff, particularly in the establishment of low temperature plasma physics for technological applications; (ii) driven a collaboration with EPSRC to create the York Plasma Institute (YPI) as a facility with an industry facing strategy; (iii) driven the appointment of an YPI industrial and outreach business officer (Dr Kate **Lancaster**); (iv) created joint PhD studentships with Culham Centre for Fusion Energy (CCFE), Intel and AWE PLC and (v) generated a substantial outreach programme (e.g. the 'Sun Dome' activity, below). Staff appointments in magnetically confined fusion (MCF) research in 2013 expanded opportunities for impact with support from CCFE (e.g. plasma wall materials, which is a key strategic area for the UK fusion programme), while staff appointments since 2011 and the construction of a new purpose-built laboratory have led to programmes using low temperature plasmas with impact in medicine and advanced manufacturing leading to new collaborations with companies such as Smith & Nephew, Intel, Element 6, and Oxford Instruments. Our fusion energy research has led to collaborations with companies including MM Microwave, AMEC, Frazer-Nash and Tokamak Solutions. Indeed, Professor Howard **Wilson** and Professor Kieran **Gibson** have been supported since 2012 by Technology Strategy Board (TSB) in a Knowledge Transfer Partnership (KTP) in the area of fusion energy with the SME Tokamak Solutions. Regional funding opportunities are also exploited; for example in 2012, the unit secured funds from the N8 Industry Innovation Forum to collaborate with Unilever and Smith and Nephew in developing new antimicrobial treatments.

Nuclear Physics

Impact is generated through a recently-established industry-facing Detector Development Laboratory with full-time experimental officer (Dr Pankaj **Joshi**). Recent projects for UK industries include developing a hand-held radiation sensor product for Kromek Ltd. and the development of a contamination sensor for power station sites for Nuvia Ltd. In addition, EPSRC and Rolls Royce, as part of the "Keeping the Nuclear Option Open" scheme, have funded work (value £100,000) to

measure neutron cross-sections relevant to the fission cycle and next generation fission reactors.

Strategic Appointments

The potential to deliver impact has been a **key criterion** for our **academic appointments** (e.g. Chantrell, Vallejo-Fernandez, Krauss, Wilson-Rae) and **equipment** purchases. Since 2008 the "York-JEOL Nanocentre", has come to fruition. This is a £6.6M capital investment, created with substantial financial support from the electron microscope manufacturer, JEOL Ltd. Impact here was facilitated by the strategic appointments of Professors Ed **Boyes** and Pratibha **Gai** to establish the centre. Boyes was appointed from DuPont in the U.S. because of his experience in working with industry, and since 2008 he and Gai have exploited this major capital investment to improve, for example, the understanding and operation of chemical catalysis with impact in chemical and biological processing industries. Further academic appointments in the period since 2008 exploited this capability as part of our strategy to invest in high impact research areas, including Dr Vlado **Lazarov** (2009) who, with Professor Jun **Yuan**, initiated research with potential impact in nanotechnology. The appointments of Professor Thomas **Krauss** in 2012 and one associated lecturer (**Wilson-Rae**) undertaking research on photonics were made to produce impacts in many areas including advanced imaging technologies for the life sciences; design, fabrication and measurement of devices for efficient conversion of solar energy into electricity; sources and sensors for automotive and consumer products; quantum-limited sensors for detection of acceleration, magnetic fields and encryption applications, and environmental sensing applications. To underline its commitment to this impact-generating strategy, the laboratory costs (£1.5M) of establishing the cleanroom and photonics laboratory have been met by the University. In Nuclear Physics, Prof Andrei **Andreyev** (appointed 2012) has been awarded a visiting position with the Japanese Atomic Energy Agency due to his expertise in fission research.

Fusion energy research at York has strong links to ITER, Fusion for Energy (the body that manages the EU's contracts for ITER) and Culham Centre for Fusion Energy (CCFE). For example, Professor Gibson was seconded to CCFE for much of 2008 to build an effective pathway to impact through a network of collaborators that have led to notable achievements such as Gibson's lead of the 25% York contribution to a £2M Thomson scattering diagnostic that was installed on the UK MAST tokamak. Further engagement with CCFE was driven by consultancy contracts for Professor Wilson with CCFE from 2008-13 and led to the appointment of Professor Bruce **Lipschultz** from MIT in 2013, with CCFE financial support, to a Chair in Experimental Tokamak physics. The appointment of Lipschultz aligns with UK needs identified by CCFE, and has led to an additional consultancy agreement for him with CCFE. Wilson serves on one of the ITER science international expert groups ("ITPA groups"), and chaired this group during 2008-2011: a key pathway that helped to generate our Impact Case Study for ITER. The appointments of Professor Timo **Gans** along with lecturers Deborah **O'Connell** and Erik **Wagenaars** in 2011 opened up a huge potential for impact across manufacturing and biomedical technology by creating a new Low Temperature Plasma research group. Gans' collaboration with Intel led to a donation of one of their commercial plasma etching devices, with an estimated £1.5M value, that will reinforce York-Intel collaborations. O'Connell's interests in biomedical applications of plasmas have been strongly supported and have led to collaborations with Smith and Nephew Plc. To complement our established experimental activity in laser-plasmas**,** a new lecturer was appointed in 2013 (Dr Chris **Ridgers**) to provide theory support, i.e. a strategic need identified to further enhance our impact with AWE PLC. The department strongly drove the establishment of the £4M investment of the University and EPSRC into the York Plasma Institute (YPI), which opened in October 2012. To drive the YPI impact agenda, Lancaster was appointed in 2011 as YPI Industry and Outreach Business Officer, supported in part by CCFE to help UK industry benefit from the multi-billion pound international fusion programme and drive academic-industry collaborations. Due to the success of Dr Lancaster's post in furthering industry interactions, she has now become a permanent member of staff supported by the department.

Institutional Support

Alongside the YPI Industry Officer, support for Physics academics pursuing impact-generating activities is provided centrally through the **Research Innovation Office** via a dedicated Business Development Manager (Dr **McGowan**) for Physical Sciences. Support for KTPs is provided to academic staff centrally through a dedicated Manager (Dr **Abeysekera**).

Industrial support has funded16 PhD students for 2008-13. Our EPSRC Fusion Doctoral Training Network is another avenue for generating impact by engaging with companies and

facilities such as CCFE, Central Laser Facility, National Nuclear Laboratory and AWE PLC, as well as major companies involved in fusion: AMEC and Frazer Nash.

The Department encourages **outreach impact** and appointed an outreach officer (Katharine **Leech**) partially funded by the Ogden Trust to advise and develop outreach activities. Several staff are involved in publishing the influential physics magazine for schools "Physics Review" which has subscriptions from > 800 schools in the UK. Dr **Jenkins** was awarded an STFC Science-in-Society Fellowship (a 25% appointment from October 2007 to September 2009) which involved developing a series of continuous professional development courses for schoolteachers at the National Science Learning Centre on nuclear/particle physics and applications. Another STFC grant to Jenkins in 2011 enabled him to produce 5000 copies of a DVD celebrating the centenary of Rutherford's "discovery" of the nucleus which was sent to 1800 IOP-affiliated schools and other destinations. Post-graduate students in the Plasma Group have been trained to operate and present a "Sun Dome" whereby primary school pupils enter a hemi-spherical tent with projected images and student commentary explaining the Sun, the energy problem and fusion research. In 2012, these students created a new Sun Dome video aimed at secondary school students which has won two national awards. In 2010-12 the Sun Dome was taken to 27 schools for a total audience of 1,825 primary school pupils.

c. Strategy and plans

Building on our approach to impact in 2008-13, the key elements of our future impact strategy are:

(i) **including impact potential as a criterion for new academic appointments and the purchase of equipment**;

We shall continue our strong track record and expand into new areas where we can deliver high impact research, such as nuclear medicine and nuclear (fission) industries; plasma-material interaction in fusion devices, plasma chemistry in manufacturing and enhancing our plasma medicine capability, photonics, bio-physics, functional materials, and quantum technology.

(ii) **engaging with industry and government organisations via joint research programmes and joint supervision of PhD students**;

We will further strengthen collaborations with existing end-users such as Seagate, JEOL, CCFE, Intel, AWE and Smith and Nephew, and seek to expand our "user" collaborators, particularly in the biophysics and photonics areas, building on recent appointments (Krauss, Wilson-Rae, Leake and O'Connell). More frequent workshops are planned to bring together industry and academics, as organised by our industry officer (Lancaster). For example, in the magnetic fusion area, workshops will be undertaken with CCFE to ensure UK industry has access to the >£15b funding of ITER.

(iii) **participating in knowledge transfer partnership schemes**;

We will actively pursue knowledge transfer partnerships. For example, with the SME companies Kromek and MM Microwave via our Industry Officer and nuclear Experimental Officer.

(iv) **appointing a dedicated industry and outreach business development manager**,

Due to the successful development of the role, our Industry Officer (Lancaster) appointed in 2011 has had her contract made permanent in 2013. The Industry Officer will help to increase emphasis on commercialisation of research outputs, including driving the development of spin-out companies. The University Research Innovation Office will also be used for support and advice.

(v) **actively engaging our External Advisory Board (EAB)**;

A Departmental External Advisory Board was established in 2012 to advise on impact as well as other issues with representatives from external research facilities, funding agencies and industry. The Board meets annually, engaging widely with members of the department.

(vi) **seeking impact funding from RCUK and others.**

We will seek funding for impact activities such as our EPSRC Impact Accelerator funding (£16.5k to Lancaster/Krauss) and STFC funding for outreach activities (Jenkins). A bid to HEFCE for a £5m Academy to 'enhance the pipeline between physics graduates and UK Plc' is in preparation.

d. Relationship to case studies

Our history from 1999 of appointing staff working in impact-generating areas has informed our approach to impact in the REF period and generated our Impact Case Studies. Recent appointments (e.g. the lecturer in high energy density physics (Ridgers), the Seagate lecturer in magnetics research (Vallejo-Fernandez) and the Chair (Lipschultz) plus lecturer in experimental tokamak physics) are further strengthening these impact generating research areas for the future, ensuring we can grow our impact in the next REF period.