Institution: University of Southampton

Unit of Assessment: 9 Physics

a. Context

The UoA 9 return from the University of Southampton represents the activity of the Department of Physics and Astronomy (P&A) an academic unit engaging more than 100 researchers at all career levels. P&A is structured around three research groups of approximately equal size; the Astronomy group, the Theoretical Particle Physics (TPP) group, and the Quantum, Light and Matter group (QLM). P&A forms part of the Faculty of Physical Science and Engineering (FPSE), together with Electronics and Computer Science (ECS) and the Optoelectronics Research Centre (ORC). The ORC, currently returned under UoA13, was jointly created in 1989 by the Departments of Physics and Electronics (as they were then) as a Science and Engineering Research Council Interdisciplinary Research Centre, with seconded staff from both Departments and a blue-skies-to-devices strategy. The close connection between researchers in the QLM group and the ORC is reflected in half of our returned Impact Case Studies (ICSs).

The main non-academic user groups, beneficiaries or audiences are:

(i) *Commercial organisations*, including spin-out companies and national laboratories;

(ii) *The general public*, especially school and college students, their parents and teachers, and life-long learners;

(iii) *Professional associations* and learned societies; specifically the Royal Society, the Royal Astronomical Society, the Optical Society of America (OSA), the Institute of Physics, the European Physical Society, the International Society for Optics and Photonics (SPIE) and International Astronomical Union (IAU).

The main types of impact created by our research include:

(i) *Economic impact and job creation*. The research of the QLM and Astronomy groups has led to the creation of 5 spin-out companies in the assessment period (*Fianium, SPI Lasers, Mesophotonics, Covesion, Symetrica*) with a combined annual turnover greater than £50 million, employing about 320 staff mostly in the UK.

(ii) *Impact on society*. All three research groups participate in a programme of roadshows and masterclasses that currently reaches about 7,000 members of the public each year.

(iii) *Impact on the environment*. The QLM-invented fibre amplifier exploited by Fianium and SPI Lasers represents at least a 3-fold improvement in efficiency (reduction in carbon footprint) over the legacy technology that it displaces.

b. Approach to impact

Our *Symetrica* case study relates how instrumentation developed by gamma ray astronomers for curiosity-driven research purposes led to economic impact through sales of novel radioisotope detector products for the security market with the continued involvement of A. **Bird**. All three research groups create *impact on society* through public engagement and outreach: a particularly vigorous contribution from Astronomy and TPP groups engages with the public currently fascinated by cosmology, exoplanets and fundamental theories of matter. In addition, the research of the QLM group leads to *economic impact*. In UoA9 the approach to impact has three aspects:

1. Engagement with potential beneficiaries in industry. We foster awareness of the potential economic impact of our research through face-to-face contact with industry researchers at regular events. QLM organises an annual technology workshop on *Nanophotonics for Energy Efficiency* (most recent was in March 2013) to which we invite the industrial partners associated with our EU-networks (more than 50 network partners in total). QLM researchers also participate in and make presentations to the *Industry Days* organised by the ORC. In 2012, delegates from 120 photonics companies attended the Industry Day, heard presentations from Southampton researchers, and toured facilities. In QLM we exploit a network of former PhD students that we have supervised or examined who are now working in industry (Sharp Laboratories, Toshiba, OSRAM, IBM, BAE systems, Toptica, Coherent Inc, Qinetic, Oclaro, Qioptic Photonics – and many others). In P&A we have a policy of maximising dissemination of our research by utilising open access publishing: P&A researchers select open access journals where possible, and make use of the arxiv.org website as well as **ePrints**, which is the University of Southampton institutional repository of publications.

The primary mechanism by which initial contacts are converted into continuing relationships is the award of EPSRC Knowledge Transfer Secondment (KTS) grants, although consultancy and the

provision of industry-funded studentships have also played a role. Since 2008, these mechanisms have resulted in secondments of eight fellows into sectors that include defence (DSTL, BAE Systems); standards and metrology (National Physical Laboratory); healthcare (Renishaw Diagnostics); photonics (Thorlabs, TeraView, Fianium) and chemicals (Merck).

2. University and Faculty support for staff to achieve impact from their research.

(i) **Exploitation.** The FPSE deploys a *Faculty Patent Panel* composed of Faculty members experienced in Intellectual Property (IP) who scrutinise proposals for filing and make recommendations on a case-by-case basis. The Faculty Patent Panel administers a dedicated patent budget of £45k per annum that is matched by a similar level of budget held by the University's *Research and Innovation Service* (RIS). The roles of RIS include providing expert support to inventors and training staff to understand IP issues. RIS also has a specialist legal team to assist in drawing up commercial contracts and three staff dedicated to support our Faculty, the **FPSE Collaboration Manager** (D Woolley) and the 2 **FPSE Research Support Officers** (E McCourt and R Di Chio). *Southampton Asset Management Ltd* is the legal entity that manages the entire IP portfolio within the University, and handles spin-out activity and licensing. QLM group members have made 9 patent proposals since 2008 and two have been supported.

(ii) **Shared facilities and multidisciplinary collaboration**. The University of Southampton has a long tradition of creating research groupings across subject boundaries, with infrastructure in common. The ORC with researchers seconded out of P&A and ECS, is perhaps the best known example of this strategy. The development and exploitation of the ytterbium fibre amplifier arising out of research by P&A staff, who had access to special fibres fabricated in (the forerunner of) ECS, illustrates the power of this approach, as does the creation of *Mesophotonics*, also a joint P&A/ECS project. The QLM group now participates in the newly-established *Zepler Institute* (ZI), formed around a £120m cleanroom complex, with the aim of bringing together the University's research capability in photonics, electronics, nanoscience and quantum technology. Within the REF period, industrial funders (including Rolls Royce and Sharp) invested more than £4.5m in the ZI cleanrooms thereby providing clear *evidence* of the industrial engagement with the initiative.

3. Engagement with the general public. P&A regularly sends early-career researchers to present posters at the annual *SET for Britain* event at the House of Commons. In 2010, QLM PhD student *D Bartczac* won the *Mendel Medal and Prize* in the biomedical sciences section for her account of *stimulation of blood vessel growth with gold nanoparticles*. Over the REF period, the support of the HEFCE-funded South East Physics Network (SEPnet; £12.5m over 5 years) has enabled a major expansion of our outreach programme. P&A has created 2 travelling demonstration lectures that visit schools, colleges and teacher training events in the south-east. The *Light Express Roadshow* (LER), an optics event built around a laser light show, was created in 2000 by A.C.**Tropper**, demonstrates how the research of P&A links to the technology of the internet. Having identified the potential of LER to engage with the general public, we made a strategic appointment, *P.John*, a full-time outreach professional employed by P&A; LER has reached about 3,000 people per annum in recent years; and is highly oversubscribed, with bookings sometimes running 2 years ahead. This enthusiastic reception prompted M.J.**Coe** to create the *AstroDome Roadshow*, based on a mobile inflatable planetarium, which in 2011/12 visited 37 schools and was seen by over 4,000 pupils. In-house events for school children include hands-on holography workshops (*P.John*), and the *Particle Physics Masterclass.* This last is an annual event on the fundamental theories of matter that captures many young scientists in the era of the Higgs boson, as does the *History of the Universe CD-ROM* distributed to 5,500 schools in the UK and since then available for free download (S.F.**King**, project with RCUK support). There is a constant demand for revisits (160) demonstrating the significance of our outreach activity. Finally P&A offers *The Newtonian Legacy* (N.J.**Evans**), which is – unexpectedly – a crime thriller, rife with sex, murder, and theories of physics, freely downloadable (above 30,000 to date).

c. Strategy and plans

The University of Southampton currently works with about 1000 external organisations; its consultancy income has more than doubled in the 3 years up to 2011/12 (£28m), and over £98m of investment has been attracted into its spin-out companies over the REF period. The University continues to invest in major cross-disciplinary facilities, such as ZI, the Institute for Life Sciences (IfLS) and, most recently, the Southampton Marine and Maritime Institute (SMMI), a £120m investment made in partnership with Lloyds Register, constituting the largest such business-focussed endeavour in any UK university.

We outline the elements of a research impact plan whose aim is to position P&A so as to exploit this opportunity-rich environment to maximum effect in the coming decade.

1: Impact fund and enterprise sabbaticals. P&A recognises that the curiosity-driven physics research of the QLM group will normally require pre-competitive evaluation in order to reach a stage where IP can be identified and protected. We have therefore set-up a *P&A Impact Fund* of £50k per annum for evaluation of potential IP. Staff bidding to the Impact Fund may also request an appropriate period of *Enterprise Sabbatical* leave from teaching duties. We will support Enterprise Sabbaticals and applications for Royal Society Industrial Fellowships and other relevant schemes for the TPP and Astronomy groups who play a key role in research projects generating Big Data with strong links to our expertise in Computer Science within ECS. The Deputy Head of P&A for Research will chair the panel that prioritises competing submissions to this resource.

2: User access to P&A facilities. At Faculty level, the facilities of the ZI cleanrooms are accessed by industrial project partners, cementing important relationships with beneficiaries. Within P&A we have the *Rapid Prototyping Facility* (RPF), which provides access to low cost lithographic techniques (FIB, e-beam, direct-write photolithography) and the possibility for experimentation prior to transfer to the higher specification instruments provided in the ZI complex. The RPF has had consistent use over the REF period from several external companies including Merck. Most recently *ULTRASPEC* (Ultrafast Spectroscopies) opened as a P&A facility in 2012. ULTRASPEC is a multi-user facility where a variety of ultrafast laser spectroscopies are performed. Funded initially by 4 EPSRC, 4 EU projects and P&A, ULTRASPEC attracts considerable interest from outside users for high temporal and spectral resolution spectroscopies in nanostructures. It will underpin future exploitation of QLM nanophotonics research.

3: Enhanced Faculty Support. QLM benefits greatly from its involvement with the ORC industry days, and the dedicated Collaboration Manager and two Research Support Officers within RIS. In the coming period this support will be extended by the resources of the ZI, with the **Research Funding Development Manager** (S Carr) and the **Zepler Institute Coordinator** (R Churchill).

4: UK Fraunhofer Centre for Applied Photonics (CAP). The very recent launch of Fraunhofer investment in the UK, and the inauguration of the CAP in Glasgow, represent an exciting development for UK photonics, opening new routes to industrial collaboration. Staff in QLM enjoy a long-standing informal collaboration with key people from the University of Strathclyde's Institute of Photonics, especially *J-M Hopkins* who is now the Head of Laser Applications, CAP. We are currently exploring initiatives around III-V lasers and microcavities, aiming at industry-funded collaboration with TSB support.

5: Increased public engagement impact. In section a. we described the P&A outreach effort that makes contact with thousands of people every year. We will continue to strengthen this effort and broaden its rearch through developing new web and social media tools to document the impact of this work. Participants will report how our events have affected their outlook on science and subsequent career decisions, allowing us over time to target our work to maximum effect. The HEFCE investment of £2.75m in the second phase of SEPnet is significant here: SEPnet 2 will establish a coordinated Impact Framework across the region, support the 7 constituent physics Departments to work collaboratively, evaluate initiatives and spread best practice.

6: Diversity. P&A is currently working towards achieving an Athena Swan award, to stimulate greater diversity, more equitable environment, and to foster creativity and adventure.

d. Relationship to case studies

Our 4 ICSs reflect the planned progression from research discovery, through IP management and engagement with industry, to deployment, spin-out, licensing or other value-generation streams and we briefly outline how each of these exemplifies our approach to impact. ***Ytterbium fibre amplifier:*** SPI Lasers Ltd and Fianium Ltd employ 250 and 50 staff respectively, exemplifying our approach to successful *engagement* and *exploitation*. ***Symetrica:*** A gamma-ray detection and imaging technique developed into a high-end product for security; shows close *interaction* with very large industries in the US, and UK and US *governmental agencies*. ***Photonic crystal* LEDs** A photonic crystal technology increasing the brightness and directionality of LEDs initially spun out as Mesophotonics and now with LUXTALTEK, a subsidiary of UniLite, a global industry in lighting, exemplifying an *agile follow-through response*. **Engineering nonlinear materials for optoelectronics:** Through Covesion exemplifying exploitation of research outcomes to produce direct economic impact and improve the business performance of industry.