Institution: University of Surrey

Unit of Assessment: UOA 9 Physics

a. Context. Achieving impact from research is part of the culture in the Department of Physics. Our six research groups each make an impact on different beneficiaries and end-users.
Nuclear Physics Group has beneficiaries in the nuclear power industry. They have made a major impact on the general public and society via their high-profile, pro-active public engagement work, in collaboration with national media and science communication organisations. They have made an impact on policy-makers via service to the Health Protection Agency (HPA) and testimony to the House Select Committee.
Radiation and Medical Group has research beneficiaries in hospitals and in the nuclear and radiation protection industries. They made an impact on the health and safety of radiation workers and the general public through their radiation protection research. Economic impact was achieved through product development in collaboration with the detector industry and the NHS. The Group is entrepreneurial, being awarded several patents and creating a successful spin-out company.
Photonics Group and Theory & Computation Group, based in the interdisciplinary Advanced Technology Institute, have a tradition of close collaboration with industry, *e.g.* Philips, Astrium and Oclaro, their main research beneficiaries. They have communicated research innovations to the general public via print and broadcast media and have influenced policy-makers on renewable energy via interactions with the UK Energy Minister. Economic impact was achieved through product development and new technology, especially using strained-layer devices. Impact continues from the breakthrough ideas on quantum well lasers of Prof. Alf Adams FRS (now emeritus), one of "ten Britons who shaped our world," according to *The Independent* newspaper.
Soft Matter Group has primary beneficiaries in the chemical and materials industries. Their research has made an economic impact by contributing to the development of coatings and adhesives (in collaboration with large multi-national companies) and optically-transparent electrical conductors (with an SME). The Group's NMR technology has been commercialised by an SME.
Astrophysics Group, established in 2013, expanded our research portfolio and is already making an impact on society via their outreach activity.

b. Approach to impact.
Our approach to impact (2008-13) has been characterised by a culture of building partnerships with industry and end-users, entrepreneurial flair, agility in responding to technological needs, and a genuine enthusiasm for engaging with the public. Our Research Strategy Committee, comprised of Group Leaders, oversaw the many mechanisms by which impact was achieved. We were informed by our University's Industrial Advisory Group which offers advice on ways to improve our interaction with end-users of research.

Knowledge Transfer (KT): Our Department is characterised by a high level of KT activities and extensive end-user collaboration, with >10% of our research income coming directly from industry. With strong University support, we use (inter)national schemes to stimulate and sustain KT. An EPSRC KT Account (*ca*. £4M) was used in collaboration with the National Physical Laboratory (NPL), who seconded experts in technology transfer, to ensure that our discoveries are taken up by end-users. Since 2008, we carried out KTA projects on stem-cell growth on scaffolds (HPA), textured coatings on glassware (Marks & Spencer, Heraeus), carbon nanomaterials for electronics (MSOLV), and feedback monitoring for solid-state lighting (NPL), which led to two jointly-filed patents. Since 2012, our EPSRC Impact Acceleration Account (IAA) has provided matching funds for projects to transfer research outputs. Moreover, our well-established BSc and MPhys industrial placement schemes (with *ca*. 25 students *p.a*.) impart a culture of commercial awareness and strengthen contacts with research end-users, as we make regular visits to our students in industry.

Industrial Doctorate Centres (IDC): We supervise 11 industry-based Engineering Doctorate students in our IDC in Micro- and NanoMaterials Technologies. Embedding students in industry, while providing access to our labs, ensures the maximum impact of research on products. Collaborating companies include AkzoNobel (polymer colloids in coatings), MSOLV (nano-electronic devices), NPL (polymer/CNT composites for fuel cells and ultrafast nano-ferroelectrics), Lafarge (dynamics of water in porous media), Rutherford Appleton Lab (pixellated X-ray imaging detectors and scintillators for medical applications). Via the Nuclear Engineering IDC, we are developing a next-generation radiation detection system for the assay of Pu with the AWE plc.

Industrial Partnerships: These ensure that research outputs are readily transferred to end-users. In a large EC collaboration, *NAPOLEON* (FP6), polymeric nanocomposites were developed

with eight industrial partners (*e.g.* BASF, Wacker, L'Oreal), leading to five patents being filed and influencing the development of coatings, adhesives and cosmetics. In *BIANCHO* (FP7), Surrey's patent on efficient Bi lasers was verified, and exploitation is now being achieved through Huawei. Our nuclear and radiation researchers' collaboration with HPA, NPL, and AWE provide environmental radiation assay, nuclear stewardship, and security applications. Within the period, 15 Physics PhD students were co-funded by industry. KT Partnership fellows worked in collaboration with Harkness Screens (leading to new products), and with Plastipack Ltd. on new designs for swimming pool covers for solar heating, contributing to a new product. Walker (Nuclear Physics Group) engaged with AWE as a Penney Fellow (2006-12) on exploiting isomer research, *e.g*. a nuclear "battery" with an energy density 10^6 times a chemical battery.

Training for Industry: We have a two-way engagement with end-user industries in our MSc courses in radiation/medical physics (with *ca*. 50 students *p.a*.). Course contributors include AWE, NEXIA Solutions, GE Healthcare, HPA, & NPL. We have delivered bespoke CPD courses in radiation protection and nuclear instrumentation to Atkins. Soft matter researchers offer workshops to industry and have presented seminars at six companies with advice to solve industrial problems.

SEPnet: Another mechanism for achieving impact and sustainability is our membership in the South East Physics Network (SEPnet), a consortium of nine University departments formed with a £12.5M HEFCE grant in 2008 to promote physics. Its Outreach programme, regarded as an exemplar for collaborative outreach, uses the combined knowledge and resources of each partner to provide greater impact and reach by rolling activities out through the network, thus increasing the number of attended events (>60 *p.a*., reaching >50k people (including >7k children) in 2011/12). Our SEPnet Outreach Officer (0.5 FTE) supports researchers' public engagement and bids for RC Pathways to Impact funding, and also trains PGRs and staff. Outreach, highlighting our research activity, has contributed to a sharp increase in our undergraduate applications (up 230% since 2009 and a record intake in 2013). Our experience has informed SEPnet's Employer Liaison Director, guided its summer internship scheme, and contributed to its Employer Advisory Panel.

Engagement with Media Organisations: We have established a close working relationship with the *Science Media Centre* and with *Sense About Science*, which has led to invitations from news organisations to inform the public. Surrey Physics is one of the "first ports of call" for journalists reporting on nuclear power (*e.g*. the Fukushima incident) and radiation detection (*e.g.* Po poisoning). We engage directly with the public through personal blogs, on-line chats (*e.g*., a web-chat on Mumsnet after Fukushima), and writing articles for national newspapers and magazines.

Communicating Research to the Public: The RCUK report, "*What's in it for me?"* explained the benefits of public engagement for publicly-funded research and cited Al-Khalili and Regan as exemplars of good practice. Their Group organized a session on nuclear physics at the 2009 British Science Festival at Surrey. The Photonics Group was selected to stage a research-led exhibition on "Schrödinger's Cat" at the Royal Society Summer Science Fair (2011) with EPSRC funding and SEPnet Outreach support. It has since been used at many science festivals (*e.g*. 2012 Big Bang Fair) with attendance >50,000. Our research has been featured in *The Economist*, *New Scientist*, and *The Sunday Times*. The University Press Office and a media consultant have assisted us in publicising research via 28 press releases since 2008, *e.g*. on atomic physics relevant to astrophysics, on harvesting solar energy from space (appearing in >10 publications), and on advances in quantum information processing. Our on-line repository (Surrey Research Insight) makes research outputs *freely* available to the wider world. 850 of our outputs are now on-line, and >2k per month are downloaded. We reach >700 followers on Twitter@PhysicsatSurrey, and many read our blog: www.uniofsurreyblogs.org.uk/physics/. Our musings and anecdotes on research in blog-posts inform readers about recent discoveries and "life as a physicist".

Chair in Public Engagement in Science: With full backing from the University, we established this Chair, which was taken up by Al-Khalili. He is enabled to carry out media work, such as developing and presenting television programmes to inform and stimulate the general public. His two EPSRC Senior Media Fellowships (2006-11) allowed him to devote 50% FT to this activity.

University Support: We are supported in our approach to impact by the Research & Enterprise Support (RES) Office, who provide project management for key partnerships and assist us in contract negotiation, patent applications, legal agreements and company spin-outs. We have worked with RES's Technology Transfer team on patent applications (five since 2008) and licensing agreements to ensure effective commercial exploitation. The Director of RES co-operates with our Faculty Associate Dean (Research) in managing our mechanisms to achieve impact.

c. Strategy and plans. Successes in the mechanisms outlined in Section b have informed our impact strategy: (i) to forge partnerships with industry at all levels; (ii) to influence and exploit networking opportunities funded by EC Horizon 2020 and TSB; (iii) to enthuse and inform the public about physics via continued media work and outreach; and (iv) to develop our staff.

University/Industry Links: Surrey has signed MoUs with NPL and AWE as strategic partners. This has led to close collaborations, including co-funding of four Physics academic positions and a secondment to facilitate industrial transfer. We will pursue other partnership agreements and use IAA funds for collaborations to make an impact on industry. Impact on nuclear industries will be made through experimental studies of nuclear decay in international research programmes.

SEPnet: Our leadership in SEPnet is a key means to achieve our impact strategy. From 2013, HEFCE is providing £2.75M (coupled with Universities' investment of £9M) to expand the network, to address diversity issues, and to establish a dedicated regional PGR Network (GradNet) led by McDonald at Surrey. Through GradNet, we will offer training in transferable, leadership and public engagement skills for maximum impact of research. In a new initiative, employability skills of PGRs will be developed via internships to support regional employers, arranged through our many research contacts and our well-established network of industrial placement providers, all co-ordinated by our Employability Officer (0.5 FTE). The SEPnet Impact Leader (0.2 FTE) will execute work to optimise the range of impact, to inspire stakeholder engagement, and to apply for an STFC Innovations Partnership Scheme Fellow to assist in generating economic impact from our STFC-funded research in nuclear physics and astrophysics. SEPnet departments will share best practice.

Public Engagement: With the installation of new portable and student telescopes, projected animations and research-led numerical simulations, the Astrophysics Group will share the wonders of the night sky with the region's public. They plan to take part in the BBC "Sky at Night" activities in 2014. The continuation of Al-Khalili's popular radio programme, *The Life Scientific*, and new science documentaries are planned with full BBC backing. We will continue to draw upon strong links with science festivals, the BBC, Channel 4, IoP, Royal Society, Royal Institution, and the print media. We will work closely with the STFC Science in Society and Press Office teams to develop joint ideas for cultural impact of scientific research. We will contribute to public engagement work by the STFC Outreach Director, based at Surrey. We will engage with regional schools, using SEPnet input, to enthuse pupils about the excitement and enjoyment of physics. Our activity will expand over the next five years under our SEPnet Outreach Officer, who will continue to support our researchers in public engagement activities, *e.g*. school visits and science fairs.

Staff Development: Annual staff appraisals are being updated to recognise and reward achievements in impact, and excellent impact will be encouraged through annual Impact Awards. We will continue to encourage sabbatical leaves of academic staff to nurture contacts with end-users. Increased dissemination of impact activity will be led by the University's Impact Champions.

d. Relationship to case studies.

Our four case studies (CS) exemplify our approach to impact.

(**1**) Our CS on "*Communicating Physics through Public Engagement*" is a direct result of our media and outreach strategy coming to fruition. Nurturing media links connected us with science journalists. Al-Khalili built close relationships in the broadcast and print media, enabled by his Fellowships and Chair, to achieve the research impact described.

(**2**) Our CS on "*Next-Generation Airport Baggage Scanners*" describes economic impact made possible through institutional support in IP protection, licensing, and successful spin-out of radiation imaging technology. With close interaction with industrial lecturers, project supervisors and employers on the MSc courses, our researchers benefited from an atmosphere in which entrepreneurship flourished. Impact was achieved as the result of a deliberate strategy.

(**3**) Our CS on "*3D Radiation Dosimetry*" reports exploitation of research that similarly benefited from institutional support. Here, impact was achieved through a variety of mechanisms: student MSc projects, consultancy, research contracts, patenting, and industrial engagement.

(**4**) Our CS on "*Commercial Exploitation of Strained Semiconductor Alloys*" explains how scientific innovations in the 1990s onwards were transferred to the semiconductor and burgeoning laser industries. Impact emerged because of the Photonics Group's embedded culture that encourages industrial collaboration. Continuing impact was enhanced by Sweeney's sabbatical leave, during which he built new commercial links and developed a TSB-funded proposal. Impact was also achieved through KTA and KTP mechanisms as part of a planned strategy for exploitation.