Institution: Aberystwyth University

Unit of Assessment: 9 Physics

a. Context

The impact generated by our research in **Materials Physics, Solar System Physics and Quantum Structures, Information and Control** occurs in the following areas:

- **Economic impacts**: we assist local Small- and Medium-sized Enterprises (SME) in targeted projects in areas including materials and instrumentation, for example in new applications of coloured glass and vacuum thin film deposition. We also have impacts on larger multinational companies and international research and development laboratories through dissemination of new techniques and applications, for example industry-funded projects in optical instrumentation and diamond electronics.
- **Impacts on society, culture and creativity**: we target schools, science fairs and festivals for young people and, in particular, have a significant effect on the Welsh landscape in the stimulation of the general public and school children's understanding of physics through lectures, hands-on exhibits, school visits and large events, for example establishing a science pavilion, Gwyddon*Le*, at the Urdd National Eisteddfod.

The main users of physics research from the Department of Mathematics and Physics (DMAP) are therefore SMEs, multinational companies, the public and schoolchildren.

b. Approach to Impact

Physics research at AU has a long history of engagement with industry and the public. This is now formalised through nominated "champions" within DMAP for innovation, enterprise and outreach, overseen by the DMAP research committee (RC). Impact is discussed and recorded at individual biannual research monitoring meetings with the Head of Department and the DMAP Director of Research, and staff are encouraged to put themselves forward for policy-forming committees (e.g. Evans chairs the Welsh Optoelectronics Forum steering committee). The DMAP Research and Impact Fund supports activities that aim to generate research impact, for example visits to companies and trade fairs (e.g. Photonex).

Assistance in generating impact-related activities is provided by AU's Research Office, particularly in preparing "Pathways to Impact" documents. DMAP also draws on AU's Research Fund, which provides selective support for strategic, non-recurrent, research initiatives, for example funding early stage work in instrument development, leading to larger projects, funded by industry, government and EU initiatives. In addition, AU has recently appointed Professors of Public Engagement in Science and Engagement with the Public Imagination; DMAP is developing close working links with these professors to further enhance research-related impact on society.

Economic impacts: Partnerships with industry generate impact through research collaborations, contract research and consultancy. Research of commercial value is co-ordinated and negotiated through AU's Commercialisation and Consultancy Services (CCS), recently brought under the aegis of the Research Office. Working with CCS, we have generated 17 contracts, Non-Disclosure Agreements (NDA) and Material Transfer Agreements (MTA) with seven SMEs, four UK companies and centres and six international companies and centres in sectors including manufacturing, aerospace, photonics, chemicals and electronics. We have filed three patents in the census period, bringing our total to four, in charged particle detection, imaging ellipsometry, graphene fabrication and transparent ceramics. Projects with industry include:

- EU-funded Knowledge Economy Skills Scholarships (KESS) partnerships with SMEs in areas including (i) coloured glass with Ten Green Bottles (Wilding), (ii) vacuum deposition of polymers with Scanwel Ltd (Evans). Research underpinning project (i) has also been applied in spacecraft technology, introducing coloured glass as new camera calibration targets (Wilding, Barnes). Research underpinning project (ii) has also led to NDAs and MTAs with organic electronics companies (Evans, Finlayson) and a EU-funded Knowledge Exchange Partnership (KEP) in intelligent polymers (Evans, Finlayson).
- EU-funded innovation partnerships, including (i) an Academia for Business (A4B) project to

prove the feasibility of patented charge particle detector technology in partnership with a UK SME (Langstaff) and (ii) an A4B project on developing patented instrumentation for imaging ellipsometry. Research underpinning project (i) has also led to industrially funded projects in electronics and chemicals (Evans) and a patent in graphene fabrication (Evans). Research underpinning project (ii) has also led to NDAs with optical instrument developers and industrially funded projects in optical instrumentation (Langstaff).

- Directly-funded projects with companies in areas such as diamond electronics (consultancy with UK and international companies) (Evans), metal alloys (consultancy with a UK company) (Evans), and hyperspectral imaging (consultancy with a UK SME and large US company) (Barnes, Langstaff) applied, for example, to new imaging systems for remote sensing.

Additionally, we engage with industry to identify training needs for graduate and postgraduate employment and CPD for existing staff, for example in optical materials and instrumentation with HE-STEM funding.

Impacts on society, culture and creativity: We are aware of the need to educate the general public and school children about the value of physics as an intellectual discipline and its role in underpinning economic growth. Outreach activities are co-ordinated within DMAP and recorded on a continuous basis, through the university's Current Research Information System (PURE), and staff have been encouraged to use questionnaires following activities with school children and the general public.

DMAP recognises the value of training in outreach skills: we run annual seminars for staff on outreach and work closely with AU's Centre for Widening Participation and Social Inclusion. These include hosting and delivering HE-STEM-supported activities with a strong physics theme at Aberystwyth such as *STEM Discovery Days*, *Science Circuit Skilling the Future, Gwyddfan / Science Van,* and *Roadshow masterclass.* We engage with National Science and Engineering Week and host projects funded by initiatives such as Nuffield Science Bursaries. In 2013, two students undertook projects on the *Development of Solar Imaging System*. In 2011, one of the Nuffield-supported students was awarded a Golden Crest award.

We promote physics locally through relationships with teachers in local schools allowing us to acquire feedback on the activities and hence to design events customised for students, for example, running a workshop for year 12/13 students making future career decisions.

We promote physics nationally, co-ordinating through organisations such as the Institute of Physics (IOP) and the Royal Society of Chemistry (RSC), for example delivering lectures and providing leadership, including the secretariat and chair of the IOP Wales branch (Grande, Pryse, Cross), membership of the IoP External Engagement Committee (Grande) and the IOP Diversity and Inclusion Committee (Pryse).

Physics research feeds into teaching programmes through representation on the Welsh Joint Education Committee (WJEC) that determines and examines the physics syllabus at A-level (Pryse) and, at HE level, representation on the Academic Board of the Coleg Cymraeg Cenedlaethol (CCC) (Pryse). CCC co-ordinates Welsh medium provision across the universities, funding academic staff, networking and new initiatives, including funding a DMAP project on workplace skills for students of Mathematics and Physics (Pryse). In Europe, DMAP leads the outreach activities of the EuroPlanet network (Grande).

Interdisciplinary research is promoted within DMAP, leading to impact, for example, on young people with the Department of Computer Science in a EU-funded project in robotics (Technocamps) and on the wider public with the Department of History in a funded project recreating Victorian physics demonstrations.

Staff regularly provide information to the media on their research and its relevance to current topics of interest, working closely with the university's Communications Office to publicise research projects and findings and to provide expert commentators for programmes. In particular, a strong relationship exists with the BBC and S4C in Wales, with staff describing research including solar tornados, space weather and graphene. Internet visibility of physics research includes www.quantiki.org, on quantum information processing, and solar physics nuggets at www.uksolphys.org/category/nuggets.

DMAP takes great pride in our Welsh medium outreach, being the lead provider of Welsh-medium HE provision in physics and mathematics, and principal authors of the CCC HE strategy document for these STEM subjects. We host a hands-on science activity (Infinity) run by DMAP staff, assisted by our students. Infinity includes a portable planetarium where presentations on the solar system and wider universe are delivered bi-lingually by research staff. Feedback from local primary schools includes: "*When we came out of the planetarium, it seemed that we'd been in space!"* Bethan and Siwan, Ysgol Talybont.

We have an annual presence at both the Gwyddonle (the science pavilion at the Urdd National Eisteddfod, aimed at young adults) and the National Eisteddfod (for all ages). The Urdd National Eisteddfod is one of Europe's largest youth festivals, attracting close to 100,000 visitors each year. DMAP staff led the science committee at the 2010 Eisteddfod and played a key role in the re-establishment of science activities at the event.

c. Strategy and Plans

DMAP has rationalised physics research, organising research within three main areas, co-ordinated by the Research Committee and integrating all experimental and modelling facilities and support staff to provide a critical mass and single point of contact for generating economic impact. Our facilities are collated on our website and our photonics facilities are listed on Expertise Wales.

In recruiting staff to research groups, we raise the issue of research impact as an interview criterion. By concentrating our effort across research groups, we guide research projects towards those that have greater impact potential. In particular, our experience with SMEs, large companies and EU funding is informing our developing impact strategy. Monitoring is also key to success and we are using AU's PURE database to record impact activity for discussion in biannual individual research monitoring interviews. Feedback is provided to staff on draft applications to maximise the use of DMAP funds to promote impact. Impact is a standing item on the agenda of the Research Committee and the results of these discussions are passed on to research groups.

Regular meetings between the Commercialisation and Consultancy Services (CCS) Technology Transfer Team and DMAP staff are organised to identify research with commercial potential. A new initiative is for a member of staff from CCS to spend time in DMAP on a monthly basis.

In the future, DMAP seeks to use AU expertise across different disciplines to further train staff in using their research beyond academia, and to then reward staff who seek to do this through the introduction of a resource allocation matrix. We will continue to fund exploratory projects that may lead to research impact, and will require that research proposals include a clear impact strategy, which will be monitored by the Research Committee.

We will continue to co-ordinate, enhance and focus our public engagement activities, for example by working with the university's Centre for Widening Participation and Social Inclusion and its Communications Office, and with outside organisations.

d. Relationship to the Case Studies

The nominated case studies demonstrate the impact of physics research at Aberystwyth as supported by the approaches and mechanisms outlined above, and illustrate both types of impact.

Case Study 1, on knowledge transfer from the research laboratory to a local SME, illustrates the impact on visibility, knowledge and capacity for Ten Green Bottles; it exemplifies how glass research has enabled an impact on a social enterprise and business.

Case Study 2, on impacting the work of the Urdd Eisteddfod and enhancing outreach to young people in Wales, describes the reinstatement of science activities at this major event for young people based on physics researchers' expertise in solar system physics and commitment to Welsh-medium science. An STFC supported activity in solar system physics provided a centre stage event for the science pavilion at the 2010 Eisteddfod, whose legacy remains in a prominent and successful event attracting external funding in each successive year.