Institute of Physics Spring Budget Submission

1 February 2023

Executive summary

Crucial to preserving the UK's status as a science superpower and to the Chancellor's ambition to make Britain the world's next Silicon Valley, investment in physics is a catalyst for innovation and growth through the development of new technologies and applications. But if we don't unlock physics' full potential, we will not get there. Physics-based businesses span sectors including manufacturing, energy and services, and contribute 10.6% of UK GDP, employing more than 2.7 million people (10% of total UK employment). R&D taking place in physics-intensive industries makes up 34% of business-conducted R&D.

The UK must:

- Increase R&D funding beyond the 2.4% milestone to reach the upper band of comparator nations above 3% and beyond.
- Increase QR university funding for world-class domestic physics research to address the impact of inflation and higher running costs, and increase the proportion of full economic costs recovered on all publicly funded research grants, to sustain UK university research at the forefront of global science.
- Optimise private sector R&D activities through additional funding at the early and development stages, a focus on long-term funding schemes, and a more attractive tax environment.
- Maintain the funding set aside for association to Horizon Europe – or for alternative programmes, if necessary – for the duration of the programme.
- Make further investment in world-class domestic research and innovation infrastructure.
- Invest up to £100 million over three years in subject-specific professional development and retraining for teachers in the sciences.

Why physics?

Crucial to the science superpower agenda and to the Chancellor's ambition to make Britain the world's next Silicon Valley, investment in physics is a catalyst for innovation and growth through the development of new technologies and applications like metamaterials and spintronics. Physics-based businesses span sectors including manufacturing, energy and services, and contribute 10.6% of UK GDP, employing more than 2.7 million people (10% of total UK employment). Labour productivity in the sector is strong at £84,000 per worker, per year.[1] Based on research carried out in 2021, R&D taking place in physics-intensive industries (industries where ongoing physics research is most concentrated) equalled £8.9 billion, or 34% of business-conducted R&D. Given the right conditions, such as a stable policy environment based on a long-term vision with broad coverage, long-term and sustainable funding, and improved approaches to career progression, skills development, diversity and inclusion

[1] See the IOP's 'Physics and the Economy' report: Physics and the Economy – 2022 findings | Institute of Physics (iop.org)

across the physics R&D workforce[2], 59% of physics innovators in industry expect their R&D/innovation spending to increase over the five years from 2021[3].

Physics, as a discipline, is fundamental to almost every modern-day and emerging technology, with many of these applications being built upon the world-leading discovery science of UK physicists. From developing new materials and nanotechnology to drive the engineering advances that underpin quantum computing, robotics and artificial intelligence, or creating new cancer diagnostics and treatments to improve outcomes for patients, UK physics has been indispensable to many of the world's most impactful and successful innovations. As an example, photonics – the applications of which include fusion energy, laser surgery, and quantum computing, among other areas – has for many years been a UK strength and remains a hidden economic engine: in 2020, companies manufacturing and delivering services based on photonics technology in the UK produced £14.5 billion in output, employed nearly 80,000 people and contributed £6.5 billion of gross value added (GVA) to the UK economy.

The benefits of physics innovation are also not limited to one geographic area: the compound semiconductor cluster, CSconnected in South Wales, is a world-leading centre of innovation, showcasing Wales's unique capability to be centre stage in the development of new and emerging technologies and strengthening the long-term economic prospects for the regional economy. Research from the Welsh Economy Research Unit at Cardiff University found that CSconnected firms and institutions directly supported £121 million of Welsh GVA in 2020.

Push UK R&D beyond the 2.4% of GDP milestone to above 3%

The historical leadership that the UK has been able to demonstrate, as a science superpower, in physics and foundational science will only be sustained if investment is at levels that match or exceed international comparator nations and allow us to retain innovation and IP within the UK. Global competitors, such as Germany, Japan, South Korea and the US, are already investing more than 3% of their GDP in R&D and are pulling further ahead, with international expenditure growing more strongly in recent years than at any point since the mid-1980s. **Investment in R&D needs to push past the 2.4% milestone into the upper end of the range for comparator nations, above 3%, to propel the UK towards these goals.** This investment will bring with it significant contributions to growth, productivity, employment and living standards, as well as having big impacts on the Government's net zero ambitions, meaning that additional support for physics R&D will also fuel the green industrial revolution.

Reverse the decline in QR funding and ensure funding meets more than the full economic cost of research

Both elements of the UK's dual support system – the block grant largely comprising quality-related (QR) funding and Research Council funding to support specific research projects and programmes – provide essential support to the world-leading research that takes place in UK universities upon which technological discoveries are built. The long-term, flexible nature of QR funding enables universities to act strategically, explore new and high-risk avenues of research that underpin future innovation, and pursue excellence in line with their institution's and local strengths. Without QR funding, the UK would

[2] See the IOP's blueprint for the future of physics in the UK: Physics-Investing-in-our-future.pdf (iop.org)
[3] See the IOP's 'Paradigm Shift' report: Paradigm-Shift-physics-innovation-final-oct-2021.pdf (iop.org)

not have had innovations and discoveries such as graphene (a metamaterial with a huge range of potential applications from more powerful solar panels to the next generation of computer circuit boards that could run up to 1,000 times faster than silicon-based components), genomics, opto-electronics (a foundational technology for quantum computing), and new tests and treatments for everything from bowel disease to diabetes, dementia and cancer.

However, analysis from the Russell Group revealed that there was a 22% real-terms decline in QR across the higher education sector in England between 2010/11 and 2020/21, and that the balance of funding between QR and Research Council funding had fallen from 80p in the pound in 2007 to 50p in the pound in 2018. **Though there have since been announcements of increases to QR funding, to sustain UK university research at the forefront of global science, the Government – working in partnership with UKRI – must ensure levels of QR funding take account of rising inflation and running costs.** A more sustainable balance between QR and Research Council funding will allow universities to continue to forge new partnerships with business and industry, invest in the talent pipeline, build research capacity, support groundbreaking discovery science and use R&D to help power future economic growth.

In addition, research in the UK's universities is currently funded at levels below the full cost of performing that research, with the total deficit for research activity in universities in England and Northern Ireland reaching more than £4 billion in 2019/20. In particular, universities only recovered 71% of the full economic costs (FEC) of research funded by the Research Councils, substantially less than the 80% committed to. This deficit requires universities to cross-subsidise research from other income-generating activities and leads to an unsustainable system in which research capacity is dependent on factors, such as tuition fee income from overseas students, which were negatively impacted by the Covid-19 pandemic and which vary between institutions. The **Government should increase the proportion of FEC recovered on all publicly funded research grants to safeguard the sustainability of the world-leading research that takes place within the higher education sector and ensure long-term capacity exists in all universities, in all parts of the UK, to deliver an increase in research activity.**

Secure international physics collaboration

The UK's physics and wider scientific communities are dependent upon international networks, infrastructures, partnerships and programmes. A strong, long-term international presence must be maintained, if we are to remain in the vanguard of scientific discovery and innovation as well as realise the knowledge-sharing, economic, and political benefits of science diplomacy. The Government must both maintain existing and develop new international collaboration channels, to catalyse the movement of people between countries, sectors and roles, and facilitate knowledge exchange. **The IOP has strongly advocated for the UK's continued participation in EU science funding programmes. We therefore ask HM Treasury to maintain the funding set aside for association to Horizon Europe (or an alternative programme, if necessary) for the duration of the programme.**

The IOP has also invited BEIS to invest in the development and implementation of a strategic partnership programme to develop physics capacity in sub-Saharan Africa (SSA), strengthen the region's physics talent pipeline, and facilitate stronger equitable research and innovation linkages across SSA and with the UK to tackle key global challenges. The Africa-UK Physics Partnership project can be a productive and effective partnership between the UK and SSA centred on global challenges-oriented physics research and innovation (primarily focused on climate, weather management and energy), implemented with the support of established UK and African partners. This example of a vital form of

science diplomacy will ensure the UK is best placed to develop good relationships with countries across Africa, which will be of increasing importance as we look to expand our network of global trading partners. Working with Africa to help the continent deliver on its potential, both in terms of meeting environmental targets and in terms of the massive potential of its people, will pay dividends in finding solutions to the problems we all face.

Invest in world-leading research facilities and infrastructure

Having a national large-scale physics facility is a key ingredient of 'science superpower' status and is an asset that nations compete for. Nations compete both for the demonstration of capability that hosting a flagship international science infrastructure indicates, and the concurrent benefits in terms of the attraction of high-quality intellect, the clustering of technology businesses and the associated GVA and jobs.

For some businesses, a lack of access to suitable facilities and equipment can be a barrier to R&D/innovation activity. 16% of physics innovators have reported that a lack of suitable facilities or equipment limits their ability to undertake R&D/innovation activity, with 26% pointing to a lack of suitable buildings or space and 20% citing a lack of physical testing equipment[4]. Targeted investment in facilities can have specific scientific benefits but can also create significant spill-over benefits ranging from regional or national economic impacts (such as job creation) to the increased demand for specific skills, training or education to very direct benefits arising from application.

UKRI's announcement that it will invest £481 million in major infrastructure projects over the next three years will help ensure that we renew and upgrade the UK's capability to keep pace with technological advances, empowering our researchers and innovators to go further faster. But if we are to build on the underlying excellence of physics as a discovery science in the UK, **there should be continued development of existing facilities and their capabilities, to ensure that the UK remains a centre for world-class science.**

Additional investment in world-leading research facilities and infrastructure will also signal to our partners that the UK is open for business, ready to embrace the opportunities of a changing world, and would be a necessity to support any push to make Britain the world's next Silicon Valley.

Invest in science education through subject-specific professional development and retraining

There is currently a shortage of specialist teachers in the sciences (especially physics). Investment in increasing the number of teachers with the necessary expertise and making the most of the teachers that we have – through high-quality professional development – is an effective way to improve student outcomes, providing them with skills that will increase their opportunities and their employability, and in turn contribute to economic growth. It will also help with retention by making teachers more confident and feel valued.

Existing shortages reduce both the number of students with the experience and qualifications we need and also equality of opportunities: 70% of physics A-level students come from 30% of schools (with

[4] See the IOP's 'Paradigm Shift' report: Paradigm-Shift-physics-innovation-final-oct-2021.pdf (iop.org)

similar proportions observed for other sciences)[5]; students in the lowest quintile of SES are three times less likely to take A-level physics than those in the highest quintile and about 500 schools do not have a physics teacher. The scientific, engineering, manufacturing and data industries have traditionally been a route to social mobility and financial security for talented individuals whatever their background. Ensuring that all students in all schools have access to high-quality physics teaching that leads to the qualifications and skills that are valued by these industries is a means of opening up new opportunities to children in areas of social disadvantage.

Those opportunities are now being lost:

- students in more deprived areas are being denied opportunities to succeed in the sciences
- the nation is missing out on the diversity of creative minds that drives innovation.

We are calling for investment of up to £100 million over three years to develop and deliver an ambitious approach to subject-specific professional development and retraining in the sciences as part of a STEM education strategy and bring together the subject elements of existing programmes – as outlined in the IOP's Subjects Matter report.[6]

Specifically, **we are calling for £2 million of this sum to be allocated to support existing teachers with bursaries to retrain as physics teachers** thereby quickly addressing the existing shortfall in schools that have a desperate shortage of physics teachers.

About the Institute of Physics (IOP)

The Institute of Physics is the professional and learned society for physics in the UK and Ireland, inspiring people to develop their knowledge, understanding and enjoyment of physics. We work with a range of partners to support and develop the teaching of physics in schools; we encourage innovation, growth and productivity in business, including addressing significant skills shortages; and we provide evidence-based advice and support to governments in the UK and Ireland. Our members come from across the physics community, whether in industry, academia, the classroom, technician roles or in training programmes as an apprentice or a student. However, our reach goes well beyond our membership to all who have an interest in physics and the contribution it makes to our culture, our society and the economy. We are a world-leading science publisher and we are proud to be a trusted and valued voice for the physics community.

[5] See the IOP's 'Limit Less' report: https://www.iop.org/sites/default/files/2020-11/IOP-Limit-Less-report-2020-Nov.pdf
[6] https://www.iop.org/sites/default/files/2020-12/Subjects-Matter-IOP-December-2020.pdf.