Our survey said...

A survey of researchers has canvassed opinion on the 'grand challenges' to be faced in physics research — asking what might become achievable if more collaborative efforts are supported.

The UK's Engineering and Physical Sciences Research Council (EPSRC) has a significant remit, each year investing more than £850 million of government funding in research areas as diverse as algebra and number theory, coastal and waterways engineering, plasmonics, robotics and synthetic chemistry. Funding is won through the traditional method of grant application, in which individual academics outline the likely progress should their group be the recipients of EPSRC cash. But earlier this year the EPSRC turned the tables and asked the physicists among its researchers the following question: "What could be achieved in 20–40 years if physicists, from different research groups, disciplines or institutions, were to work in a coordinated way towards an established stimulating scientific goal?"

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This query became the basis of the 'physics grand challenges', put together by the EPSRC with the help of an advisory board of UK physicists, with the aim of encouraging the kind of collaboration across the physics community, and beyond, that might accelerate progress in the field. The return would be the general societal benefit of advancing knowledge, of course, but also the economic benefit of claiming (and maintaining) a leading position in the worldwide science community at a time when the UK is enduring, as most countries are, severely straitened economic circumstances and public-sector cut-backs.

As food for thought, the EPSRC threw nine grand challenges at its physicists: assembly and control on the nanoscale; developing new physics in extreme conditions; developing quantum physics for new quantum technologies; imaging at the limits; room-temperature superconductivity; the smart design of functional materials; understanding emergence in real systems; understanding physical phenomena far from equilibrium; and understanding the physics of life.

Researchers taking part in the survey were asked to respond to the same set of questions for each challenge — first of all, being asked their opinion as to whether each was a 'challenge' or not. Further questions covered the scientific advances required to make progress in each area, what the societal and economic impacts might be, and then, specifically, about the UK's ability to address the challenge and what kind of international collaboration might be sought. The report, *Outputs from EPSRC Physics Grand Challenge Surveys*, is now available (http://www.epsrc.ac.uk/SiteCollectionDocuments/Publications/reports/ReportOfOutputsFromEPSRCPhysicsGrandChallengeSurvey.pdf), and it's an interesting read.

There is unsurprising consensus on several points — and an equally unsurprising lack of consensus on others. 'Quantum physics for new quantum technologies' conclusively won most votes in favour of being a grand challenge, although there were also naysayers discounting it, claiming its potential impact is "overhyped". The challenge of room-temperature superconductivity showed a remarkable capacity to split the vote almost equally in every direction on each question: over whether it might be accomplished in 11–20 years, in 21–40 years, or in more than 40 years' time; over whether the number of groups in the UK who could contribute numbers fewer than two, more than 21, or somewhere in between; over what level of expertise those UK groups, collectively, have (ranging from "none" to "world-leading"); and over the potential for collaboration with other disciplines. It's a confused picture.

Now the votes are in, however, the advisory board has stepped in to distil the results into a forward-looking strategy, consolidating the original challenges into just four. The first is quantum physics for new quantum technologies, where coherent control, fault tolerance and scalable architecture are required advances; the potential for collaboration with groups in the USA and Europe, in particular, is mooted, but wider collaboration with the Asia–Pacific region is also explored, as Japan, China, Singapore and Australia mobilize in this field.

Nanoscale design of functional materials also makes the cut: the ability to design and build materials, from first principles and in large quantities, would have major technological implications in areas from healthcare to energy storage. And the last two selected challenges share a requirement for major collaboration not only internationally, but cutting across scientific disciplines. 'Emergence and physics far from equilibrium' embodies the complexity of systems and the challenge of non-equilibrium physics; 'understanding the physics of life', directly embedding physics in biological and medical research, is similarly complicated, but facing down both of these challenges could also result in wholly new technologies.

The EPSRC is offering its challenges as a starting point only, and stresses that success rests with the research communities who must "identify with them and drive them forward". However, it also recognises that in the cases of 'physics of life' and 'emergence and physics far from equilibrium' there is need for a sharper focus, and support may be forthcoming for networks and activities that will define it.

Although the conclusions from this exercise in identifying the 'grand challenges' of physics may not be startling, the outcome and specific targets are sensible. Most of all, it is the thinking about collaboration — domestic and international, of the kind that has made so much other science (particle physics, astronomy) possible and rewarding — that is to be commended. If UK researchers have explicit, solid support and encouragement from their funders to engage in collaboration and build research networks, it is to be hoped that their colleagues around the world will be ready to meet them. ❐