UK NATIONAL QUANTUM TECHNOLOGIES PROGRAMME

Enabling a strong foundation of capability in quantum technologies

Quantum technologies have the potential to revolutionise the modern world. In 2013 the UK government recognised the transformative potential of new quantum technologies by announcing a £270 million investment to form the UK National Quantum Technologies Programme (UKNQTP).

The vision is to create a coherent government, industry and academic quantum technology community that gives the UK a world-leading position in the emerging multi-billion-pound new quantum technology markets, and to substantially enhance the value of some of the biggest UK-based industries.

As one of the world's major investors in quantum science, over the last two decades the UK has built a dynamic academic community. Building on a strength in quantum science, the UKNQTP has provided vital support for this community to work with industry, bridging the innovation gap between fundamental science and new technologies.

To make the most of the opportunities that new quantum technologies offer, the UK needs to continue to ensure that it maintains a strong foundation of capability for the current and future development of these technologies. This flyer aims to demonstrate some examples of how the UKNQTP is enabling a strong foundation of research and innovation in quantum technologies.

The UK's national strategy for quantum technologies identifies enabling a strong foundation of capability in the UK as one of five areas for action. The others are:

- Stimulating application and market opportunities.
- Growing a skilled UK workforce in quantum technologies.
- Creating the right social and regulatory context.
- Maximising UK benefit through international engagement.

The programme is enabling a strong foundation of capability in quantum technologies by investing through five pathways:

The national strategy for quantum technologies can be found on our website: **uknqtp.epsrc.ac.uk**

Investing wisely: £24 million for capital equipment

A recent EPSRC capital investment call awarded seven grants for strategic facilities and pieces of equipment to enable the development of quantum technologies by researchers across the UK.

From establishing a quantum device prototyping service at the University of Bristol to installing the world's first single ion implantation tool with a 20nm lateral beam focus at the University of Surrey, investing in equipment and facilities is providing essential infrastructure for users, academia and industry.

The success of the UK National Quantum Technologies Programme relies on maximising the benefits of having a robust foundation of infrastructure, research, innovation and people throughout the UK.

Professor Martin Dawson, Director of Research in the University of Strathclyde's Institute of Photonics, spoke of the synergy of the institutions involved with the four Hubs, and of the international recognition received by the UKNQTP:

"The UK's flagship Quantum Technologies Programme, with its mission to accelerate the development and commercialisation of quantum technology across a broad front, has deservedly garnered worldwide attention for its boldness and timeliness. The four Hubs have been chosen carefully to build on UK research strengths and for their complementarity and potential to work together."

Professor Dawson's current research includes investigating LED-based optical communications and structured illumination sources developed through the EPSRC-funded programme grant 'Ultra-parallel visible light communications' (EP/K00042X/1). Building on this strong foundation, these technologies are now being further developed at the University of Strathclyde, which is involved with all four Quantum Technology Hubs, and extended towards object location, tracking and data beaming.

A new generation of atomic clocks

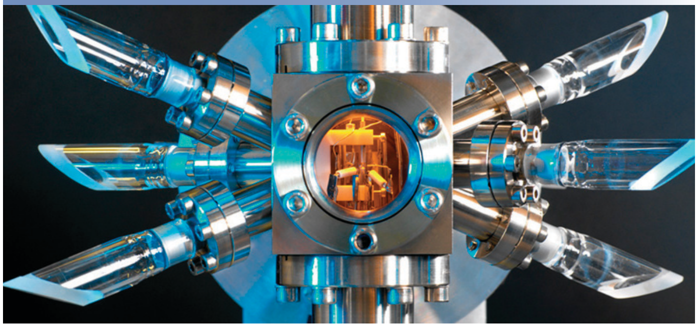
The UK National Quantum Technologies Hub for Sensing and Metrology, led by the University of Birmingham, is an investment which builds on the UK's long standing strength in timekeeping.

As well as research and innovation into sensors that, for example, can build a map of the Underworld (see right), the Hub provides a focal point for the development of a range of portable and robust atomic clocks. Researchers from the Hub are developing increasingly precise clocks which could have a wide range of applications; from improving Global Positioning Systems to enabling high-speed internet and telecommunications.

The measurement of time has formed a major part of the research activity undertaken by researchers at the National Physical Laboratory where, 60 years after they built the world's first caesium atomic clock; they are developing a new generation of optical atomic clocks based on laser-cooled trapped ions and atoms. It is hoped that these might reach an accuracy 100 times better than the current best atomic clocks; equivalent to gaining or losing no more than one second in the age of the universe.

NPL also plays a significant role in Europe-wide efforts to develop space-borne optical clocks. With the ability to work in the absence of gravity, these clocks could be used to test fundamental theories such as the principle of equivalence which forms the basis of Einstein's theory of relativity as well as removing barriers to deep space exploration.

The ion trap at the heart of NPL's strontium ion optical atomic clock



Mapping the Underworld: Using quantum sensors to assess the underground

Congestion, disruption and expense caused by delayed roadworks due to not knowing the exact location of water and gas pipes under the ground could soon be a problem of the past. Researchers from the Quantum Technology Hub for Sensors and Metrology are working on ways of accurately identifying what is below the ground, enabling us to assess the underworld in a way that could lead to savings in resource, time and money.

Dr Nicole Metje, from the University of Birmingham, leads the Gravity in Civil Engineering work package in the Hub, which is developing a highly-sensitive quantum technology-based gravity gradient sensor to map what is under the ground.

"While the physicists work on creating an advanced QT sensor, the Civil engineering team provides guidance on how it needs to be used and what problems need to be addressed. In this way we are making a significant contribution to the National Quantum Technologies Programme by ensuring the gravity gradiometer sensor is fit for purpose and by accelerating the impact of the research by providing the link to applications" - Dr Nicole Metje

At the University of Birmingham, which also leads the EPSRC-funded Mapping and Assessing the Underworld (MTU and ATU) programmes, the UKCRIC National Buried Infrastructure Facility and the Innovate UK and EPSRC funded Study of Industrial Gravity Measurement Applications (SIGMA), researchers are ideally placed to pioneer innovation in this area, building on expertise in both quantum technologies and civil engineering.