

Full-Stage Applications to the EPSRC Quantum Technologies Research Hub Call

Grant Refence: EP/Y024486/1

Project Title: Engineering Quantum Technologies (EQuaTe)

Lead Applicant: Professor Sandrine Heutz

Lead Research Organisation: Imperial College London

Summary:

Technologies enabled by quantum superposition and entanglement have progressed from laboratory-based propositions to commercial realities. The National Quantum Technologies Programme has been immensely successful in catalysing UK research and investment in quantum technologies (QTs), which are being developed by a thriving quantum start-up community. As a result, QTs have the potential to revolutionise many aspects of UK life; from drug discovery to personalised medicine, national security to materials design. They could help to achieve net zero by reducing demands to data centres, optimising the use of our energy infrastructure, and lowering the environmental impact of large-scale constructions projects. The quantum revolution now requires a major engineering contribution to realise this immense potential. Devices and networks must be reliable and robust, with non-complex supporting infrastructure and the ability to be integrated into hybrid architectures that exploit quantum-enhanced performance, ideally with low energy demands. EQuaTe brings together physicists, materials scientists, engineers, chemists, and mathematicians to provide the engineering breakthroughs that enable a step-change in the scalability, practicality, and sustainability of QTs. EQuaTe will provide the engineering solutions to these deployment challenges.

Grant Refence: EP/Y024478/1

Project Title: Enabling Quantum Integrated Photonics (EQUIP)

Lead Applicant: Professor Jon Heffernan

Lead Research Organisation: University of Sheffield

Summary:

We propose a new Quantum Technology (QT) Research Hub that will equip the UK with a strategically important, world class centre of excellence in the design, fabrication, and application of Quantum Photonic Integrated Circuits (QPICs). QPICs are 'chip' technologies that allow quantum optical devices such as lasers and detectors to be placed with ultra-high accuracy on a single chip and connected. This is very similar to the way that millions of transistors on a microprocessor chip are laid out and interconnected to allow computation in digital electronics. In the case of QPICs, instead of transistors and electronic function, we will use millions of optical devices that emit and detect photons (quantum units of light) that are connected. The photon can be used as a unit of quantum information and therefore a QPIC represents a form of integrated circuit that enables the creation of large-scale quantum information processors containing millions of quantum devices. The research, innovation, skills, and know-how created in this Hub will place the UK at the forefront of a new industry in quantum systems that are uniquely scalable, mass-manufacturable, and fully compatible with exploitation in numerous applications that will transform our modern technological society

Grant Refence: EP/Y02446X/1

Project Title: UK Quantum Technology Hub in Sensing, Imaging and Timing (QuSIT)

Lead Applicant: Professor Michael Holyński

Lead Research Organisation: University of Birmingham

Summary:

QuSIT will be a centre of excellence for the development of Sensing, Imaging and Timing based on the quantum properties of atoms and photons. It will create systems that can sense and image invisible wavelengths, radiofrequencies, magnetic and gravitational fields and provide precision timing signals. These will address challenges in healthcare, infrastructure, transportation, and security, enabling safer, healthier, and more sustainable societies. We will demonstrate game-changing capability for pollutant detection, medical screening and analysis, border security, underground infrastructure, and transportation. Realising systems that bring benefit for these important use cases is underpinned by a common theme: they all require mastery of the underlying physics, engineering and computational science needed to realise them in a practical configuration. Building on the track-record of two successful Quantum Hubs and their ongoing deep engagement with industry, we will provide thought leadership and coordination across the UK quantum technology landscape. We will do this by supporting government initiatives and fostering exploitation pathways for organisations ranging from fledgling start-ups to internationally established systems integrators. The interface between economically and societally significant use cases and the enabling science will be managed through a combination of systems engineering, data analysis, and exemplar field trials. Our work programme will deliver the research necessary to support companies across the value and supply chains in making informed investment decisions resulting in new products and services.

Grant Refence: EP/Y024451/1

Project Title: A U.K. Hub for Quantum Enabled Position, Navigation and Timing (QEPNT)

Lead Applicant: Professor Douglas Paul

Lead Research Organisation: University of Glasgow

Summary:

Our vision is to deliver the technology for atomic clocks, quantum inertial sensors, single-photon LiDAR sensors and quantum-classical hybrid sensors that will create the practical systems for resilient position, navigation, and timing (PNT) applications. We propose a UK Quantum Technology (QT) Hub to build an internationally recognised UK community and ecosystem for quantum enabled PNT by bringing together experts from academia, industry, and Government agencies to deliver the technologies required for national security, critical infrastructure, aerospace, connected and autonomous vehicles (CAVs), finance, maritime and agriculture applications. To deliver this vision we have assembled an interdisciplinary team across physics, engineering, photonics, ICT, computer science, artificial intelligence, PNT system engineering and connected and autonomous vehicles. The QEPNT Hub will create the community and ecosystem and the technologies required for the UK to be a global leader in future PNT systems.

Grant Refence: EP/Y024435/1

Project Title: Quantum Interconnects (QuIC) Hub

Lead Applicant: Professor Martin Weides

Lead Research Organisation: University of Glasgow

Summary:

The Quantum Interconnects (QuIC) hub will create a new UK Centre of Excellence in a crucial emerging domain of quantum technology, strategically placing the UK at the forefront of global developments. Our ambition is to solve critical scientific and engineering bottlenecks in the realisation of a quantum internet. It holds immense potential to revolutionize various aspects of computation, sensing, and communication. Quantum internet uses qubits to process and transfer data with exceptional speed and computational power. It will pave the way for distributed quantum computing (QC), seamless connections among distant quantum sensors, providing unprecedented precision in measurements and enabling novel applications across various fields such as finance, healthcare, and defence. It is critical for addressing emerging challenges and shaping of future technology. Simply stated, the central scientific question we address is as follows: How to connect individual quantum computers to the fibre optic networks that we use for today's internet communications? QCs are very tiny and work at microwave frequencies at ultra-cold temperatures. Qubits encoding this information are highly delicate in nature. To transmit these signals over long distances while preserving their quantum integrity, we will build 2 types of chip-integrated quantum interconnects.

Grant Refence: EP/Y024419/1

Project Title: Integrated Quantum Networks (IQN) Quantum Technology Research Hub

Lead Applicant: Professor Gerald Buller

Lead Research Organisation: Heriot-Watt University

Summary:

The Integrated Quantum Networks (IQN) Research Hub will be at the forefront of advances towards the so-called "quantum internet", where quantum resources will be used at distance to enable the game-changing power of quantum computing and quantum metrology for critical applications, whilst being verifiably secure. The Hub will focus on the distribution of quantum entanglement at all length scales for quantum communications, distributed quantum computing, and quantum sensing. By delivering technologies and techniques to our industrial innovation partners, the IQN Hub will enable UK academia, national laboratories, industry, and end users to be at the forefront of the quantum networking revolution. The IQN Hub will address major challenges currently preventing full establishment of the quantum internet - a worldwide series of networks interconnecting remote quantum devices through quantum links working alongside classical systems - and, in so doing, create fundamentally new communications and computing capabilities. Basic research challenges include use of matter qubits with sufficient storage time, coherent processing, and error correction; implementation of large-scale entanglement-based networks with agile routing capabilities; connection between quantum processors at long-range, cost-effective scalability, standardisation, and certification.

Grant Refence: EP/Y024400/1

Project Title: Interdisciplinary Quantum Computing Hub

Lead Applicant: Professor Andrew Fisher

Lead Research Organisation: University College London

Summary:

Our Interdisciplinary Quantum Computing Hub aims to keep the UK at the forefront of this new and very rapidly developing field. Many of the key scientific ideas originated in the UK but we now find ourselves in a new situation where quantum computing is making the transition to commercial products with dedicated start-ups and multinationals making the first generation of quantum hardware and software. To realise the full potential of quantum computers, it is essential that academic-led initiatives continue to provide key enabling ideas and the longer-term goals and visions. We believe that a step-change is only possible by linking researchers in different hardware domains, thus cross-fertilizing between platforms, and by connecting them to pioneering work in theory and quantum software. This requires the outstanding within-discipline science and engineering expertise we have assembled, and an investment in time and in mechanisms to ensure that staff in the Hub have a broad and deep understanding of other hardware domains and software approaches. We have assembled a consortium from a cross-section of the UK's leading university research groups and start-ups, both in quantum hardware and quantum software, to address critical challenges for the field.

Grant Refence: EP/Y024397/1

Project Title: EPSRC Quantum Biomedical Sensing Research Hubs: Outline Stage

Lead Applicant: Professor Rachel McKendry

Lead Research Organisation: University College London

Summary:

We will establish a world-leading UK Quantum Biomedical Sensing Research Hub (Q-BIOMED) that will transform the future of early disease diagnosis by exploiting emerging advances in quantum sensors. The Hub will combine two major disciplines in which the UK is a global leader - Quantum Technologies and Biomedicine - for the first time, bringing together developers of quantum sensors with biomedical researchers into a single research hub with a common vision and joint programme that runs from user needs specification to quantum sensor development, to prototyping and testing. We will extend and exploit the coherence of various quantum systems, including solid state defects such as nitrogen vacancy (NV) centres and atomic systems in optically pumped magnetometers (OPMs), develop new quantum control methods, quantum-limited amplifiers, squeezed states and enhanced MASERs (microwave amplification by stimulated emission of radiation). We will use these to build sensing and imaging capabilities (including magnetic induction tomography, MIT), in vitro diagnostic tests, smart interventional tools and support basic biomedical research for the early diagnosis of infectious diseases, cancers, and cardiovascular and neurodegenerative diseases. The Hub will position the UK at the forefront of this emerging field, and bring major health economic benefits to patients, the public, health systems, society, and provide new jobs in the growing quantum-enabled sector of the economy.

Grant Refence: EP/Y024389/1

Project Title: QCI3: Hub for Quantum Computing via Integrated and Interconnected Implementations

Lead Applicant: Professor Dominic O'Brien

Lead Research Organisation: University of Oxford

Summary:

Over the next few decades, quantum computing (QC) will transform the way we design new materials, plan complex logistics and solve a wide range of problems that conventional computers cannot address. The Hub for Quantum Computing via Integrated and Interconnected Implementations (QCI3) brings together more than 50 investigators across 21 universities to address key QC research challenges, and to deliver applications across diverse areas of engineering and science. The hub will focus on three interconnected themes:

- (1) Developing integrated quantum computing systems, with a goal of creating small scale quantum processors that will show real utility for specific problem examples.
- (2) One of the key challenges in building the million qubit machines of the future is that of 'wiring' together the small-scale quantum processors that will create such a machine. The hub will develop technologies that help achieve this, as well as developing models to understand how such machines will scale.
- (3) Developing applications in science and engineering, including materials design, chemistry, and fluid dynamics.