Innovate UK

Results of Competition: Exploring the commercial applications of Quantum Technologies
Competition Code: 1607_CRD_EE_QUAN

Total available funding for this competition is £6M from Innovate UK and £6M from EPSRC

Note: These proposals have succeeded in the assessment stage of this competition. All are subject to grant offer and conditions being met.

Participant organisation names	Project title	Proposed project costs	Proposed project grant
Kromek Ltd University of Edinburgh	Quantum Entanglement Tomography for enhanced medical imaging	£832,655	£641,830

Project description - provided by applicants

This proposal presents Quantum Entanglement Tomography (QET) as a technique which utilises the quantum entanglement of photon pairs to create a low noise imaging technology. When a positron annihilates with an electron, two photons of equal energy are emitted in approximately opposite directions. Positron Emission Tomography (PET) imaging determines the position of a positron-containing radiotracer by counting numerous photon pairs, but the imaging is hindered by physical processes, including in-patient scattering and random coincidences, making it difficult to separate truephoton pairs from falsepairs caused by other processes. QET utilises the quantum entanglement of the photon pairs from the positron emission, and this project will use the technique to create a medical imaging technology which will show improved image quality over PET. Other benefits include lower doses and faster examination times. The project combines the University of Edinburgh, who have proven the feasibility of QET, with Kromek, a leading developer and supplier of radiation detector technology. The project will see the development of a prototype detection system, alongside the reconstruction algorithms required for commercialisation

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Optocap Ltd Fraunhofer UK Research Ltd University of Strathclyde STFC - Laboratories	REMOTE – (RuggEd Mirco-ECDL technology for cOld aTom applications in spacE)	£834,718	£604,056
Project description - provided by applicants			
It is difficult to overestimate the impact of electronic computers on modern society and yet, just a few decades ago, computer technology was a creature of the research laboratory due to their enormous complexity, power requirement, and cost. The uptake of such technology by wider, non-specialist society was only possible once improvements in the size, cost and performance of the subsystems upon which computers depend had been realised. Quantum technology finds itself at a similar junction. These systems are now a reality and hold enormous potential to revolutionise our lives, but they are only found in research laboratories because they depend upon very expensive, very large laser systems. In this project, we will reduce the size and cost of these critical components enormously, without losing performance, in order to place the UK at the vanguard of QT development and commercialisation.			

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e2v technologies (UK) Ltd Gooch & Housego (Torquay) Ltd Clyde Space Ltd XCAM Ltd Covesion Ltd University of Birmingham University of Southampton	Cold Atom Space Payload (CASPA)	£2,072,227	£1,372,114

Project description - provided by applicants

New developments in quantum technology have resulted in the ability to cool atoms close to absolute zero using lasers. At these temperatures, laboratory experiments have shown that these cold atomscan be used as ultra-sensitive sensors for measuring gravity. CASPA will translate leading UK science into commercial products for space and other markets. It will take the technology out of the laboratory and build it into a small satellite payload that is capable of producing cold atomsin space. Demonstrating this new technology in space is a vital first step towards realising real instruments that are capable of mapping tiny changes in the strength of gravity across the surface of the earth. The extreme sensitivity brought by cold atomsensors will provide the ability to finely monitor the movement of mass within Earth systems. This has multiple applications including more accurate monitoring of changes in polar ice mass, ocean currents and sea level. Higher resolution data will lead to the ability to monitor smaller water sources and discover new underground natural resources which are currently not detectable. Similar technology will also be used for deep space navigation and for providing higher precision timing sources in space.

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e2v technologies (UK) Ltd NPL Management Ltd	MINAC Miniature Atomic Clock	£1,761,828	£1,214,423
Project description - provided by applicants			
The precise measurement of time is fundamental to the effective functioning of the services we take for granted in modern society. This project will develop a pre-production prototype of a miniature atomic clock for precise timing in a variety of essential services such as reliable energy supply, safe transport links, mobile communications, data networks and electronic financial transactions. Today, these services rely on GPS for a timing signal which is easily disrupted either accidentally or maliciously. In prolonged GPS unavailability these services stop functioning. The reliance on GPS for precision timing and the consequent vulnerability of our essential services was made clear in a report from the Royal Academy of Engineering in 2011. That message is becoming more widely known and it is creating a demand for timing solutions that are not GPS dependent. The miniature atomic clock arising from this project fills this need and it will find widespread application in precision timing for mobile base stations, network servers for financial services, data centres, national power distribution networks and air traffic control systems. This project will address civil and military applications enabling a technical and economic success for the UK.			

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UniKLasers Ltd Fraunhofer UK Research Ltd University of Birmingham	Praseodymium Laser Architecture Investigation and Demonstrator (PLAID)	£584,960	£497,060
Project description - provided by applicants			
It is difficult to overestimate the impact of electronic computers on modern society and yet, just a few decades ago, computer technology was a creature of the research laboratory due to their enormous complexity, power requirement, and cost. The uptake of such technology by wider, non-specialist society was only possible once improvements in the size, cost and performance of the subsystems upon which computers depend had been realised. Quantum technology finds itself at a similar junction. These systems are now a reality and hold enormous potential to revolutionise our lives, but they are only found in research laboratories because they depend upon very expensive, very large laser systems. In this project, we will reduce the size and cost of these critical components enormously, without losing performance, in order to place the UK at the vanguard of QT development and commercialisation.			

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M Squared Lasers Ltd Optocap Ltd Kelvin Nanotechnology Ltd University of Glasgow University of Birmingham	DIFFRACT- Integrated Distributed Feedback Lasers for Cold Atom Technologies	£1,518,320	£1,106,361
Project description - provided by applicants			
The project aims to deliver an integrated distributed feedback laser as a key component in cold atom technologies. The partners will build on extensive expertise in microfabrication, packaging, electronics and application development to produce a highly functional yet low-cost and compact laser device suitable for use in a wide range of cold atom technologies. The project brings together three innovative Scottish companies, M Squared Lasers, Optocap and Kelvin Nanotechnology, with the Universities of Glasgow and Birmingham and the Defence Science and Technology Laboratory.			

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e2v technologies (UK) Ltd Gooch and Housego Ltd RSK Environment Ltd University of Birmingham	Reveal – Quantum Gravity Sensor for Civil Engineering	£2,198,079	£1,366,083
Project description - provided by applicants			
The presence of sinkholes, mineshafts and other buried objects under construction sites is a huge problem in civil engineering. These underground openings are a risk to the health and safety of people working on the site. They are also a risk after construction work has been completed as they can move and increase in size over time and may open up causing a building; a road or a bridge to subside or collapse with devastating effect. The REVEAL project aims to develop a quantum gravimeter which can be used for subterranean surveying to identify these underground objects before construction takes place. This reduces the risk for people working on the site and allows remedial work to be carried out before building takes place, decreasing the risk of future structural problems. The project aims to produce an instrument with at least twice the sensitivity of competing classical gravimeters so that even smaller and deeper holes in the ground can be detected.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
QxBranch LLC UBS Ltd	Commercialisation of Quantum Algorithms for Market Making	£814,105	£500,000
Project description - provided by applicants			
In this proposed collaboration, UBS UK and QxBranch UK will conduct industrial research on quantum algorithms for foreign exchange trading. These algorithms will optimize market, customer, and forecast factors for market making applications, allowing UBS to deliver more accurate prices and better service to its customers. The unique properties of recently developed quantum algorithms are expected to allow UBS to account for additional variables in pricing than is currently possible in a useful timeframe. This project will apply research demonstrated in academic literature to industrial applications. The resulting algorithms and software will decrease the transaction costs for Fx transactions to all parties.			

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The Compound Semiconductor Centre Ltd Compound Semiconductor Technologies Global Ltd NPL Management Ltd Cardiff University	MacV - VCSELs for miniature atomic clocks	£1,173,079	£936,458
Project description - provided by applicants			
Coherent population trapping (CPT) based miniature atomic clocks require low power, single mode laser diodes that can be directly modulated at a few gigahertz. Vertical Cavity Surface Emitting Lasers (VCSELs) are ideal for this application primarily due to their very low power consumption, wide wavelength tuning coefficient, reduced sensitivity to optical feedback, extended device lifetime, and small device footprint. Commercially available VCSELs have linewidths of ~50-100 MHz, and while this can be a problem for many other laser spectroscopy applications, it does not substantially compromise the quality of a CPT resonance. Conversely, due to the circular beam profile, VCSELs are particularly susceptible to polarisation instabilities; however, there are several novel design modifications that can be implemented to address this issue. Currently, there are no UK sources or any supply chain of reliable and robust VCSELs for miniature atomic clocks and a very limited number of commercial manufacturers globally developing VCSELs at the opimium wavelength for the application (CsD1 894nm). Our project will establish a UK strategic capability focussed on the development and volume production of VCSEL laser sources, tailored specifically to support the adoption of miniaturised atomic clock applications			

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