Innovate UK

Results of Competition: Accelerating the Commercial exploitation of quantum technologies

Competition Code: 1602_QUANTUM_FO

Total available funding for this competition was £2,238,660 from Innovate UK

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
M Squared Lasers Ltd Fraunhofer UK Research Ltd University of Strathclyde	COCLES - Compact Optical Clock Light Engine Sources	£243,974	£206,559

Project description - provided by applicants

Optical lattice clocks offer superior performance (>100x) over competing technologies and are required inscientific research, satellite-free navigators and timing signals for financial trading. However, existing all-opticalclocks are complex and expensive and have not met the needs of the markets. In this project we will developunderpinning technology of all-optical clocks, stabilised-frequency laser systems, using novel laser sources.These sources are essential low-cost flexible tools to unlock the full quantum technology applications potential.COCLES will develop lasers with ever more demanding performance metrics. To complete a family of laserdevices required by a full clock system.

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Covesion Ltd University of Southampton	Quantum Waveguides for Indistinguishable Single Photon Sources 2 (QWISPS-2)	£207,773	£172,087

Project description - provided by applicants

Covesion Ltd and The University of Southampton plan to extend our collaborative feasibility study investigatingthe use of periodically-poled lithium niobate crystals in single-photon sources for applications exploitingquantum entanglement. Laser pulses contain different numbers of photons and in our crystals these photonscan be split into pairs; the laws of physics state that if one of these photons is created then the other must alsoexist. Based on this premise, detecting one paired photon signals the presence of the other, providing apredictable source of single photons that can be used for computation. In this project, we seek to reduce themanufacturing tolerances required to generate similar photons from different sources and our objective is toprove our new approach across multiple devices. This is an important step in enabling scalable quantumapplications where many predictable photons with the same attributes are needed in parallel, such as quantumcomputing.

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RSK Group PLC University of Birmingham	SIGMA+ - Study of Industrial Gravity Measurement Applications	£249,966	£182,510

Project description - provided by applicants

This project is a collaboration between RSK and the University of Birmingham (UoB) to carry out a feasibilitystudy identifying the potential of Quantum Technology (QT) gravity sensors in geophysical surveys forenvironmental and engineering applications such as locating buried objects and finding sinkholes. This projectfeeds directly into the development of the QT gravity and gravity gradiometer sensors to ensure they takecognisence of practical considerations in the harsh civil engineering environment. This study will expand onthe findings from the SIGMA project by focussing on the measurement and data handling challenges that havebeen identified, the isolation of signals of interst from other variations in the shallow soil, and will make thefirst ever QT gravity maps of the subsurface through careful field trials of prototype instruments. At the sametime it engages with future clients who will demand this technology to minimise their risk of unforeseenground conditions. SIGMA+ will provide a quantitative assessment of the potential real world capability of QTgravity sensors and define a specification of capability for instrument manufacturers to strive for.

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Toshiba Research Europe Ltd University of Cambridge University of Sheffield	Fibre Wavelength Quantum Relays (FQRelay)	£249,239	£174,271

Project description - provided by applicants

Quantum communications can secure data transmission, guaranteed by the laws of physics. Technology toachieve this based on encoding information on individual particles of laser light is proven over dedicated point-to-point links. However the full potential will only be realised with multi-user quantum networks, and it isimpossible to copy and resend quantum data, preventing traditional approaches. Quantum relays offer asolution, allowing quantum keys to be teleported across fibre-optic networks. Our vision is to construct andoperate such a quantum relay, for the first time using practical semiconductor technology at the commerciallyoptimum 1550 nm wavelength band. This will be an important step towards widespread adoption ofguaranteed network security solutions for businesses and customers alike.

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Chronos Technology Ltd TMD Technologies Ltd University of Bath	FEMTO-AAD: FEMTO - Advanced Application Demonstrator	£248,882	£193,999

Project description - provided by applicants
FEMTO-AAD will play a key role in the UK's 5 year programme to bring remarkable new concepts in quantumphysics out of research labs and into real-world applications. Chronos Technology, TMD Technologies and theUniversity of Bath's Electronics Engineering and Physics Departments have teamed up to research UK-basedhollow core fibre (HCF) manufacturing, a new technique based on quantum physics that promises a generationof highly-accurate clocks. The consortium will also create a unique Advanced Application Demonstrator (AAD)that features an ensemble of Quantum Clocks synchronised to UTC ' the world timing standard. As HCF andother new-technology clocks emerge from within FEMTO and the EPSRC Quantum Hub at Birmingham andStrathclyde Universities they will become candidates to be installed in the Demonstrator, taking over fromtraditional technologies. There they will drive the nation's critical broadcasting and telecommunicationsnetworks with an accuracy and at a cost previously unachievable.

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Oxford Instruments Nanotechnology Tools Ltd Lancaster University	Prototype cryofree ultra low temperature environment for quantum enhanced sensors	£247,999	£177,551

Project description - provided by applicants

It is usually very difficult to see the subtle effects of quantum mechanics at room temperature because they arehidden by the noise of thermal agitation. For example, electrons in a circuit are constantly jostled by the atomsin the material they are moving through. However, if the circuit is cooled close to absolute zero temperature,almost 273C, then the jostling is reduced and sometimes quantum effects can shine through. In this projectwe will build a prototype instrument for detecting tiny magnetic fields, where the sensitivity comes fromquantum effects that are revealed by cooling the sensor. Existing refrigerators that can reach this temperatureare large, expensive and complicated. Our instrument will be smaller, cheaper and easier to operate. Theproject combines a team from Oxford Instruments, experts in providing low temperatures enviroments withadvanced cryogenic engineering, with a team from Lancaster University who are skilled in exploiting these lowtemperatures to manipulate and control the quantum behaviour of electronic circuits. Together we will build aprototype to demonstrate how low temperature quantum technologies can be used in a real sensing product.

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M-Squared Lasers Ltd University of Birmingham	ANAGRAM - Commercialisation of an Atomic Gravity Meter	£186,621	£147,435

Project description - provided by applicants
In a gravity meter based on atom interferometry, the atoms act as miniature test masses and are sensitive togravity and motion. This is a quantum technology as it relies on the interference of the atoms with each other,a manifestation of wave-particle duality, i.e. the fact that matter can behave like a wave under certaincircumstances; it is the quantum nature of the technique that affords it great sensitivity. This project will, forthe first time, demonstrate an atomic gravity meter in a UK commercial environment. The expertise of MSquared Lasers in laser engineering and system integration will be combined with the academic excellence ofthe University of Birmingham to create a collaborative team capable of delivering the proposed commercialproduct. Gravitational sensors enable one to see through matter and below the ground. Applications can beenvisaged in many sectors, from the detection of new oil and gas deposits, surveying unknown undergroundinfrastructure such as pipes and cables, to monitoring the water table

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NPL Management Ltd Kelvin Nanotechnology Ltd Optocap Ltd	Demonstration of high-yield, high-performance ion microtraps	£250,108	£125,054

Project description - provided by applicants

Chip-scale technology is necessary for atomic quantum devices of significantly reduced form factor. TheNational Physical Laboratory (NPL) has demonstrated a microchip device for the confinement of atomic ions. Itsunique set of performance characteristics, together with the scalable fabrication techniques used to produce it,render it an excellent platform for an elementary component in atomic quantum technologies. Clocks, sensorsand scalable superpositions and entanglement will benefit. NPL will conduct ion trapping performance tests ondevices produced in an earlier IUK Study. Kelvin Nanotechnology will enhance the existing full-wafer scalemicrofabrication process to produce ion microtraps with ~90% target yield. Optocap will develop the principlesfor a custom electronic package, to enable ample connectivity for these and more complex devices in thefuture. To the best of our knowledge, this is the first attempt worldwide at this principle for ion microchipdevices. This points the way towards the integration of these devices in atomic quantum instruments.

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Amethyst Research Ltd Lancaster University Compound Semiconductor Technologies Global Ltd	Maturing a Novel Extended IR Single Photon Detector for Quantum Systems	£248,398	£193,367
Project description - provided by applicants			
Quantum communication systems require photon detectors that are capable of single photon capture, andquantum imaging requires detectors arrays that can be tuned to specific photon energies. We will build oninitial Phase 1 work which delivered a proof of concept demonstration of a novel extended infrared SinglePhoton Avalanche Detector (SPAD) technology, based on a novel compound semiconductor active region. Theobjective of Phase 2 of the development is to further improve the performance of the core detector platform,produce a packaged SPAD, scale up the existing single element demonstrator to a 2D SPAD array and de-riskarray integration towards an industry relevant single photon imaging sub-system. The project will consolidatethe existing consortia of academia, SME's and industry led by Amethyst Research Ltd, in partnership withLancaster University, CST and Selex ES (as a subcontractor). In addition, we have extended the reach of theproject with an associate partnership with Heriot Watt University to evaluate the technology in advanced singlephoton detection applications.			

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Element Six Ltd University of Warwick	Scalable Quantum Diamond Devices (SQDD)	£249,716	£187,216

Project description - provided by applicants

Quantum technologies use quantum physics to gain performance which is otherwise unattainable. Thequantum world challenges our preconceptions, here objects can exist in two places at once. This world typicallyoccurs on the atomic level at low temperatures which has meant that quantum technologies are difficult torealise. Research shows that the quantum state of electrons trapped in an atom sized defect in diamond can bemanipulated by shining light on the diamond and read by measuring emitted light, even at room temperature.These'quantum defects' can be used for a range of applications such as nanoscale magnetic field measurementwhich may revolutionise biomedicine, or to build a quantum computer which is able solve problems no currentcomputer can. Realisation of these technologies requires quantum defects very close to the surface instructured surfaces. This project aims produce quantum ready diamond materials, with these quantum defectsretaining their exceptional properties within a few nanometres of the surface, for the manufacture of devicesstructured on the nanoscale to optimise collection of the light carrying the quantum information.

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NPL Management Ltd University College London (UCL) University of Glasgow	Superconducting nanobridge readout for single photon detector arrays: multiplexing, integration	£246,714	£166,704

Project description - provided by applicants
This project forms part of a larger scheme of work to develop nanobridge superconducting circuits for highbandwidth, low noise signal processing of signals from superconducting single photon detector arrays forcommercialisation. These arrays coupled with the high speed electronics developed in this work will impact keyquantum technology areas such as quantum computing and quantum key distribution. This extension projectfocuses on understanding and demonstrating the solution to the key technical challenges of multiplexing,device integration and device uniformity.

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Gooch & Housego (Torquay) Ltd e2v Technologies (UK) Ltd University of Birmingham	FreezeRay 2	£381,104	£212,552

Project description - provided by applicants

Quantum technology is usually seen as an academic science that sits in big experiments such as the LargeHadron Collider, but it is now coming much closer to home and within a couple of years will affect the life ofman in the street. We all tire of roadworks and get frustrated when they cut through our phone lines or watersupply. Quantum technology can provide an answer by enabling surveyors to see through the ground and mapthe hidden structure beneath our feet using gravimeters that precisely measure the small variations in gravitycaused by pipes and voids under the ground. This project is focused on developing practical technology thatcan enable the large complex experiments in University laboratories to be package into portable instrumentsthat can be carried out into the street. Two of the UK's leading technology manufacturing companies, G&Hand e2v Technologies are teaming up with the University of Birmingham, which heads up the UK quantumsensing hub, to develop lasers, vacuum systems and control electronics for these quantum based sensors.

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