Innovate UK

Results of Competition: Exploring the commercial application of Quantum Technologies FS

Competition Code: 1607_FS_EE_QUAN

Total available funding for this competition is £3M from Innovate UK and £3M 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
M Squared Lasers Ltd University of Strathclyde	QuDOS II: Quantum technologies using Diffractive Optical Structures (Phase II)	£354,707	£293,799

Project description - provided by applicants
The project will develop a compact, simplified and more robust apparatus for the preparation of cold atomic samples for a range of sensing and quantum computing applications. The project partners have successfully demonstrated the use of grating chip-based magneto-optical traps in a commercial environment. In validating the use of the grating chips with M Squared's rubidium-locked laser source, the partners have laid the foundations for increasing the technology readiness level of this key component technology. The proposed project will see the UCA trap become part of a more integrated system, and will move the technology closer to the targeted applications. Additionally, it will emphasie the key role of a single, agile laser source as a key component in the quantum technology toolbox. This technique has wide relevance to the quantum technologies as it forms one of the building blocks for practical and low-cost, atomic sensing devices and quantum computers. The project brings the academic excellence of the University of Strathclyde together with the industrial knowhow of M Squared Lasers to exploit this world-leading innovation from the UK's research base.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
M Squared Lasers Ltd Imperial College London	AXEL: Alexandrite Ring Cavity Lasers for Commercial Quantum Technology	£369,099	£310,180

Project description - provided by applicants
The emergence of nascent quantum technologies has been closely tied to the development of enabling laser sources. With commercial quantum technology applications on the horizon, the challenges in laser development move toward realising low-cost and high performance sources with the ruggedness and modularity required from a critical component in practical quantum technology instruments. The project brings the academic excellence of the Imperial College London together with the industrial capacity and skill of M Squared Lasers to exploit this promising new innovation from the UK's research base.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
M Squared Lasers Ltd Durham University	ALTITUDE: Advanced Low-cost TI:sapphire Lasers for Quantum Technologies	£398,737	£339,003

Project description - provided by applicants
The emergence of nascent quantum technologies has been closely tied to the development of enabling laser sources. With commercial quantum technology applications on the horizon, the challenges in laser development move toward realising low-cost and low volume sources with the ruggedness and modularity required from a critical component in practical quantum technology instruments. This project will fuse the partner's expertise in laser engineering, component optimisation and applications, with rapidly improving diode laser technology to achieve high performance laser output at a significantly reduced cost, suitable for widespread deployment.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
M Squared Lasers Ltd Imperial College London	POLARIS: high POwer, phase-locked LAseRs for atom InterferometerS	£398,854	£336,436

Project description - provided by applicants

Atom interferometers are at the heart of many quantum technologies, enabling high precision measurements of influences on clouds of cold atoms, such as motion, gravity, time, magnetic and electric fields. These capabilities have a wide range of applications including satellite free navigation, financial time stamping, medical imaging and geological surveying. The aim of this project is to develop a high performance laser that will be used to create, manipulate and probe the superposition state of the atom interferometer. By delivering a high power low phase noise laser the sensors capabilities are increased. The system will be demonstrated on inertial sensing that requires high powers and is particularly sensitive to phase noise. Quantum based inertial sensing units could pave the way to high precision satellite-free navigation for use in transport and mining.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Siemens Healthcare Ltd University College London	Quantum Algorithms for Cognitive Healthcare	£409,339	£209,169

Project description - provided by applicants
The healthcare industry is experiencing an explosion of data and at the same time the cost of healthcare is rising. Cognitive computing in healthcare is using big data in conjunction with advanced machine learning and supercomputers/cloud services to help doctors detect diseases earlier, improve therapeutic outcomes and ultimately reduce the cost of care. In this feasibility study we will investigate the use of quantum machine learning algorithms to improve cognitive computing in healthcare. Algorithms running on quantum processors have the potential to perform extremely fast calculations to solve problems that are computationally intractable with classical computers. This offer significant potential when extracting meaningful, decision level information from from medical images.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Coherent Scotland Ltd University College London	High-Power Unique-Stability Laser Source For Quantum Applications	£98,347	£69,472

Project description - provided by applicants

A successful development and applications of quantum technologies demands specific laser sources that can combine high-performance, long-term reliability, trouble-free maintenance, size and cost requirements. Although available on the market, these features are often scattered across different products and companies forcing the users to compromise. Bringing together two world leading laser business and academic institutions, Coherent and University College London, this feasibility project will assess the performance of unique laser product essential for trapping cold atoms and other particles in highly demanding quantum technology applications. The results will open a path for further development of such laser which would deliver a combination of quantum applications driven features in a single market solution.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Magnetic Shields Ltd University of Birmingham	Compact lightweight high performance magnetic shielding enabling portable & miniaturised quantum technology systems - "QT-Shield"	£393,954	£300,744

Project description - provided by applicants
Magnetic shielding is an essential component of all second generation quantum technology systems necessary to eliminate magnetic interference and enable quantum behaviour to be observed. A particular challenge for quantum systems is shielding of low frequency and DC magnetic fields. Existing magnetic shielding is bulky and heavy creating barriers to the realisation of portable and miniaturised quantum devices. Shielding is uniquely designed for each application, often with low production volume. Production is currently undertaken by hand in machining workshops; thereby limiting production sale-up and creating a vulnerability to low wage economies abroad. The QT-Shield solution seeks to apply advanced shielding design principles for the realisation of high performance compact-lightweight magnetic shielding delivering a >50% reduction in weight and >40% reduction in volume compared to conventional approaches. Shielding will be manufactured using a combination of advanced manufacturing processes; enabling automated production of customised shields at high volume. QT-Shield will demonstrate the feasibility of this approach through application of the advanced shielding for protection of a quantum gravity sensor demonstrator system.

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Innovate UK

Results of Competition: **Exploring the commercial application of Quantum**

Competition Code: **1607_FS_EE_QUAN**

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Compound Semiconductor Technologies Global Ltd Lancaster University IQE PLC Quantum Base Ltd	GaSb/GaAs quantum ring single photon LEDs (QR_SPLEDs)	£257,064	£210,397

Project description - provided by applicants

Quantum technologies exploit the exotic properties of nature described by quantum mechanics to deliver devices with unprecedented speed, accuracy or completely new functionalities. Quantum cryptography is one such technology: communication whose security is guaranteed by fundamental laws of quantum mechanics. The implementation of quantum cryptography relies on the ability to generate very low intensities or even single photons of light on demand . Several different physical systems have been used to generate single photons, but very few of them are suitable for commercial production. An ideal single photon source should be fast, cheap and efficient, operate at room temperature, and emit photons at the wavelengths used in existing optical-fibre telecoms networks. A practical single photon source is expected to be somewhat like a type of semiconductor laser diode called a vertical cavity surface emitting laser (VCSEL). We will assess the feasibility of mass-producing low-cost single-photon sources in the form of single-photon light emitting diodes (SPLEDs). These will exploit the unique properties of semiconductor nanostructures called self-assembled quantum rings, which we have recently used in novel VCSELs that operate at very low currents and at temperatures up to 110°C.

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Innovate UK

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
M Squared Lasers Ltd University of Birmingham	SCORPIO: Strontium COld atom package foR commercial oPtIcal clOcks	£390,670	£329,462

Project description - provided by applicants
Optical lattice clocks offer superior performance (>100x) over competing technologies and have broad applicability in scientific research, satellite-free navigators and timing signals for financial trading. However, existing all-optical clocks are complex and expensive and have not met the needs of the markets. In this project we will develop commercial cold atom packages as an underpinning technology of all-optical clocks.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Optocap Ltd Fraunhofer UK Research Ltd TMD Technologies Ltd	FLAME – Frequency-stabilised LAser Modules with integrated reference Cell	£343,530	£232,293

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 limited to the research laboratory by their enormous complexity, power requirement, and cost. The uptake of such technology by wider, non-specialist society has gone hand in hand with improvements in size, cost and performance of the subsystems upon which computers depend. 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 a few research laboratories because they depend upon very expensive, very large and very fragile laser systems and electronics. 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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Participant organisation names	Project title	Proposed project costs	Proposed project grant
M Squared Lasers Ltd Durham University	QUARTZ: QUAntum TeraheRTZ Detector using Rydberg Atoms	£364,634	£304,482

Project description - provided by applicants

The project will develop a novel terahertz (THz) detector which will be compact, inexpensive, room-temperature, and have high sensitivity. It will exploit recent breakthroughs in manipulating and interrogating atoms in Rydberg quantum states. The engineering challenge is to miniaturise and rapidly transition the technology from laboratory to product. To this aim, a prototype will be built and characterised to demonstrate the technical feasibility of the approach. Rydberg atoms have one or more electrons in hydrogen-like quantum states, and are characterised by strong response to electromagnetic fields, in particular to fields at THz frequencies (0.1-10 THz or 3000-30 µm), in effect acting as THz optical transducers. High-sensitivity THz detectors are typically bulky and require cryogenic cooling, making them unsuitable for many applications and severely limiting the uptake of THz technologies, especially in industrial settings. The Rydberg THz detector will address this problem, offering a transformative technology for THz sensing and imaging and providing a platform for industrial applications such as non-destructive testing and quality control, and security applications for the detection of chemical and biological agents.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Oxford Electromagnetic Solutions Ltd University of Birmingham	Qvision - A hybrid QT system for visualisation of buried utility assets	£111,856	£86,394

Project description - provided by applicants
An extensive buried utility network (e.g. water mains, >415,000 km, and sewer pipes, >343,000 km in the UK) underpins modern society and provides essential services for daily life. Often, the location and condition of these assets is poorly understood. OXEMS has developed a unique integrated solution offering virtualization of buried assets provided they have been located and tagged with the company's unique tags. Qvision is a feasibility study which will investigate the market potential of incorporating Quantum Technology gravitational sensors with OXEMS' integrated solution, thus enabling utility customers to access and visualize a significantly larger proportion of their network rapidly whilst retaining many of the unique advantages of the OXEMS solution. Qvision will cover the potential impact on the UK economy of manufacturing British designed QT gravitational sensors for deployment alongside OXEMS integrated solution in the global market. This will be achieved by undertaking market and commercial testing with potential UK clients and an assesment of the relative competitive strengths of the proposed new integrated solution.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
ColdQuanta UK Ltd M Squared Lasers Ltd	PICAS: Photonically Integrated Cold Atom Source	£381,019	£266,713

Project description - provided by applicants

ColdQuanta and M-Squared Lasers will develop a commercial supply chain for high-flux cold atom sources. In particular, the business partnership will take a modular approach to commercialising the high flux cold atom source which is a complex and critical element of cold matter systems. The modular commercial system will provide a robust and compact subsystem that will lower the barrier to entry and simplify the process of further system development and integration needed to address specific applications such as clocks, magnetic and electric field sensors, inertial sensors, navigation, and quantum information systems based on neutral atoms.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Compound Semiconductor Technologies Glol University of Glasgow Aston University	Quantum Cooling using Mode Controlled Blue Lasers (CoolBlue)	£272,670	£230,467

Project description - provided by applicants
CoolBlue is a highly innovative project with a goal to develop next generation laser technology for use in the emerging field of quantum sensing. CoolBlue's disruptive technology has the potential to transform conventional quantum sensing systems making them cheaper and more compact. We will make use of compound semiconductors, advanced materials that can be made to emit light over a wide range of wavelengths, and process them into laser chips using specialised manufacturing techniques. Our chips will emit high quality blue light, displacing current commercially available solutions due to superior perfomance and lower cost. The project will be led by CSTG Ltd in partnership with the University of Glasgow and Aston University.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
M Squared Lasers Ltd University of Glasgow	Gas Sight	£267,588	£221,680

Project description - provided by applicants

The ability to directly image gas emissions has significant application in areas as diverse as health and safety within workspace and public environment, security and process control. We will use bespoke laser illumination and a single pixel camera system, based upon the quantum inspired techniques of computational ghost imaging. The imaging device is based upon only a single pixel coupled to a spatial light modulator, similar to that used in video projection. The reliance only on single-pixel, rather than specialist detector array, means that the system is extremely low-cost and gives imaging opportunities across the short-wave and mid-infrared. The selectivity of target gas is set by the wavelength of the illumination source. This project combines the expertise of the University of Glasgow (through their quantum hub) in IR imagers with the optical source and commercialisation expertise of M Squared.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
M Squared Lasers Ltd University of Oxford	cCAS: compact Cold Atom Sources	£396,185	£335,812

Project description - provided by applicants

The project will develop a compact and simplified apparatus for the preparation of cold atomic samples for a range of sensing, timing and computing applications. This will be achieved by using a simplified appartus where mirrors are installed inside the cavity to control the light beams used for trapping. The device developed during this project will serve as a source of cold atoms. This device has wide relevance to the quantum technologies, because it forms one of the building blocks for practical and low-cost, atomic sensing devices and quantum computers. The project brings the academic excellence of Oxford University together with the industrial knowhow of M Squared Lasers to exploit this world-leading innovation from the UK's research base.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Polestar Engineering Ltd University of Sussex ICEoxford Ltd	QGMS: Quantum Geonium Mass Sensor. A route to market feasibility	£129,798	£107,826

Project description - provided by applicants

The Geonium Chip developed and patented by Dr Jose Verdu and his team in the Centre for Quantum Studies at the University of Sussex has significant potential as a core analytical technology in accurate mass spectrometry. The Geonium co-planar Penning trap will enable development of a Fourier Transform Ion Cyclotron Resonance Mass Spectrometer (FT-ICR MS) without the need for a large super-conducting magnet thus greatly reducing the cost and footprint of such an instrument. This will allow a wider range of applications to be addressed by this more deployable and accessible instrument. The feasibility of cooling the ICR cell by an integrated cryostat assembly will be investigated. Potential end users will be contacted and their requirements collected to determine the specification of the instrument. The feasibility of routes to market with industrial partners will be investigated by Polestar Engineering in partnership with the University of Sussex and ICEoxford.

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RedWave Labs Ltd STFC - Laboratories	Novel compact narrow linewidth laser for gravimetric and quantum applications	£364,056	£291,753

Project description - provided by applicants
This is a feasibility project developing new type of narrow linewidth compact lasers. Consortium includes RedWave Labs Ltd (opto-electronics system manufacturer) and RAL Space (world class research in laser applications). We propose to develop a narrow linewidth laser (target 0.4-0.5 kHz) with a small footprint (optical head expected to be ca 50 x 40 x 30 mm) operating in the near infrared range with output power level up 10 mW and integrated electronics control. This would significantly outperform existing commercial technologies and be ready for deployment in emerging quantum applications.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
TopGaN Quantum Technologies Ltd Fraunhofer UK Research Ltd	MagGaNet: Magnesium-clock frequency-stabilised GaN-diode lasers	£359,089	£293,694

Project description - provided by applicants
Optical clocks offer superior performance (>100x) over alternative clock technologies and are required in scientific research, satellite-free navigators and timing signals for financial trading among many other potential applications. However, existing optical clocks are complex and expensive and have not met the needs of these markets. In this project we will develop underpinning subsystems of optical clocks, stabilised-frequency laser systems, using GaN external cavity diode lasers. Specifically, the MagGaNet project will target wavelengths required for magnesium optical clocks a technology that is better suited to space and transportation compared to other clock technologies. The laser sources that will be developed are not available commercially and will deliver significant efficiency gains and footprint reductions compared to frequency-doubled alternatives. These sources will therefore be particularly well-suited to the space, aerospace and defence markets.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
York Instruments Ltd University College London NPL Management Ltd	Radio-frequency atomic magnetometer for medical applications	£322,484	£239,263

Project description - provided by applicants

The proposed feasibility study aims at the realisation of a radio-frequency magnetometer for electromagnetic induction measurements. York Instruments leads a research team that combines UCL and NPL scientists. The project includes the development of an ultra-sensitive radio-frequency magnetometer operating at 1 MHz in unscreened environment, the evaluation of its sensitivity, and the demonstration of magnetic induction measurements at 1 MHz. The ultimate goal of the project beyond the feasibility study phase is to create a map of the conductivity of the heart, which is an essential tool in the clinical treatment of atrial fibrillation. High resolution non-invasive magnetic imaging of the heart offers the opportunity to avoid prolonged invasive mapping of arrhythmias prior to ablation , thus facilitating pre-operative planning of treatment and potentially providing new insight into markers of arrhythmogenic risk relevant for the screening of patients.

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