

INSQT Workshop 2

Report of Contributions

Contribution ID: 1

Type: **not specified**

Quantum Technologies at ESA

Monday, 13 February 2023 13:10 (35 minutes)

Quantum Technologies are regarded as high-priority and strategic at the European Space Agency. The presentation will sketch how quantum technologies development activities are coordinated and supported across the different ESA Directorates and programmes.

Primary author: Dr LEONE, Bruno (ESA)

Presenter: Dr LEONE, Bruno (ESA)

Session Classification: Engineering and Policy

Contribution ID: 2

Type: **not specified**

The Challenges of Space Quantum Devices

Monday, 13 February 2023 13:45 (35 minutes)

In recent years, significant effort has been focused on developing quantum technologies for use ‘in the field’ resulting in a remarkable reduction in SWaP for portable quantum-based apparatus. The use of quantum devices in space poses yet more engineering challenges over terrestrial devices. I will present some of these challenges and discuss design considerations to overcome them, and improve the lifespan of quantum tech-based space missions.

Primary author: Dr COLQUHOUN, Craig (Craft Prospect)

Presenter: Dr COLQUHOUN, Craig (Craft Prospect)

Session Classification: Engineering and Policy

Contribution ID: 3

Type: **not specified**

How to make electronics work in the space environment

Monday, 13 February 2023 14:20 (35 minutes)

A discussion on the engineering challenges of making electronic systems work reliably in the space environment, and the wide range of options and approaches that can be used to mitigate them for different styles of mission.

Presenter: Mr SALTER, Mike (RAL Space)

Session Classification: Engineering and Policy

Contribution ID: 4

Type: **not specified**

QKD from Space to Ground at QTLabs

Monday, 13 February 2023 15:40 (35 minutes)

We will provide an overview of qtlabs' activities in space-based QKD systems. Building on pioneering work in long-distance free-space QKD and performing down links from a quantum satellite, qtlabs has developed expertise and products for space QKD over the last years. This concerns development of quantum sources for space, mission design and QKD protocols, as well as optical ground stations. Connections to relevant QKD missions and the collaboration with international partner will be highlighted.

Primary author: Dr BOHMANN, Martin (QTLabs GmbH)

Presenter: Dr BOHMANN, Martin (QTLabs GmbH)

Session Classification: Space QKD

Contribution ID: 5

Type: **not specified**

Space-Based Quantum Networking at JPL

Monday, 13 February 2023 16:15 (45 minutes)

Quantum technologies promise new capabilities for communication, sensing, and computing. Quantum system performance is generally improved through networking, and a “global quantum internet” is seen as a key infrastructure to realize this promise. Spacecraft quantum technologies will serve an important role in future quantum networking architectures. I will review active, upcoming, and planned JPL space missions that deploy quantum technologies in space, with an emphasis on quantum-networking systems.

Primary author: Dr MOHAGEG, Makan (JPL)

Presenter: Dr MOHAGEG, Makan (JPL)

Session Classification: Plenary

Contribution ID: 6

Type: **not specified**

Registration

Monday, 13 February 2023 12:00 (1 hour)

Contribution ID: 7

Type: **not specified**

Opening Remarks

Monday, 13 February 2023 13:00 (10 minutes)

Presenter: Dr VALENZUELA, Tristan (RAL Space)

Session Classification: Organizational

Contribution ID: 14

Type: **not specified**

Workshop Dinner

Contribution ID: 15

Type: **not specified**

Welcome day 2

Tuesday, 14 February 2023 09:00 (10 minutes)

Presenter: Dr BASON, Mark (RAL Space)

Session Classification: Organizational

Contribution ID: 16

Type: **not specified**

Strontium Trapped Ion Space Clock Development at NPL

Tuesday, 14 February 2023 09:10 (45 minutes)

This presentation will address current research and development of a low-SWaP laser-cooled single Sr⁺ ion clock system focused on space clock applications

Primary author: Prof. GILL, Patrick (NPL)

Presenter: Prof. GILL, Patrick (NPL)

Session Classification: Plenary

Contribution ID: 17

Type: **not specified**

Enhanced Optical Geometries for Atoms

Tuesday, 14 February 2023 09:55 (35 minutes)

There has been recent dramatic global investment in quantum technologies, which now often harness laser-cooled atom traps. Such traps yield orders of magnitude longer measurement times and concomitant accuracy enhancements promised within the small physical footprint already demonstrated in warm atomic systems. Six-beam magneto-optical traps (MOTs) are ubiquitous in cold atomic physics experiments, delivering dense and cold atomic vapours. Grating MOTs (GMOTs), used either in- or ex-vacuo, enable simple and robust MOT generation with a single input laser beam. We present recent Strathclyde GMOT-based experimental results including a truly compact vacuum cell, a clock etc [1], and highlight GMOT developments in other groups. Prospects for utilising reflective and transmissive micro-fabricated planar optics for single-input-beam high-stability optical lattices [1] and Fresnel optical waveguides will also be discussed [2].

[1] <https://eqop.phys.strath.ac.uk/atom-optics/grating-mots/>

[2] <https://eqop.phys.strath.ac.uk/atom-optics/qt-atom-interferometers/>

Primary author: ARNOLD, Aidan (University of Strathclyde)

Presenter: ARNOLD, Aidan (University of Strathclyde)

Session Classification: Atoms and Ions

Contribution ID: 19

Type: **not specified**

Roundtable discussion: EDI in QT in Space

Tuesday, 14 February 2023 11:15 (1h 45m)

Session Classification: EDI in Space Quantum Tech

Contribution ID: 21

Type: **not specified**

A Cold-Atom Microwave Clock for Compact Time Keeping

Tuesday, 14 February 2023 14:00 (35 minutes)

We present a cold-atom pulsed optically pumped (POP) microwave atomic clock based on an additively manufactured loop-gap-resonator microwave cavity and grating magneto-optical trap (GMOT). Additive manufacturing allows for almost arbitrary electrode geometries, more difficult to produce with traditional manufacturing. This approach is also highly scalable and requires minimal assembly. The use of a GMOT allows for a significant simplification of the optical requirements for laser cooling and reduces the optical access requirements of the cavity body. In this demonstration we use a single laser to trap and cool a sample of 87Rb atoms, prepare them in the clock-state and read out the resulting populations after microwave interaction. A Ramsey type interrogation scheme is employed resulting in a short-term stability of $<2e-11 \tau^{-1/2}$. This work is a novel approach towards cold-atom frequency standards for the next generation of compact time keeping.

Primary author: Mr BREGAZZI, Alan (University of Strathclyde)

Presenter: Mr BREGAZZI, Alan (University of Strathclyde)

Session Classification: Atoms and Ions

Contribution ID: 22

Type: **not specified**

Towards a QT Roadmap

Tuesday, 14 February 2023 14:35 (35 minutes)

Primary author: AGNEW, Martin (Airbus)

Presenter: AGNEW, Martin (Airbus)

Session Classification: Atoms and Ions

Contribution ID: **23**

Type: **not specified**

WS Photo

Tuesday, 14 February 2023 15:10 (20 minutes)

Contribution ID: 24

Type: **not specified**

Welcome to Harwell

Tuesday, 14 February 2023 15:30 (15 minutes)

Presenter: Dr GHINELLI, Barbara (STFC)

Session Classification: Welcome to Harwell

Contribution ID: 25

Type: **not specified**

Welcome day 3

Wednesday, 15 February 2023 09:00 (10 minutes)

Primary author: Dr VALENZUELA, Tristan (RAL Space)

Presenter: Dr VALENZUELA, Tristan (RAL Space)

Session Classification: Organizational

Contribution ID: 26

Type: **not specified**

Towards Entangled PhotonSources for Space Quantum Coms

Wednesday, 15 February 2023 09:10 (35 minutes)

Recent developments in space quantum communications have highlighted the role robust quantum sources onboard small satellites and CubeSats could play in enabling trustless QKD and helping to implement a global quantum communication network. A major step in this direction would be to perform satellite-to-ground QKD using entanglement-based protocols such as BBM92 where correlations remove the need for additional trusted devices to ensure security. This presentation will focus on the expanding capabilities of QKD satellite applications and the impact a commercially available low SWaP entanglement-based source could have in next-generation quantum communications and beyond.

Primary author: Dr SHIELDS, Taylor (Craft Prospect)

Presenter: Dr SHIELDS, Taylor (Craft Prospect)

Session Classification: Space QKD

Contribution ID: 27

Type: **not specified**

Emulating Gravitationally-Induced Frequency Shift Towards Space-Based Quantum Optics

Wednesday, 15 February 2023 09:45 (35 minutes)

Space-based quantum networks require highly efficient quantum links between ground systems on Earth and orbiting spacecraft. A test system at JPL emulated timing desynchronization and polarization rotation driven by the relative motion between Earth and a spacecraft. These dynamics are introduced to a single-photon communication system and addressed using compensation systems. The system under development at JPL is planned to be deployed at the Optical Communication Telescope Laboratory in Wrightwood, CA, and coupled to the 1-m aperture primary mirror in support of near-term quantum communications space missions.

Primary author: Dr LOHRMANN, Alex (JPL)

Presenter: Dr LOHRMANN, Alex (JPL)

Session Classification: Space QKD

Contribution ID: 29

Type: **not specified**

Coincidence Detection QKD protocol

Wednesday, 15 February 2023 11:35 (35 minutes)

We will discuss a method based on coincidence detection to increase the key rate in a prepare and measure protocol. The proposed protocol provides higher key rate compared to the most popular BB84 and Decoy State QKD protocols.

Primary author: Prof. SINGH, Ravindra (Physical Research Lab)

Presenter: Prof. SINGH, Ravindra (Physical Research Lab)

Session Classification: Space QKD

Contribution ID: 30

Type: **not specified**

Realistic Thread Models for Satellite-based Quantum Key Distribution

Wednesday, 15 February 2023 12:10 (35 minutes)

We study the security of prepare-and-measure satellite-based quantum key distribution (QKD) in restricted eavesdropping scenarios where Eve has limited access to the transmitted signal by Alice. An artefact of such an assumption is the possibility of having bypass channels, those which are not accessible to Eve, but may not necessarily be characterized by the users either. This creates interesting scenarios for analyzing QKD security. Here, we present generic bounds on the key rate in the presence of bypass channels and apply them to continuous-variable QKD protocols with Gaussian encoding with direct and reverse reconciliation. We find regimes of operation in which the above restrictions on Eve can considerably improve system performance. We also develop customised bounds for several protocols in the BB84 family and show that, in certain regimes, even the simple protocol of BB84 with weak coherent pulses is able to offer positive key rates at high channel losses, which would otherwise be impossible under an unrestricted Eve. Our work opens up new security frameworks for spaceborne quantum communications systems.

Primary author: RAZAVI, Moshen (University of Leeds)

Presenter: RAZAVI, Moshen (University of Leeds)

Session Classification: Space QKD

Contribution ID: **31**

Type: **not specified**

Final Remarks

Wednesday, 15 February 2023 12:45 (15 minutes)

Primary author: Dr OI, Daniel (University of Strathclyde)

Presenter: Dr OI, Daniel (University of Strathclyde)

Session Classification: Organizational

Contribution ID: 33

Type: **Poster**

Finite-key analysis in satellite quantum key distribution for 1-decoy and 2-decoy protocols

Tuesday, 14 February 2023 16:00 (2 hours)

The decoy state technique in quantum key distribution (QKD) has been proven as the most optimal strategy to counter photon number splitting (PNS) attacks. In the asymptotic limit of running the experiment an infinite time, it was shown that 2-decoy outperforms 1-decoy protocol. However, it was also showed that 1-decoy reached higher key rates than 2-decoy for finite block sizes except for short (below 79 km) and long (above 290km) distances. This analysis was performed for a simple channel loss. Here, we present a comparison for a free space channel. Our numerical simulation toolkit (SatQuMa) was used to compare the two decoy methods in a satellite scenario. Our research may provide implications in future satellite QKD missions.

Primary author: Mr POUSA, Roberto (University of Strathclyde)

Presenter: Mr POUSA, Roberto (University of Strathclyde)

Session Classification: Poster Session

Contribution ID: 34

Type: **Poster**

Engineering of QT Systems for Space at Fraunhofer CAP

Tuesday, 14 February 2023 16:00 (2 hours)

Poster will give an overview of three current projects undergoing at Fraunhofer CAP. One project is based on satellite based Quantum Key Distribution (QKD) encoded communication to be packaged in a compact, robust and commercially-viable form. More details in a second project on photon entanglement with different sources for space applications. Finally, a quick overview of the project in collaboration with Craft Prospect in designing a compact, low-loss optical telescope for QKD.

Primary author: Dr LE FRANCOIS, Emma (Fraunhofer UK)

Presenter: Dr LE FRANCOIS, Emma (Fraunhofer UK)

Session Classification: Poster Session

Contribution ID: 35

Type: **Poster**

Towards an optical ground station terminal

Tuesday, 14 February 2023 16:00 (2 hours)

Primary author: Dr PICKSTON, Alexander (Heriot-Watt University)

Presenter: Dr PICKSTON, Alexander (Heriot-Watt University)

Session Classification: Poster Session

Contribution ID: 36

Type: **Poster**

Stand-alone vacuum cell for compact ultracold quantum technologies.

Tuesday, 14 February 2023 16:00 (2 hours)

In the drive to develop cold-atom quantum technologies, compact vacuum systems are key to enabling quantum sensing for real world applications. These vacuum systems not only have to be reduced in size, weight, and power compared to their traditional counterparts, but face other challenges.

Eliminating active pumping addresses both size and power, but introduces the issue of helium gas permeation as passive vacuum pumping techniques do not remove noble gases. Here we present a centilitre-scale vacuum cell, constructed from low helium permeable materials, with an integrated grating magneto-optical trap optic. This small vacuum cell can form the basis of a compact cold-atom source, when used in conjunction with a quadrupole magnetic field and a single laser beam. This is step towards cold-atom sources being an off-the-shelf component, much like lasers are sources of coherent light.

Primary author: Dr BURROW, Oliver (University of Strathclyde)

Presenter: Dr BURROW, Oliver (University of Strathclyde)

Session Classification: Poster Session

Contribution ID: 37

Type: **Poster**

A guide to an optical ground station site selection and evaluation using CV QKD protocol

Tuesday, 14 February 2023 16:00 (2 hours)

Primary author: Ms ANIPEDDI, Naga Lakshmi (Walton Institute, South East Technological University, Ireland)

Presenter: Ms ANIPEDDI, Naga Lakshmi (Walton Institute, South East Technological University, Ireland)

Session Classification: Poster Session

Contribution ID: 38

Type: **Poster**

CASPA atmospheric drag mission

Tuesday, 14 February 2023 16:00 (2 hours)

To gain better understanding of the upper atmospheric dynamics requires more accurate determination of the mass density distribution in the thermosphere. Improved measurements of drag, by means of satellite accelerometry, can be used to more precisely determine this distribution. In addition, atmospheric drag in Low Earth Orbit (LEO) is particularly of interest for climate modelling, weather forecasting and satellite orbit prediction. RAL Space and the University of Birmingham are developing a Cold Atom Space Payload Atmospheric Drag Mission (CASPA-ADM). The aim of the project, supported by the UK Centre for Earth Observation Instrumentation (CEOI), is to develop a technology demonstrator based on Cold Atom Interferometry (CAI) to take sensitive measurements of atmospheric drag. The underlying CAI technology has been previously flown on the Chinese Space Station, the International Space Station, and in sounding rockets. However, it has not yet been used as the fundamental sensor technology in a free flight space mission. The team is producing a space-suitable accelerometer that can be embedded in small satellites such as 16U CubeSats and are addressing the engineering challenges associated with space qualification and miniaturisation, while keeping the performance level of systems with larger Size, Weight and Power (SWaP)

Primary author: Dr FERRERAS, Jorge (RAL Space)

Presenter: Dr FERRERAS, Jorge (RAL Space)

Session Classification: Poster Session

Contribution ID: **39**

Type: **Poster**

TBC

Tuesday, 14 February 2023 16:00 (2 hours)

Primary author: GHALALI, Masoud (University of Leeds)

Presenter: GHALALI, Masoud (University of Leeds)

Session Classification: Poster Session

Contribution ID: 40

Type: **Poster**

Optical reference cubic cavities for space deployment

Tuesday, 14 February 2023 16:00 (2 hours)

The development of cubic optical cavities for high TRL low SWaP stabilization of laser light for applications in the space sector, such as fundamental physics, Earth observation and future navigation, will be presented.

Primary author: Dr BARWOOD, Geoffrey (NPL)

Presenter: Dr BARWOOD, Geoffrey (NPL)

Session Classification: Poster Session

Contribution ID: 41

Type: **Poster**

Your Partner for Space QKD

Tuesday, 14 February 2023 16:00 (2 hours)

Primary author: Mr ACHATZ, Lukas (Quantum Technology Laboratories GmgH)

Presenter: Mr ACHATZ, Lukas (Quantum Technology Laboratories GmgH)

Session Classification: Poster Session

Contribution ID: 42

Type: **Poster**

Space Quantum Tehcnologies for Children

Tuesday, 14 February 2023 16:00 (2 hours)

Primary author: FILIPOVA, Mariana (University of Library Studies and Information Technologies)

Presenter: FILIPOVA, Mariana (University of Library Studies and Information Technologies)

Session Classification: Poster Session