Small Photon Entangling Quantum System (SPEQS) for Space Based Quantum Experiments

Rakhitha Chandrasekara, Z.K Tang, Y.C Tan, C. Cheng and Alexander Ling. Quantum Optics Group
Centre for Quantum Technologies, NUS, Singapore.
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Motivation

• Public key cryptography is not provably secure
• One time pad is optimal and provably secure
• Symmetric key distribution problem
• Quantum Key Distribution provides enhanced security based on Quantum Mechanics

• ………& Explore Fundamental physics
A secret key can be shared between two parties using quantum particles (QKD).

Most secure form of QKD relies on quantum entanglement.

Polarization entangled photon systems are mature enough for practical QKD demonstrations.
Global QKD Proposals

Nobody has demonstrated a working entangled source in Space
Entangled Sources & Satellites

A typical entangled source requires a large satellite due to their power and space requirements.

CubeSat
SWaP

Size < 300 ml

Weight < 300 g

Power < 2W
Small Photon Entangling Quantum System (SPEQS)

A miniaturised Polarization Entangled Photon Source

Develop an entangled photon source which can fit into a CubeSat.

As a part of series of missions leading to Space to ground QKD.
Small Photon Entangling Quantum System (SPEQS)

- Polarization entangled photon source
- Detecting single photons onboard
- Follows 1U CubeSat specifications

**SubSystems**
- Laser Diode Controller
- Polarization Rotator
- Single Photon Detectors
- Thermal Management
Verifying SPEQS onboard

Visibility quantifies the quality of the source

\[
\text{visibility} = \frac{\text{max} - \text{min}}{\text{max} + \text{min}}
\]

Visibility quantifies the quality of the source
Single photon detection onboard
Optical unit Integrated with Electronics

Electronics Platform of SPEQS
Space qualification tests

- Radiation tests
  - Total Ionising Dose (TID) - gamma
  - Displacement Dose (DD) - protons
- Vacuum test
- Thermal test
- Vibration tests
  - sine sweep
  - random vibration

Electronics board preparation for proton testing at Crocker Nuclear Lab, UC Davis

GaN Laser diode & Si APDs
**Post Vacuum Test**

-10 mbar over 24 hours

**Post Thermal Cycling Test**

-10 °C to 40 °C ramping up and down 50mins

**Post Vibration Test**

sine sweep (5 -100Hz) 2.5g
random (20 - 2000 Hz) 7.4 g rms
Near Space Demonstration

Location - Sursee, Switzerland
Altitude - 35.5 km
In collaboration with Sursee Radio club
SPEQS performance
CubeSat Integration - GomX-2
SPEQS 1.0 CubeSat Integration

Galassia mission
NUS, Singapore

- 2U CubeSat
- equatorial orbit
- SPEQS + other payloads
- Launch in Q4 2015
- Full operation in Q1 2016

Photo Courtesy Galassia, NUS
What’s Next?

- Low brightness, proofs of concepts
- Balloons, shared CubeSats, TEXUS

- Full “QKD-strength”, tech demo
- CQT-built 3U SpooQySat
- Detection on-board

- Space-to-ground QKD demos
- Optical ground stations
1st Space to ground QKD shopping list

- SPEQS-2 sources
- Optical ground stations
- Large aperture relay optics
- High accuracy position data
- micro-radian ADCS
- Optical beam steering

Collaborators Welcomed!
Thank You

http://www.quantumlah.org

Alexander Ling Group