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SMALL PHOTON ENTANGLING QUANTUM SYSTEM (SPEQS) FOR SPACE-BASED QUANTUM KEY DISTRIBUTION (QKD).

Abstract

Spurred by the threats to existing secure communications posed by quantum computers, quantum-safe cryptography (such as Quantum Key Distribution, QKD) has become a very active research field. Since there are fundamental challenges to establishing a global QKD network using optical fibres, several communication protocols using satellites have been proposed. To enable this, the Centre for Quantum Technologies (CQT) at the National University of Singapore (NUS) are developing SPEQS (Small Photon Entangling Quantum System), a source of entangled photons ruggedized to survive deployment in space and greatly miniaturised so that it conforms to the strict form factor and power requirements of a 1U CubeSat.

Entangled photon pairs are generated through spontaneous parametric down conversion in BBO crystals, the optical pump being provided by a wavelength-stabilised laser-diode. A photo-diode based feedback system is implemented to maintain constant pump power, which is a function of the laser-diode junction temperature. The photon pairs generated are detected on board using single-photon Avalanche Photo Diodes (APDs) operating in Geiger mode. Since APD operation is affected by temperature fluctuations along the orbit, thermo-electric coolers would be desirable, except that they exceed the typical power budget allowed for scientific payloads on a CubeSat. Consequently an alternative, more power efficient temperature compensation mechanism has been designed for APD operation.

Our system is also capable of monitoring the quality of the entangled photons produced in orbit. This is achieved through an opto-electronic design which changes the polarisation states of the photon pairs without using motor based polarisers. In addition to being power efficient, this does not interfere with the attitude control mechanisms of the satellite.

The fully autonomous system has undergone thermal, vacuum and vibration qualification tests and has been tested in a weather balloon in near space conditions, confirming the robustness of the system ahead of upcoming in-space demonstrations.The successor to SPEQS, SPEQS2 is now also under development. This

will be a bigger and brighter entangled photon source than SPEQS1, yet maintain CubeSat-compatibility and will be demonstrated on the CQT-led SpooQySat CubeSat programme.