National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Communications

Optical De-Multiplexing Method for QKD Encryption

Space-and-wave division for quantum key distribution photon detection

NASA inventors have developed a space-and-wave (SAW) division method to de-multiplex low energy quantum key distribution (QKD) photons from high energy free space optical transmissions. The method exploits available double-clad fiber optic cable with 9um core fiber diameter and 105um 1st cladding outer diameter. By optimizing wavelengths used for QKD photon and data transmission (wave division), a focusing lens can be used to create a diffraction pattern that focuses QKD photons on the core and the higher energy signal onto the 1st cladding (spatial division). The SAW method enables de-multiplexing of simultaneously transmitted optical data and built-in photonic QKD encryption keys. The method was developed by NASA to send and receive encryption keys using weak coherent pulsed light rather than entangled photons; it can be applied to the encryption of any free space optical communications.

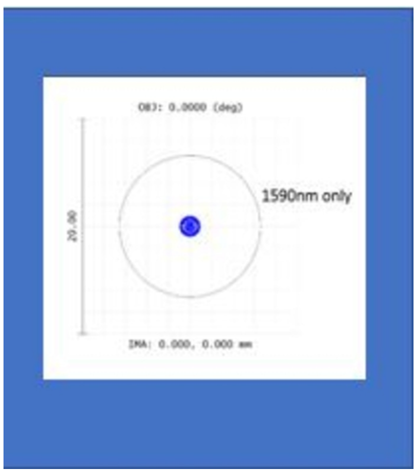
BENEFITS

- Enabling: allows practical application of QKD to free space optical communication
- Universal: can be applied to the encryption of any free space optical communication
- Expandability: additional channels can be included for timing and synchronization duties
- Hardware compatibility: leverages commercially available double-clad fiber

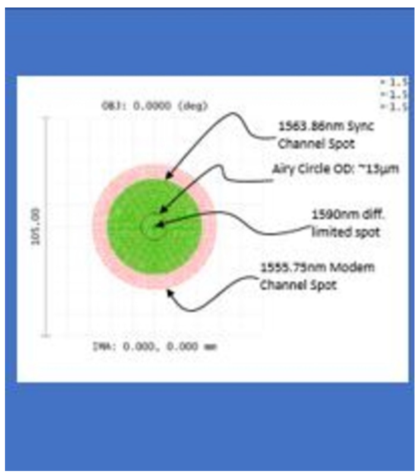
THE TECHNOLOGY

Classical laser communication gimbals are coupled to 105um multimodal receiving fibers for the high-power transmission of data, fine pointing, and tracking. These fibers cannot be used in free space optical communication applications using Quantum Key Distribution (QKD) since polarization state information encoded by QKD photons is not retained. To accommodate low energy QKD photons and high energy data streams necessary for encryption of optical links, the inventor adopted a space-and-wave (SAW) division de-multiplexing approach.

The SAW division method uses a double clad fiber with a 9um core and a 105um 1st cladding. This arrangement captures 1590nm wavelength QKD photons in the core channel and a 1555.75nm wavelength data channel in the 1st cladding. By defining wavelength separation between 30-40nm, a single focusing lens can be used to focus only one wavelength to a diffraction limited spot (see figures included). Using this method, a QKD channel is focused to a diffraction limited spot on the 9um core of the double clad fiber. The chosen wavelength separation generates a defocused diffraction pattern with a hollow center, and with remaining optical power in concentric rings outside of the 9um core, yet inside the 105um core. The QKD signal is directed into the 9um core, and the data channel is coupled into the 105um secondary core for traditional data demodulation.



Caption: A 1590nm quantum laser spot diagram to show coupling of a QKD channel into a 9um single mode core. Solid blue circle demonstrates the laser spot size with accompanying 20um scale bar.



Demonstration of spot size difference resulting from use of lasers with wavelengths of 1563.86nm (synchronization channel) and 1555.75nm (model channel).

APPLICATIONS

The technology has several potential applications:

- Telecommunications: QKD-encrypted optical data links (satellite-to-ground, satellite-to-satellite, aircraft-to-ground, etc.)

PUBLICATIONS

Patent No: 11,588,628

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More Information

National Aeronautics and Space Administration

Agency Licensing Concierge

Glenn Research Center

21000 Brookpark Road
Cleveland, OH 44135
202-358-7432
Agency-Patent-Licensing@mail.nasa.gov

www.nasa.gov

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