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OVERVIEW OF NASA'S NATIONAL SPACE QUANTUM LABORATORY PROGRAM

Abstract

The development of entanglement-based quantum networks promises substantial benefit to quantum-enabled applications including distributed quantum sensing, improved timing/synchronization, multi-processor quantum computing over short-range interconnects, and distributed computing or secure communication over long-haul links. Photonic-based systems are the primary technology for realizing quantum networks due to the relative ease of photon transport while maintaining the quantum state. Significant development is required, however, to realize entanglement distribution rates commensurate with quantum network application requirements.

In FY18, NASA initiated a hardware development program at MIT Lincoln Laboratory (MIT-LL) to enable a series of near-term space-based quantum communication demonstrations that leverage the

agency's significant investment in classical lasercom hardware pathfinders. Our program is focused on developing technology to enable entanglement-based quantum network demonstrations over satellite-based downlinks and crosslinks. Critical technology development underway today includes: precision synchronization, high-rate heralded entanglement sources and variable storage-time quantum memory. The ultimate goal of the program is to deploy this quantum communication infrastructure on the International Space Station to provide a National Space Quantum Laboratory (NSQL) that can be used collaboratively by the quantum information science research community to characterize new quantum technologies and evaluate new quantum system applications enabled by quantum states distributed over long distances.

Quantum free-space communication links also require beam pointing, acquisition and tracking (PAT) and a classical communication channel provided by RF or lasercom terminal technology. Today, MIT-LL is developing next-generation lasercom terminal hardware for NASA that will be used to demonstrate LEO-to-GEO bi-directional crosslinks and high-rate downlink communications for Lunar downlinks. We envision that two near-term NASA free-space lasercom pathfinders will be leveraged to demonstrate NASA's first space quantum communication links. First, the Laser Communication Relay Demonstration (LCRD) satellite will host two lasercom terminals in geosynchronous orbit after its planned 2020 launch. By configuring one of the lasercom terminals for low-flux output, LCRD will be used to validate ground terminal interoperability for classical and quantum optical space downlinks. Next, the Integrated LCRD Low-Earth Orbit User Modem and Amplifier Terminal (ILLUMA-T) program will host a next-generation lasercom terminal developed by MIT-LL on the International Space Station in the 2022 timframe. The ILLUMA-T lasercom terminal integrated with a quantum modem will be used to demonstrate high-rate space-to-ground entanglement distribution and explore the feasibility of smallsat quantum crosslinks.

In this presentation, we describe the objectives of NASA's NSQL quantum communications program and discuss key technologies employed in the space and ground terminals.