Quantum Science Satellite

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ABSTRACT

Quantum Science Satellite is one of the first five space science missions, slated for launch in the framework of Chinese Academy of Sciences (CAS) Strategic Priority Research Program on space science. The project aims to establish a space platform with long-distance satellite and ground quantum channel, and carry out a series of tests about fundamental quantum principles and protocols in space-based large scale. The satellite will be launched at Jiuquan and on orbit for 2 years. The orbit will be circular and Sun-synchronous with an altitude of 600 km. It crosses the descending node at 00:00 LT. The satellite is under early prototype development currently.

KEY WORDS

Quantum science satellite, Strategic priority research program, Quantum

1 Scientific Objectives

The scientific goals are to implement a series of science missions between Quantum Science Satellite and quantum communication ground stations. The major tasks are as follows.

(1) Quantum Key Distribution from Satellite to Ground

To set up an ultra-long-range quantum channel between ground and satellite with the assistance of high-precision acquisition, tracking and pointing system, implement a quantum key distribution between the satellite and the ground stations, and carry out unconditional secure quantum communication experiments.

(2) Global Scale Quantum Communication Network

To set up a real wide-area network for quantum communication using the satellite repeater and two arbitrary quantum ground stations and their auxiliary local-area fiber quantum networks.

(3) Quantum Entanglement Distribution from Satellite to Two Ground Stations

Distribution of quantum entangled photons from the satellite to two distant ground stations whose distance is larger than one thousand kilometers; test of the entanglement properties at a large scale and nonlocality of quantum mechanics.

(4) Quantum Teleportation from Ground to Satellite

As a totally new way of communication, quantum teleportation is the fundamental process of quantum networks and quantum computing. A high quality quantum entanglement source on the ground will be built to achieve ground-to-satellite teleportation experiments based on photon entanglement.

2 Satellite System

Quantum Science Satellite is a microsatellite for science, research, and technology payloads. It was designed to affordably allow quantum science missions. The satellite carries quantum key communicator, quantum entanglement emitter, quantum entanglement source, quantum experiment controller and processor and high-speed coherent laser communicator. Figure 1 shows the Quantum Science Satellite spacecraft schematic with four quantum science instruments.

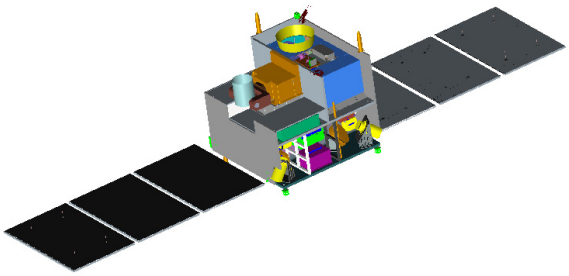

Fig.1 Quantum Science Satellite

2.1 Satellite Platform

The Quantum Science Satellite consists of several different subsystems: the attitude control subsystem, power subsystem, thermal control subsystem, telemetry and command subsystem, communications subsystem, structure subsystem, and housekeeping subsystem.

In order to design the Quantum Science Satellite, the mission activities, requirements, and mission analysis have been completed at the end of 2011. Mission definition and justification and key technique researches have been finished by the end of 2012. Detailed definitions of the spacecraft have been completed in March 2013. Prototypes of onboard devices and components have been built for verification, and have been checked and approved at the end of August 2013. Electronic characteristic tests on the prototypes have been carried out by the end of September 2013. After that, in October 2013, the structural prototype of the satellite has been assembled, and the mechanical environmental simulation tests have been completed. Subsequently, the thermal balance tests have been finished in December 2013 on thermal characteristic prototype of the satellite.

At the end of October 2013, some prototypes of onboard devices, which are designed for qualification tests, have been put into production. They have been checked and accepted by the end of March 2014. At present, an electronic characteristic testing of those prototypes is in progress.

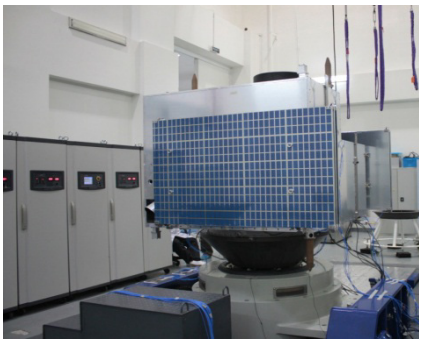

Fig.2 Mechanical environmental simulation test

2.2 Satellite Payload

The payload of the quantum science experimental satellite includes quantum key communicator, quantum entanglement emitter, quantum entanglement source, quantum experiment controller and processor and high-speed coherent laser communicator. The key techniques of the optical communication terminal consist of high-precision tracking and pointing, wideband high-extinction-ratio polarization-maintaining capabilities and the aviation engineering of quantum entanglement source.

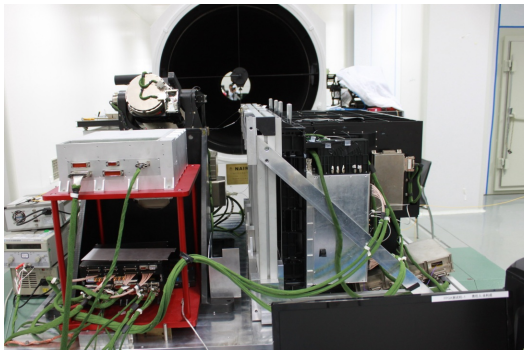

Fig.3 Joint test of satellite payload entanglement source

The electronic sample of the optical communication terminal has been developed and finished the joint test. The evaluation sample of the optical communication terminal is under integration and testing.

3 Scientific Application System

The scientific application system is the core of space quantum scientific experiment system. As the brain of quantum scientific experimental mission, it is responsible for the planning and the operation control of scientific experiments, but also for the processing, transfer, storage, management and publication of the scientific data and applications in the whole Quantum Science Satellite project. Moreover, the science application system will form an integrated ground-satellite system together with the satellite system. The scientific application system is responsible for the construction of ground systems which support the scientific experiments, including one scientific experimental center which is located in Hefei; two wide-area QKD application platforms which are located in Beijing and Urumqi respectively; four ground stations, each with a large-diameter telescope for quantum communication, *i.e.* 1-meter-diameter telescope at Xinglong Station of National Astronomical Observatories/NAOC (to be upgraded and rebuilt), 1.8-meter-diameter telescope at Lijiang Station of Yunnan Astronomical Observatory/YAO (to be upgraded and rebuilt), 1.2-meter-diameter telescope at Nanshan Observatory of Xinjiang Astronomical Observatory/XAO (to be built), 1.2-meter-diameter telescope at Qinghai Station of Purple Mountain Observatory/PAO (to be built); one single station with three small transmitter-telescope located in Ngari, which is constructed for the quantum teleportation experiment.

Fig.4 Geographic distribution of scientific application system

4 Future Plan

According to the plan, the satellite's prototype for qualification test will be assembled in June 2014, and the verification activities will be finished by the time of August 2014. At the end of June 2015, building and testing activities of the satellite will be finished.