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ANALYZING QUANTUM BASED PROTOCOLS IN LEO AND GEO SATELLITE COMMUNICATIONS

Abstract

The quantum mechanical based computing could be an effective tool in the future, compromising the security of current cryptography algorithms. For example messages protected by the RSA key can be easily decrypted with the help of quantum Shor-algorithm. However quantum cryptography provides new ways to transmit information with unconditional security (e.g. by using the BB84 or B92 protocols). In today's communication networks, the widespread use of optical fiber and passive optical elements allows using quantum cryptography in the current standard optical network infrastructure, but the distance of such communication is limited due to loss and imperfect equipment. A possible alternative is the Free-space Quantum Key Distribution that promises lower losses and distortion-free channels. It was first implemented over an optical path of about 30 cm in 1991. In 2006, the distance was extended to 144 km by an international research group, which allows ground-to-satellite or satellite-satellite quantum communication. In 2008, the European Space Agency named the quantum-based satellite communication as one of the most important targets for the next five years.

To establish successful quantum communication we need precise models of quantum channels. We have created a mathematical model based on the properties and performance of recently-used single-photon sources and detectors, the loss caused by the gases and aerosols of the atmosphere and the pointing error. This model enables us to analyze and determine the parameter requirements to the implementation of a satellite quantum channel for Earth-satellite and satellite-satellite communication. In this paper we present our results which show that we can realize quantum communication over intercontinental distances. We analyzed the properties of the quantum channel between satellites on Low Earth Orbit (LEO) and Geostationary Earth Orbit (GEO), and between Earth-LEO/GEO orbits. We have dealt with different quantum protocols in Earth-LEO and in Earth-GEO communication and between LEO and GEO satellites.

In this paper we present a simulation software as well which we developed to demonstrate and illustrate the properties of the free-space channels for different quantum communication scenarios between ground stations and satellites.