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INVESTIGATION OF THE FEASIBILITY OF DIFFERENT QUANTUM MEMORIES IN SATELLITE-BASED QUANTUM INTERNET

Abstract

Quantum computing, a technology based on quantum physics, is developing at a fast pace. It is accelerating not only the process of building quantum computers, but also the development of quantum networks that connect them, namely the quantum internet. A crucial question is whether it will be possible to maintain a quantum network over long distances. Optical fiber-based experiments are promising, but due to the limitations of optical fiber, free-space solutions including satellite-based quantum communication systems could play an important role. To ensure that the state of the quantum bit carrying quantum information is not corrupted even over long distances, we would need to use quantum memories. These devices, as reliable nodes, will be able to preserve the state of incoming quantum bits without violating the so-called No-Cloning Theorem. With quantum teleportation, a useful protocol in quantum communication, we can transmit quantum information between quantum nodes including quantum memories. In our work, we investigate several types of quantum mechanically important material structures as possible quantum memories for satellite-based systems. In general, the list of quantum memories includes nitrogen-vacancy-centers, EIT (Electromagnetically Induced Transparency), warm vapor cells, cold atomic gases, REIDs (Rare-earth Ion Doped) and the single atoms and ions. But not all of them can be used in space environment. The optical path between quantum memories is the quantum bit, and this influences the choice of memory in several ways. Just mentioning a few of them: choosing a structure that can form a photon-spin interface with high efficiency; the length of coherence time; capable of miniaturization to fit into a satellite; resistance to mechanical vibration of launch and many other factors. In our work, we focused on the feasibility of quantum memories in satellite communication as well as on their application possibilities. We designed a satellite-based quantum internet network which uses quantum memories onboard of satellites on different orbits and carried out different simulations to analyze the efficiency of such a system. Among others, we investigated the distances at which a secure and efficient quantum communication network can be maintained using quantum memories in satellite constellations on different orbits (including LEO and GEO orbit).