7
Conclusions

In the proposed probabilistic CBRSP, deterministic CBRSP and deterministic CJBRSP, the probabilistic CBRSP is the best choice in terms of classical resources required as compared to deterministic BCST schemes like deterministic CBRSP. This situation is equivalent to the one-directional case. The beauty of such protocols especially in deterministic CBRSP is that the operations used in deterministic CBRSP can be used with some modifications in the protocol of deterministic CJBRSP and also all such protocols can be performed using many alternative quantum channels. In addition to this, deterministic protocols can be converted into bidirectional probabilistic RSP (remote state preparation) by sharing non-maximally entangled GHZ states between sender and receiver. These protocols have many useful and real field applications and can be realized experimentally by available technologies. We have proposed the effect of noise on bi-directional quantum communication protocols. Here the effect of noise such as amplitude damping, phase damping on the studied protocols makes the protocols more realistic because we cannot neglect the effect of noise in a practical quantum communication.

In an interesting application of quantum-based satellite communication, the use of the technique of quantum controlled error correction teleportation (QCECT) makes the communication process more practical, efficient and fault-tolerant. The rotational and phase operators keep tracking the satellite movement and provide an adaptive mechanism to store the exact coordinated at a particular time instance. In addition to this, the use of fault-tolerant quantum computing in quantum-based satellite communication requires less computing time and also reduces the errors generated in the communication process. Hence the QCECT approach is capable of handling and exchanging a large amount of data between space-ground quantum communication.

There are many interesting conclusions in the single qubit and entangled-state based quantum communication schemes. Performance of single qubit or entangled qubit quantum communication is based on the noise of the channel under consideration. From the analytical results obtained it is observed that single qubit based approaches perform better under AD (Amplitude Damping) and PD (Phase Damping) noises. On the other hand, entangled based schemes perform much better under collective noise. SGAD and GAD are the generalizations of the AD channels, hence similar conclusions are also applicable for these two channels. It is observed that fidelity decays with the increase in temperature and squeezing is an important quantum resource in various applications of quantum communication. Performance of any quantum communication also depends on how many times the traveling qubit passes under the particular noisy channel. In connection with these results, it is seen that the QKD protocols are least affected for the same noisy channel under communication as compared to QD protocols.

In DPS QKD scheme, similar to B92 protocol, Alice prepares random quantum states and sends a set of two non-orthogonal states to Bob. Opposite to B92 protocol, weak coherent pulses (WCP) are used in DPS QKD protocol to avoid the PNS attack. The advantage of using DPS QKD protocol is its high-speed data rates and simple experimental circuit. The DPS-QKD protocol can be deployed in quantum repeaters to achieve the long-distance quantum communication. The imperfections present in the optical fibers limit the communication distance. The non-birefringent phenomenon and losses inside fiber degrade the performance. A lot of efforts are devoted to overcome such limitations.

In all the classical and quantum communications, noise is generally undesirable and degrades the performance of the communication system. In the present work, it is shown that noise could be helpful. In real field applications, Eve is also restricted by the noise generated due to the external environment. In Ping-Pong QKD protocol, we have shown that noise is helpful to the legitimate users. Also, noise affects the communication channel more than the eavesdropping channel. In our work, we have shown that the security of the Ping-Pong QKD protocol is improved under a non-unital decoherence, but deteriorates under unital decoherence. Also, Eve is unable to replace the noisy communication channel by a noiseless channel.

In quantum-based satellite communication, we have simulated two QKD protocols, SARG04 and BB84. Out of these two protocols, we find that SARG04 protocol performs better as compared to the BB84 protocol, especially for quantum-based satellite communication. It is also shown that the two decoy state based SARG04 protocol is the best choice from a security point of view where we can protect the satellite communication system from photon number splitting (PNS) attack. In addition to this, we optimized the mean photon number to achieve maximum key generation rate and communication distance.

The other practical issue is high link losses which should be minimized to enhance the communication distance. The transmitter and receiver design based on actual data can be deployed in real field applications which may be helpful to better understand the turbulence effects on the particular communication system. Our telescope design data could be used for the future Earth-space quantum links and new quantum protocols can be exploited to perform much better under atmospheric turbulence.

As compared to downlink, uplink suffers from high link losses due to atmospheric effects, which requires highly tailored photon pulses and high-quality photon detectors. Further, to enhance the performance of the quantum-based satellite communication system, it is required to consider the pointing and misalignment errors. In addition to this, performance can be improved by using six or more nonorthogonal states.