Broadcasting Single-Qubit and Multi-Qubit-Entangled States: Authentication, Cryptography, and Distributed Quantum Computation

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The no-cloning theorem forbids the distribution of an unknown state to more than onereceiver. However, quantum entanglement assisted with measurements provides various pathways to communicate information to parties within a network. For example, if the sender knows the state, and the state is chosen from a restricted set of possibilities, a procedure known as remote state preparation can be used to broadcast a state. In this talk, we first examine a remote state preparation protocol that can be used to send the state of a qubit, confined to the equator of the Bloch sphere, to an arbitrary number of receivers [1]. The entanglement cost is less than that of using teleportation to accomplish the same task. We also present variations on this task: probabilistically sending an unknown qubit state to two receivers, sending different qubit states to two receivers, sending qutrit states to two receivers, and discuss some applications of these protocols. Next, we generalize the basic broadcasting protocol to broadcast product and multi-partite entangled quantum states in a network where, in the latter case, the sender can remotely add phase gates or abort distributing the states [2]. The generalization allows for multiple receivers and senders, an arbitrary basis rotation, and adding and deleting senders from the network.

We also discuss the case where a phase to be applied to the broadcast states is not known in advance but is provided to a sender encoded in another quantum state. Applications of broadcasting product states include authentication and three-state quantum cryptography. We also study the distribution of a single multiqubit state shared among several receivers entangled with multi-qubit phase gates, giving the graph states as an example. As an application, we discuss the distribution of the multi-qubit GHZ state. We close with a discussion of the capabilities and limitations of implementations using linear optical quantum networks [3].

References

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