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Entanglement-Based Quantum Cryptography and Quantum Communication[1]

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Quantum entanglement, to Erwin Schroedinger the essential feature of quantum mechanics, has become a central resource in various quantum communication protocols including quantum cryptography and quantum teleportation. From a fundamental point of view what is exploited in these experiments is the very fact which led Schroedinger to his statement namely that in entangled states joint properties of the entangled systems may be well defined while the individual subsystems may carry no information at all. In entanglement-based quantum cryptography it leads to the most elegant possible solution of the classic key distribution problem. It implies that the key comes into existence at spatially distant location at the same time and does not need to be transported. A number recent developments include for example highly efficient, robust and stable sources of entangled photons with a broad bandwidth of desired features. Also, entanglement-based quantum cryptography is successfully joining other methods in the work towards demonstrating quantum key distribution networks. Along that line recently decoy-state quantum cryptography over a distance of 144 km between two Canary Islands was demonstrated successfully. Such experiments also open up the possibility of quantum communication on a really large scale using LEO satellites. Another important possible future branch of quantum communication involves quantum repeaters in order to cover larger distances with entangled states. Recently the connection of two fully independent lasers in an entanglement swapping experiment did demonstrate that the timing control of such systems on a femtosecond time scale is possible. A related development includes recent demonstrations of all-optical one-way quantum computation schemes with the extremely short cycle time of only 100 nanoseconds.

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