Quantum Communications using Semiconductor Devices

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Applying quantum theory to information systems brings new functionalities that are not possible in conventional networks and computers. For example, the secrecy of encoded single photons transmitted along optical fibres can be tested directly and used to distribute cryptographic keys and digital signatures on communication networks. I will discuss recent work to realise practical systems for quantum key distribution (QKD) and their application to point-to-point and network-based encryption. In the latter part of the talk I present progress on quantum relays using semiconductor entangled photon sources.

Simple semiconductor devices for the generation and detection of quantum light states are central to the development of practical QKD. Semiconductor avalanche photodiodes operated in gated Geiger mode allow detection of telecom single photons at GHz rates. These room temperature devices enable portable and reliable QKD systems with key rates in excess of 1 Mb/s and individual fibre links over 200km in length.

QKD has been demonstrated using single photons, entangled pairs, attenuated laser pulses and Gaussian modulated coherent pulses. Of these, attenuated laser diodes give the best performance today and, thanks to the decoy pulse protocol and privacy amplification, have identical security to the case of ideal single photon sources. Recently direct phase modulation of laser diodes, based on optical injection locking, has been shown to reduce the complexity of QKD transmitters and allow a very flexible device that can operate several different protocols.

The past few years have seen rapid progress in the technology required to operate QKD in conventional data networks. I will discuss recent progress on introducing QKD to multi-user access networks and to operate QKD on fibres carrying very high bandwidths (up to 10 Terabit/sec) of conventional data simultaneously.

In the future, new quantum sources will be needed for entanglement based networks that can be used for long distance quantum repeater networks, as well as distributed quantum sensing and computing. Entangled photon sources, based on the electroluminescence of a semiconductor quantum dot, offer an attractive solution. I discuss recent work to develop quantum dot sources that emit entangled photons at 1300nm and to apply these to fibre-based quantum relays.