Quantum Dot Single-Photon Source in Applied Physics

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Commentary

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ABOUT THE STUDY

A single quantum dot is positioned in an optical cavity to create a quantum dot single-photon source. It is a single-photon source available on demand. In a quantum dot, an excitation-a pair of carriers can be excited by a laser pulse. One photon is released when a single excitation decays as a result of spontaneous emission. Because of interactions between excitations, the emission from a quantum dot with a single excitation differs energetically from one with many excitations. As a result, a laser pulse can deterministically produce a single excitation, and the quantum dot transforms into a non-classical light source that emits photons one at a time and exhibits photon anti-bunching. By measuring the second order intensity correlation function, it is possible to demonstrate the emission of single photons. The integration of the quantum dot in an optical cavity can increase the rate of spontaneous emission of the photons released. The cavity also causes emission in a clearly defined optical mode, improving the photon source's efficiency. Since the dawn of the twenty-first century, there has been an increase in interest in quantum information science, which has led to an increase in study into various single-photon sources. Early single-photon sources, including the 1985-first-reported heralded photon sources, are based on non-deterministic processes.

In 2000, a quantum dot in a micro-disk structure was used to create a single-photon source. After that, sources were incorporated into other architectures like micro-pillars or photonic crystals. Distributed Bragg Reflectors (DBRs) were used to boost emission efficiency and enable emission in a clearly defined direction. It is still a technical problem for most quantum dot single-photon devices to operate at cryogenic temperatures. Realizing superior telecom wavelength quantum dot single-photon sources for fiber communication applications is the other difficult task. According to the first study on Purcell-enhanced single-photon emission of a telecom-wavelength quantum dot in a two-dimensional photonic crystal cavity with a quality factor of 2,000, the emission rate and intensity were increased by five and six folds, respectively. An excited state, or so called excitation, is produced when an electron in a semiconductor is excited from the valence band to the conduction band. A photon is released when this excitement undergoes spontaneous radioactive decay. It is possible to ensure that there is never more than one excitation occurring in a quantum dot at once since quantum dots have discrete energy levels. The quantum dot is a single photon emitter as a result; making an effective single-photon source requires a number of technical challenges, including ensuring that the emission from the quantum dot is gathered effectively. The quantum dot is positioned in an optical cavity to do that. Two DBRs in a micro-pillar, for instance, may make up the cavity. The Jayne's Cummings model can then be used to approximate the system. Only one mode of the optical cavity interacts with the quantum dot in this paradigm. The optical mode's frequency is clearly identified. If a polarizer aligns the photons' polarization, it blurs their differences. A vacuum Rabi oscillation is the Jayne's Cummings Hamiltonian's solution. An excitation-polariton is a vacuum Rabi oscillation of a photon that has interacted with an excitation. Making sure that there can only be one excitation occurring in the cavity at once will avoid the possibility of two photons emitting simultaneously. A quantum dot can only undergo one excitation due to its discrete energy states.