Characterizing the temporal variations in quantum light sources

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Introduction
The light produced through spontaneous emission decay in a quantum emitter can be non-classical, and is of interest in a variety of fundamental experiments as well as emerging schemes in quantum information processing. Single-photon purity and coherence are important properties of the light field but are often treated statically, even though in many systems they are dynamic. Using two-time second-order correlation measurements in conjunction with pulsed excitation, we measure the dynamics of the non-classical light produced from a single InAs quantum dot (QD) state. This reveals the temporal evolution of the photon field during the excitation-relaxation cycle of the QD. The technique allows for the measurement of multi-photon content and coherence. Depending on the pump condition, variations in the time-dependence of multi-photon emission and in the degree of photon coherence are observed, and are accurately modeled using rate equations describing the two-dimensional second-order correlation function.

Multi-photon Dynamics

Photon indistinguishability measured through the coalescence probability, $C(t_1, t_2)$. Pulsed excitation at 755 nm (above band) and 893 nm (wetting layer).

$$C(t_1, t_2) = 1 + g_1^{(2)}(t_1, t_2) - 2g_2^{(2)}(t_1, t_2)$$

The width of the ridge is proportional to the coherence time. With infinitely fast detectors, the value at the ridge peak would be 1. With real detectors, the value gets averaged over the response time and becomes proportional to the width of the ridge. Probabilistic excitation during the transient time after the pump pulse reduces indistinguishability at small times.

Exciton Capture Model
Multiple exciton capture processes can occur depending on the excitation wavelength.

Reservoir population can come from multiple reservoirs.