Sub-natural linewidth single photons from a quantum dot

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Quantum dot (QD) resonance fluorescence provides direct access to resonantly generated photons and has proven to be a useful technique in recent years for studying self-assembled QD spin dynamics\(^{[1-2]}\). Our approach to isolating QD fluorescence from the exciting laser scattering at the same frequency takes advantage of the optical selection rules of QD transitions and linear optical elements. Using cross-polarisation we achieve a signal to background ratio exceeding 1000 when driving a transition at saturation. We proceed to study the coherence of QD resonance fluorescence directly via first-order correlation measurements and via spectral measurements over six orders of magnitude in excitation power.

In the limit of strongly dressed states the first-order correlation measurements reveal a marked dephasing dependence on the excitation power. Yet, in the low power limit, the Heitler regime, we recover the properties of textbook atomic systems where emission is dominated by elastic scattering \(^{[3]}\). Here, the single QD are no longer restricted to obey the \(T_2 < 2T_1\) relationship and show coherence times dictated and limited by laser coherence.

The direct observation of elastic scattering from a QD transition offers a new path to generating single photons with tailored phase and spectral properties. This approach does not need to rely on interactions with a cavity, nor shaping of photons after they are emitted, but rather on appropriate shaping of the excitation. We demonstrate the ability to create such photons and provide measurements on their coherence and indistinguishability. Shaping the QD emission spectrum will allow us to generate phase-locked single photons from disparate QD transitions.

**Figure 1**: QD resonance fluorescence spectra at intermediate (top) and low (bottom) excitation powers recorded with a spectral resolution of 30 MHz. The insets show the raw second-order correlation measurements at corresponding Rabi frequencies.

References