Resonant Excitation of Nanowire Quantum Dots

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A single photon source is a key technology for realizing quantum information processing tasks such as quantum key distribution, linear optical quantum computing and measurement-based quantum computing (MBQC). Many of these tasks - including MBQC – require deterministic generation of identical single photons [1]. Quantum dots (QD) embedded within nanowires are promising candidates for the on-demand generation of indistinguishable single photons [2]. What sets them apart from other QD based emitters is their scalability and ease of on-chip integration. It is widely known that a strictly resonant excitation scheme is necessary for the generation of transform-limited single photons. However, two main indicators of single photon resonance fluorescence, i.e., sub-poissonian statistics and Rabi-oscillations have not been demonstrated in nanowire QDs yet.

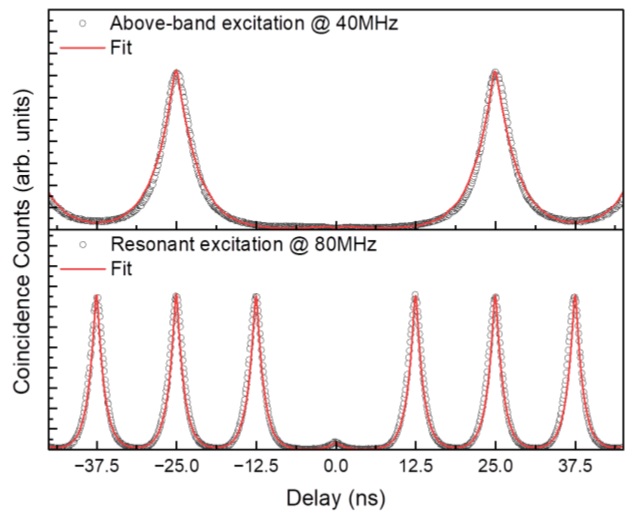

Fig.1. Second-order correlation functions, $g^{(2)}(\tau)$, of the fluorescence from pulsed above band (upper panel) and resonant (lower panel) excitation of the neutral exciton.

In this work, we implement a dark-field microscope setup [3] to demonstrate the resonant excitation of the neutral exciton (X) in an InAsP QD embedded within an InP nanowire at 4K. The QD is excited by 20 ps long laser pulses at a repetition rate of 80 MHz. To observe resonance fluorescence with a high signal to background ratio, the back-reflected laser must be suppressed in the detection path. We achieve this by using orthogonal excitation and detection polarization states. The confocal configuration of the microscope enhances the laser suppression by spatially rejecting the clover-leaf shaped profile of the reflected laser beam – resulting in laser suppression by a factor of 10^6. We record excitation laser power-dependent count rates on superconducting nanowire single-photon detectors to demonstrate Rabi oscillations—a clear signature of coherent driving. Our second-order correlation measurements on resonance fluorescence reveal a $g^{(2)}(0)\approx 0.06$ at an excitation power corresponding to a $\pi/2$ pulse (see Fig. 1). Ways of further reducing the non-zero coincidences at zero delay are discussed, as are the implications of resonance fluorescence on linewidths and two-photon interference visibilities. This important milestone will enable us to take another step towards transform-limited, indistinguishable single photon generation and coherent control of excitons in nanowire quantum dots.

References

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