Coherent Excitation of Nanowire Quantum Dots using Notched Adiabatic Rapid Passage (NARP)

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The quantum internet promises unprecedented encryption security, enhanced computation, and hypersensitive metrology. However, it is predicated on Bell State Measurements (BSMs). BSMs require network users to deterministically encode single photon qubits that are indistinguishable in spectrum, timing, spatial mode, and polarization. Quantum dots can theoretically generate the indistinguishable single photons needed. However, above-band and quasi-resonant excitation methods introduce excitation timing jitter and spectral wandering, which limit the qubit encoding fidelity and indistinguishability of subsequent emissions. Conversely, resonant excitation preserves emission quality; however, filtering the pump light by polarization rejection reduces collection efficiencies by 50%, and limited extinction ratios reduce the single photon purity. Generally, it is complicated to optimize output efficiency and emission quality simultaneously. However, a new excitation scheme "Notched Adiabatic Rapid Passage" (NARP), was proposed [1] in which a linearly-chirped pulse with a spectral filter drive a population inversion from ground to excited state. Unlike other excitation schemes [2], NARP is robust against variations in transition energy, pump pulse duration, and pump power, and excites a quantum dot while mitigating phonon coupling effects. In this way, NARP is a practical method to generate single photons without timing jitter, spectral wandering, or reduced collection efficiency. So far, NARP has only been demonstrated quasi-resonantly in a proof-of-principle experiment on randomly-assembled quantum dots with poor collection efficiencies. In this talk, we report successful excitation of a nanowire quantum dot [3] using NARP, demonstrating a collapse in excitation timing jitter and an order of magnitude improvement in the single photon purity to $g^{(2)}(0) = 0.003$.

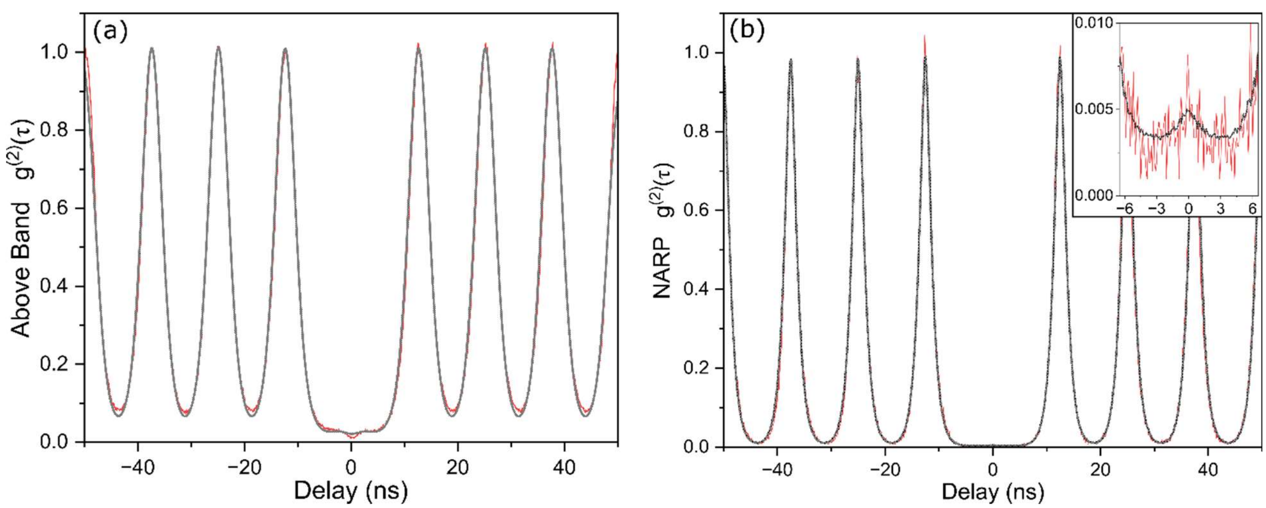

Fig. 1: Second-order auto-correlation $g^{(2)}(\tau)$ for (a) above-band and (b) NARP excitation, fitted using a stochastic model [4].

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[3] P Laferrière *et al*. Science Reports **12**, 6376 (2022).
[4] K. Mnaymneh *et al.* Adv. Quantum Technol. **3**, 1900021 (2020).