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(G*) Suppression of Phonon-Mediated Decoherence using Frequency-Swept Laser Pulses in Optically-Driven Semiconductor Quantum Emitters

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Among solid state quantum emitter systems, semiconductor quantum dots are particularly attractive due to their high radiative quantum efficiencies [1], their strong optical coupling enabling fast [2] and arbitrary [3] qubit rotations, and their tunable emission in the range of standard telecommunication wavelengths. For applications such as quantum light sources and quantum nodes, it is essential to maximize the fidelity of the optical control process governing quantum state initialization and control. While the dephasing time tied to radiative relaxation is many orders of magnitude longer than control times achievable with subpicosecond laser pulses, resonant coupling of the electron-hole pair to phonons in the solid-state environment can still contribute to decoherence during the optical control process [2]. This decoherence channel is often referred to as excitation-induced dephasing since the impact on fidelity is dictated in part by the characteristics of the driving laser field. Here we report the demonstration of suppression of phonon-mediated decoherence through the application of frequency-swept laser pulses via adiabatic rapid passage in the strong-driving regime [4]. We also investigate the dependence of the threshold for decoherence suppression on the size and shape of the quantum dot. Our findings indicate that the use of telecom-compatible quantum dots leads to decoherence suppression at pulse areas comparable to a single Rabi oscillation period.

[1] Atature et al. Nat. Rev. Mater. 3, 38 (2018).

[2] Mathew et al. Phys. Rev. B 90, 035316 (2014).

[3] Mathew et al. Phys. Rev. B 84, 205322 (2011); Gamouras et al. J. Appl. Phys. 112, 014313 (2012); Gamouras et al. Nano Letters 13, 4666 (2013); Mathew et al. Phys. Rev. B 92, 155306 (2015).

[4] Ramachandran et al. Opt. Lett. 45, 6498 (2020).

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