

Single Photons from Cavity-Enhanced Biexciton-to-Exciton Transition

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Abstract

High-quality photon emission from semiconductor quantum dots (QDs) necessitates effective excitation and photon extraction techniques [1, 2]. Optical resonators have been shown to significantly improve photon extraction [3]. One proven excitation method is two-photon excitation (TPE), which targets the biexciton state in uncharged QDs. However, the intrinsic lifetime ratio between biexciton and exciton states leads to a fundamental limit for the achievable indistinguishability of single photons emitted through the biexciton–exciton cascade [4, 5]. For single photons from the biexciton, this limitation originates from the presence of a metastable final state for the biexciton-to-exciton transition. Here, we demonstrate that selectively enhancing the biexciton–exciton transition using a resonant optical cavity can significantly improve the single-photon quality. We show that phonon-assisted cavity feeding can be sufficiently avoided even in high-quality cavity systems. Besides optimization of the cavity parameters, we demonstrate applicability of that scheme with TPE. Our theoretical insights are substantiated by corresponding experimental results, demonstrating a significant advancement towards the realization of practical quantum light sources. [1] N. Heinisch et al., PRR **6**, L012017 (2024). [2] D. Bauch et al., PRB **104**, 085308 (2021). [3] N. Tömm et al., Nature Nanotechnology **16**, 399 (2021). [4] E. Schöll et al., PRL **125**, 233605 (2020). [5] D. Bauch et al., Adv. Quantum Technol. **7**, 2300142 (2024).