Purcell-enhancement and resonance fluorescence from a low-noise emitter in diamond

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The nitrogen-vacancy center (NV) in diamond exhibits attractive spin properties but lacks the optical characteristics required for fast quantum communication. Only a marginal fraction (2.5-3%) of all the emitted photons are emitted into the zero-phonon-line (ZPL), the radiative lifetime is long, and extraction of photons out of diamond is inefficient [1]. We demonstrate efficient selective coupling of a coherent NV transition to the optical mode of a microcavity [2-4], mitigating these problems. We use a 1.6 µm thick diamond with NVs created via carbon implantation post-fabrication [5]. The ZPL count rates are as high as 140 kcts/s under off-resonant excitation, exceeding the state-of-the-art achieved for photonic interfaces based on solid-immersion lenses (SILs) [6] (Fig. 1). The high photonic flux is achieved through a net Purcell enhancement of 1.9, increasing the fraction of ZPL photons from 3% to 47%. By efficient suppression of the resonant excitation, we measure resonance fluorescence from an NV for the first time without relying on time-bin filtering and extract an NV linewidth of 170 MHz (Fig. 2). In two-photon protocols for spin-spin entanglement, our platform would increase the entanglement success probability by more than an order of magnitude, and by more than two orders of magnitude with feasible system improvements. The ability to generate coherent single photons resonantly and with high probability establish our system as an attractive spin-photon interface and is an important step towards quantum networks based on defects in diamond.

References

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Figures

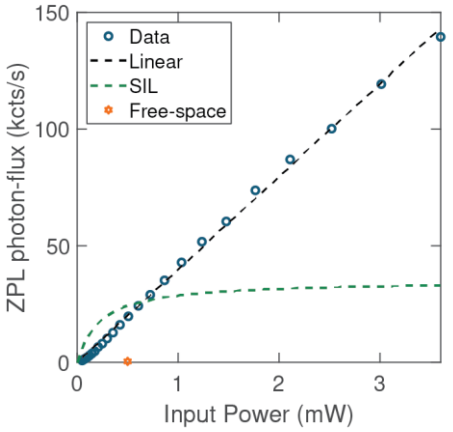

Figure 1: ZPL counts under off-resonant excitation as a function of power, compared to the state-of-the-art count rates with a SIL [6] and typical count rates in free-space.

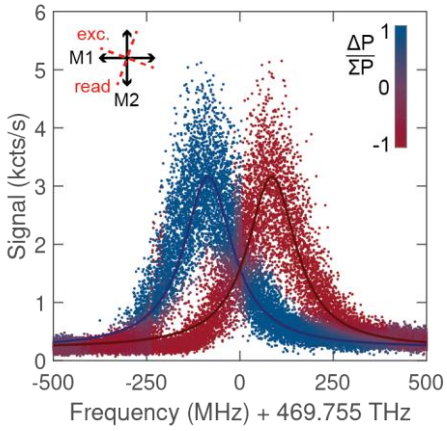

Figure 2: NV resonance fluorescence. The center emission frequency depends on the occupation of a nearby charge trap.