Deterministic enhancement of coherent photon generation from a nitrogen-vacancy centre in ultrapure diamond

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The nitrogen-vacancy (NV) centre in diamond is a workhorse for quantum science, due to its highly coherent electron spin and the associated spin-flip and spin-conserving optical transitions. Quantum networks relying on NV centres hinge on coherent photon emission, which, however, is typically inefficient (~3% of the emission).

In our experiments, we enhance this coherent photon emission by coupling NV centres to a tunable Fabry-Pérot microcavity [1]. Our device consists of a high-quality, nano-fabricated, single-crystalline diamond membrane [2] bonded to a planar mirror; the cavity is completed by a concave mirror. Using piezo positioners, we achieve full spectral and spatial tunability and freedom in selecting NVs with favourable emission properties. The compact design of our microcavity facilitates performing cryogenic experiments.

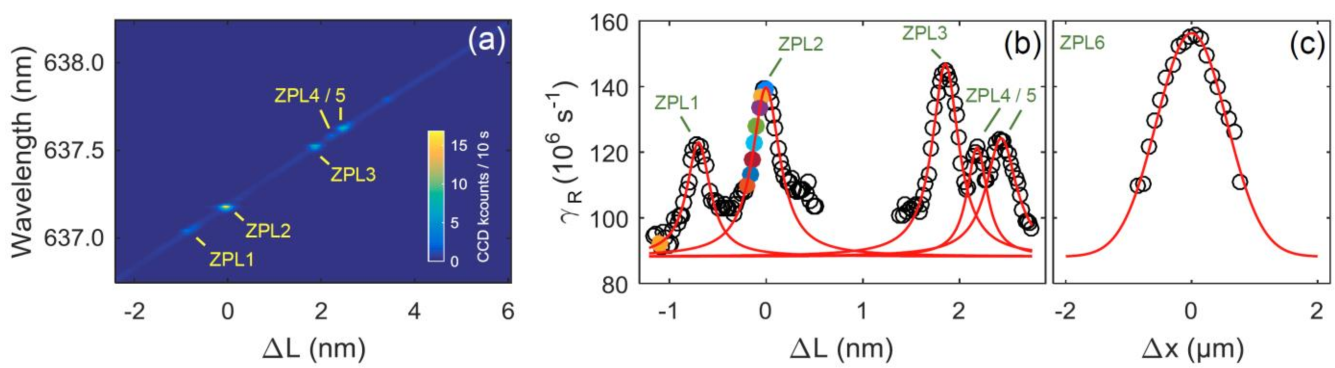

Figure 1: (a) PL spectra for different relative cavity lengths ΔL. (b) Enhancement of the emission rate for several NV ZPL transitions for different spectral and (c) spatial detunings.

We perform photoluminescence (PL) spectroscopy as a function of cavity length L (Fig.1(a)). On resonance we find a significant enhancement of the 637nm zero-phonon line (ZPL) for several NVs which is accompanied by a strong reduction of the overall PL lifetime (Fig.1(b,c)). Upon maximizing the spatial overlap of NV and cavity mode we find a 30-fold enhancement of the ZPL transition rate at best. The fraction of the coherent photon emission is thereby increased from 3% to 46% [1].

Our results constitute a significant leap on the route towards the implementation of fast long-distance quantum networks, which are currently limited by the photon emission rate in their nodes [3]. Furthermore, our versatile design is readily applicable to other solid-state quantum emitters like colour centres in silicon carbide [4].

References

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