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Quantum- and Nano-optics with Optical Microcavities

Spatio-temporal confinement of light can dramatically enhance light-matter interactions. To achieve this capability on an accessible platform, we have developed microscopic Fabry-Perot cavities based on laser-machined optical fibers [1].
We employ such cavities to realize efficient and narrow-band single-photon sources by means of Purcell enhancement of fluorescence emission. We study color centers in diamond such as the Nitrogen-Vacancy center [2] and explore different regimes of the cavity enhancement, aiming at applications in quantum cryptography, all-optical quantum computation, and efficient spin-state readout.
In the context of sensitive microscopy, we use microcavities for imaging and spectroscopy applications. We have developed scanning cavity microscopy as a versatile method for spatially and spectrally resolved maps of various optical properties of a sample with ultra-high sensitivity. We demonstrate the technique by quantitative imaging of the extinction cross-section of gold nanoparticles and measurements of the birefringence and extinction contrast of gold nanorods [3]. Finally, we show that the Purcell effect can be used for cavity-enhanced Raman spectroscopy and hyperspectral imaging [4]. Simultaneous enhancement of absorptive, dispersive, and scattering signals promises intriguing potential for optical studies of nanomaterials, molecules and biological nanosystems.

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[2] H. Kaupp et al., Phys Rev Applied 6, 054010 (2016)
[3] M. Mader et al., Nature Commun. 6, 7249 (2015)
[4] T. Hümmer et al., Nature Commun. 7, 12155 (2016)