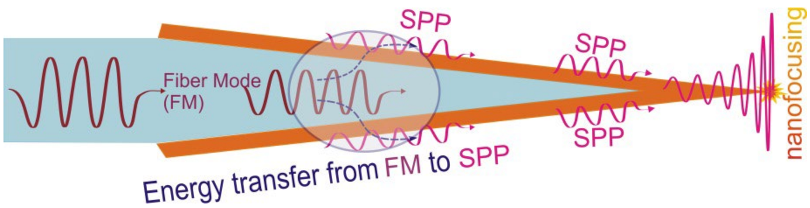
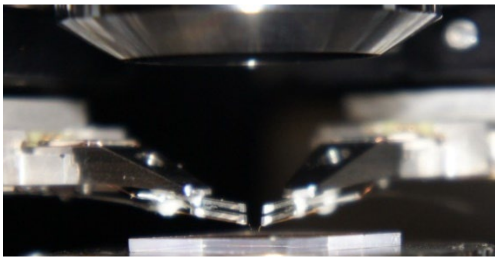
Strong coupling to quantum emitters by plasmonic superfocusing

Nanosized quantum emitters are the basis of many quantum photonic circuits. However due to the size mismatch between the nanosized emitters and the micron scale radiation fields, their coupling to propagating electro-magnetic waves is weak and difficult to control. Therefore, exploiting strongly localized nearfields of nano-resonators or plasmonic elements is considered to be a key element for the realization of strong coupling.

Scanning near-field optical microscopy (SNOM) is a powerful technique to measure and study simultaneously the architecture of nanostructures and their electromagnetic near fields. Among the different types of SNOMs, the scattering pseudo-heterodyne SNOM (ps-het SNOM) offers two main advantages: high resolution in topographical and optical images by employing sharp cantilever tips and simultaneous detection of field intensity and phase by exploiting lock-in detection methods and interferometry.

In this project, we aim to take the performance of ps-het SNOM-based near-field detection and control to the next level with the vision to realize strong coupling to quantum emitters, as e.g. vacancy centers, quantum dots, quantum dots, lanthanide nanoparticles, and emission centers in atomically thin membranes of MoS_2. To achieve this goal we study a new generation of high-performance plasmonic tips, which promise to provide unprecedented performance parameters. As a first step, the SNOM tips' performance parameters are to be evaluated by exploring the tip's interaction with different quantum systems. To explore the spectral and temporal characteristics of the quantum systems, a superfocusing SNOM setup will be combined with a time correlated single photon counting system and a single photon sensitive optical spectrometer. After establishing stable measurement methods and skills, we want to apply this tool to the in depths investigation of the interaction of the nano-sized quantum systems with plasmonic and dielectric nano-antennas. Besides experimental characterization, analytical and computational modeling shall be carried out to understand the complex behavior of the quantum emitters and their interaction with the tips.





Left: Schematic for the excitation of a superfocusing surface plasmon-polariton at a metalized fiber tip by resonant coupling to a propagating fiber mode. Right: Two-tip nearfield scanning optical microscope for direct measurement of the optical near-field Green's function of photonic nanostructures.

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