Towards single spin control with an optically manipulated Abrikosov vortex

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Abrikosov vortices are the most compact magnetic objects, with a characteristic size of a few tens to hundreds of nanometers. They are flux tubes penetrating type II superconductors (such as niobium) and carrying a magnetic flux quantum h/2e, around which supercurrents flow. Recently, our group has demonstrated the possibility of manipulating individual flux quanta with a laser beam, as simply as with optical tweezers (Fig 1a, d, e). The main goal of the thesis project is to explore the magnetic interaction between an optically manipulated Abrikosov vortex and a single spin present in a quantum nano-emitter such as the colored centers of diamond.

Prior to the characterization of this interaction, the choice of the nano-emitter, and thus of its optical and magnetic properties, is crucial. The colored centers of diamond have almost ideal characteristics to answer our problem, they endorse here the role of nano-emitter. They are localized defects, present in the crystalline matrix such as the negatively charged Nitrogen-Vacancy (NV) center or Silicon-Vacancy (SiV). Both of them are studied in the framework of this PhD thesis.

So far, we have demonstrated a substantial improvement of SiV coherence properties when fabricated in nanometric-sized diamond particles (nanodiamonds). Their spectral and decay properties were extensively studied at room-temperature in small nanodiamonds. Linking their photonic properties to the size of the host employing single-defect correlative light-electron microscopy (CLEM), we unveiled for the first time strong blue photonic Lamb shifts and hint at phonon bottleneck effects arising from particle size confinement. Indeed, size constriction induces both electromagnetic modes confinement, and suppresses the population of phonon modes at desired frequencies diminishing the electron-phonon collision probability, respectively responsible for the above-mentioned physical observations.

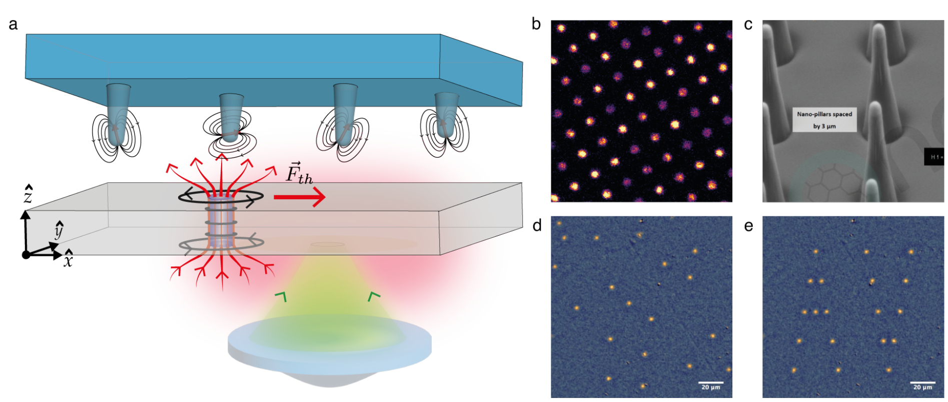

Figure 1: **a)** Schematic representation of the experimental layout for the vortex-spin interaction. The top material is diamond and the bottom one is Niobium. **b)** Confocal fluorescence microscopy image of NV centers in nanopillars like displayed in **c)**. **d)** Image of vortices randomly distributed in a Niobium film. **e)** Patterned organization of vortices created using optical manipulation.