

SPIN-OPTOMECHANICS USING DIAMOND NANOMECHANICAL OSCILLATORS

Nanoscale mechanical resonators have been explored in recent years for applications as diverse as ultra-sensitive nanoscale force-detection [1], highly efficient charge-sensing [2] or coherent shuttling of quantum-information [3]. Experiments on nanomechanical systems raise fundamental questions related to the cross-over between quantum-mechanics and the classical world [4] and have recently culminated in the demonstration of ground-state cooling of mechanical systems [5, 6]. Our research is focussed towards the next generation of such experiments and aims at the preparation and study of non-classical states of nanomechanical oscillators. This can most efficiently be achieved by coupling a nanomechanical resonator to a well-controlled, isolated quantum system, such as single electronic spin [7].

To that end, we will explore diamond nanomechanical resonators (Fig. 1a) and their coupling to the individual electronic spins in "Nitrogen-vacancy" (NV) centres embedded in the diamond host matrix (Fig. 1b); a material-system particularly well-suited for our goals. In particular, in the proposed project we will explore the strain-induced coupling of a single NV spin to vibrations of a diamond nanomechanical oscillator [7]. Our work will focus on the room temperature, coherent dynamics of a single NV spin in the presence of a time-varying strain field – a physically rich situation which will lay the groundwork for our studies in spin-optomechanics. On the long run, our work will provide key steps in the field of hybrid quantum systems and nanomechanical oscillators. Potential extensions with far-reaching consequences include "sideband-cooling" of an oscillator using a single spin, quantum state transfer between the spin and the mechanical oscillator or the generation of squeezed spin-ensembles using resonator-induced interactions [8].

We are looking for candidates with strong interests in quantum physics, coherent single spin manipulation and quantum optics and with high motivation to work on an experimentally challenging project. This work will involve diamond-nanofabrication, confocal microscopy and coherent single spin manipulation. Our group is highly connected on all levels and provides an excellent international network.

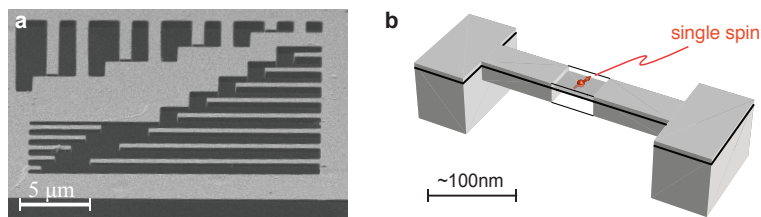


FIG. 1: a.) Prototype single crystal diamond cantilevers. Similar devices will be employed in the proposed project. b.) Illustration of device configuration: A single, well-controlled NV spin embedded in a diamond nanomechanical oscillator (here a suspended "bridge") forms a hybrid system with a nanomechanical oscillator. Typical device dimensions are indicated and will lead to mechanical resonances of ~ 1 GHz.

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