Strong Mechanical Driving of a Single Spin

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The coupling of an intrinsic quantum system to mechanical oscillators, known as hybrid-optomechanics, offers rich perspectives in both fundamental and applied research. These systems can be used to perform mechanical cooling [1], generate squeezing [2], or shuttle information between distant quantum systems [3]. A main achievement towards these applications is the mechanical driving of the quantum system faster than decoherence. Our system consists of a single electronic spin (NV center), embedded inside a single-crystal-diamond mechanical resonator [4]. The coupling is obtained through strain, allowing the coherent driving of a single spin through mechanical motion, as represented figure 1.

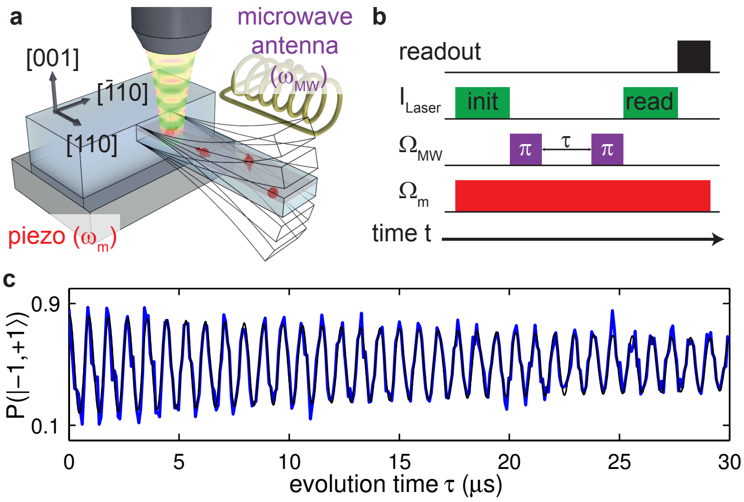

Figure 1: a) Schematic of the system: A Nitrogen-Vacancy defect is embedded inside a single-crystal-diamond mechanical resonator. The microwave antenna and the confocal microscope are used to initialize and readout the spin states. Piezoelectric actuation generates the phononic field. b) Sequence used to generate the strain-driven Rabi oscillations. c). Coherent strain driving of a dipole forbidden transition. Decay time of the Rabi oscillation is around 40 µs at room temperature.

The strength and robustness of strain driving allows us to demonstrate two major applications of our hybrid spin-oscillator device. First, we show that strain driving enables us to reach the strong driving regime, where the spin manipulation frequency significantly exceeds the energy splitting between the two involved spin states. So far this regime has only been accessible to superconducting qubits at cryogenic temperatures [5]. We make use of the strong driving regime to perform for the first time direct spectroscopy of the dressed spin states on a single electronic spin [6]. These experiments will pave the path for future experiments on the physics of strongly driven two-level quantum systems. Second, we employ strain driving to effectively decouple the NV center's spin from environmental noise, leading to significantly increased coherence times. Such coherence protection is of great importance for emerging quantum technologies and again emphasizes our system's suitability for future applications in the quantum regime.

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