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**Strong coupling between an electronic spin qubit and a nano-mechanical resonator** PETER RABL, PAULA CAPPELLARO, Harvard-Smithsonian CFA, GURUDEV DUTT, University of Pittsburgh, LIANG JIANG, JERONIMO MAZE, MIKHAIL LUKIN, Harvard University — We discuss the coupling between a nano-mechanical resonator and a spin qubit associated with a nitrogen-vacancy center. The coupling is achieved via a magnetic tip on the resonator which leads to an oscillating Zeeman shifts of the spin states. Under realistic conditions the shift per quantum of motion can approach 100 kHz and exceed both the spin coherence time ($T_2 \sim 1$ ms) and the motional heating rate of high-$Q$ mechanical resonators. The spin then becomes strongly coupled to mechanical motion in analogy to strong coupling of cavity QED. We first show how this regime can be accessed in a practical setting by a preparation of dressed spin states which eliminate fast dephasing ($T_2^* \sim 1\,\mu$s) of the spin due to interactions with the nuclear spin bath. Optical spin preparation and readout techniques then allow quantum ground state cooling and the generation and detection of arbitrary superpositions of motional states. We extend this scheme to a whole resonator array where charged resonators interact with each other capacitively and thereby mediate spin-spin interactions over distances up to a few 100 $\mu$m. We discuss the implementation of basics gate operations in this setup and propose a scalable quantum computing architecture for a general class of isolated spin qubits.

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