ABSTRACT

QUANTUM REGISTER BASED ON INDIVIDUAL ELECTRONIC AND NUCLEAR SPIN QUBITS IN DIAMOND

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The key challenge in experimental quantum information science is to identify isolated quantum mechanical systems with long coherence times that can be manipulated and coupled together in a scalable fashion. We describe the coherent manipulation of an individual electron spin and nearby individual nuclear spins to create a controllable quantum register. Using optical and microwave radiation to control an electron spin associated with the NitrogenVacancy (NV) color center in diamond, robust initialization of electron and nuclear spin qubits and transfer of arbitrary quantum states between them at room temperature was demonstrated. We further show that nuclear spin qubits can be well isolated from the electron spin, even during optical polarization and measurement of the electronic state. Finally, coherent interactions between individual nuclear spin qubits were observed, and their excellent coherence properties were demonstrated. These registers can be used as a basis for scalable, optically coupled quantum information systems. Quantum registers are controllable quantum systems composed of several qubits. They form fundamental building blocks for quantum information science, and can be connected into useful communication and computation systems, for example via quantum optical channels [1, 2]. A useful register must support both high fidelity local operations between its qubits, and allow for excellent isolation of the qubits from each other and the external environment. Over the last few years, quantum registers consisting of a few interacting trapped ions with exceptional coherence properties have been implemented experimentally [3], and the first steps towards optical inter-connections have been taken [4]. We report on the realization of a quantum register in a room temperature solid using controlled manipulation of individual electron and nuclear spins.

ABSTRACT

CHARGED MECHANICAL OSCILLATORS COUPLED TO VARIOUS QUANTUM SYSTEMS

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At NIST, we're investigating the coupling of charged mechanical oscillators to various systems, with the goal of exploring the quantum regime. A precursor to recent work is provided by the coupling of the internal states of an atomic ion to its quantized mechanical motion [1]. In a practical extension of this work, we couple one atomic ion qubit species to another through their (shared) mechanical motion, and realize efficient detection [2]. We have also recently observed passive cooling of a (charged) micro-cantilever by coupling it to a driven RF resonant circuit [3], similar to the cooling of cantilevers coupled to driven optical resonators. In the quantum regime, this cooling would be analogous to resolved sideband laser cooling of an atom. Other candidates being investigated include coupling a laser-cooled ion's motion or that of a group of ions to a mesoscopic harmonic oscillator, either mechanical or electromagnetic.

* In collaboration with the other members of the NIST Ion Storage Group (http://tf.nist.gov/ion/index.htm)

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