Individual solid-state nuclear spin qubits with coherence exceeding seconds

James O'sullivan*[1], Jaime Travesedo , Pallegoix Louis , Zhiyuan Huang , Alexandre May , Boris Yavkin , Patrick Hogan , Sen Lin , Renbao Liu , Thierry Chanelière , Sylvain Bertaina , Philippe Goldner , Daniel Esteve , Denis Vion , Patrick Abgrall , Patrice Bertet , and Emmanuel Flurin

[1]CEA Saclay – CEA/ DRT/LIST – France

Résumé

The ability to coherently control and read out qubits with long coherence times in a scalable system is a crucial requirement for any quantum processor. Spins in the solid state have shown great promise as long-lived qubits, however, control and readout of individual spins has proved extremely challenging. Existing spin-based platforms with this capability typically utilise specific systems with optical transitions suitable for optically detected magnetic resonance. We present a new platform for quantum information processing, consisting of 183W nuclear spin qubits adjacent to an Er3+ impurity in a CaWO4 crystal, interfaced via a superconducting resonator and detected using a superconducting single microwave photon detector. We study two nuclear spin qubits using stimulated Raman driving of nuclear spin transitions via the Er3+ spin excited state to perform coherent nuclear spin control. We measure T2* of 0.8(2) s and 1.2(3) s, T2 of 3.4(4) s and 4.4(6) s, for the two qubits, respectively. We demonstrate single-shot quantum non-demolition readout of each nuclear spin qubit using the Er3+ spin as an ancilla. Utilising AC Zeeman shifts due to the strong off-resonant Raman driving pulses, we realize single- and two-qubit gates on a timescale of a few milliseconds. We prepare a decoherence-protected Bell state with 77% fidelity and T2* of 1.7(2) s. These results are a proof-of-principle demonstrating an all-microwave toolkit for controlling solid state nuclear spin qubits in a novel platform, with potential applications in quantum computing, quantum sensing and electron paramagnetic resonance. This architecture has the potential to scale to tens or hundreds of qubits via the superconducting resonator and the techniques developed are applicable to a wide range of alternative solid-state spin systems

*Intervenant

sciencesconf.org:gdr-meso-ple-24:586231