A single-atom electron spin qubit in silicon

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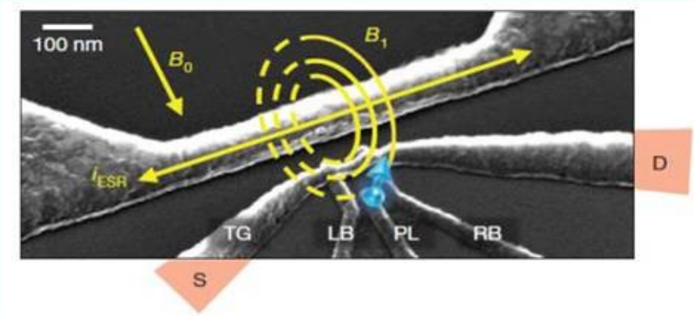

Scanning electron micrograph of a qubit device (the donor [blue] is subject to an oscillating magnetic field B_1 from the transmission line).

A single atom is the prototypical quantum system, and a natural candidate for a quantum bit, or qubit—the elementary unit of a quantum computer. Atoms have been successfully used to store and process quantum information in electromagnetic traps, as well as in diamond through the use of the nitrogen–vacancy-centre point defect. Solid-state electrical devices possess great potential to scale up such demonstrations from few-qubit control to larger scale quantum processors. Coherent control of spin qubits has been achieved in lithographically defined double quantum dots in both GaAs and Si. However, it is a formidable challenge to combine the electrical measurement capabilities of engineered nanostructures with the benefits inherent in atomic spin qubits. Here we demonstrate the coherent manipulation of an individual electron spin qubit bound to a phosphorus donor atom in natural silicon, measured electrically via single-shot readout. We use electron spin resonance to drive Rabi oscillations, and a Hahn echo pulse sequence reveals a spin coherence time exceeding 200 ms. This time should be even longer in isotopically enriched 28Si samples. Combined with a device architecture that is compatible with modern integrated circuit technology, the electron spin of a single phosphorus atom in silicon should be an excellent platform on which to build a scalable quantum computer.

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PUBLICATION ABSTRACT