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A high-temperature silicon qubit and its quantum interference

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Spin qubits are attractive building blocks for quantum computers. Si is a promising host material for spin qubits since it could enable long coherence, high-density integration, and high compatibility with classical computers. Spin qubits have been implemented in Si using gate-defined quantum dots or shallow impurities. However, these qubits must be operated at temperatures <0.1 K, limiting the expansion of qubit technology. We used deep impurities in Si to achieve room-temperature single-electron tunnelling and spin qubit operation at 5–10 K [1]. We employed tunnel field-effect transistors (TFETs) instead of conventional metal–oxide–semiconductor field-effect transistors and achieved strong confinement of the single quantum dots embraced in TFETs up to 0.3 eV. Furthermore, double-quantum-dot devices were operated as spin qubits, and read-out was realized using a spin blockade. These results will enable broadening of the range of spin qubit applications such as sensing, security, and quantum computing.

We also study quantum interference effects of a qubit whose energy levels are continuously modulated [2]. The qubit energy levels are modulated via its gate-voltage-dependent g-factors, with either rectangular, sinusoidal, or ramp radio-frequency waves. The energy-modulated qubit is probed by the electron spin resonance. Our results demonstrate the potential of spin qubit interferometry that is implemented in a Si device and is operated at a relatively high temperature

[1] K. Ono, T. Mori, S. Moriyama, High-Temperature Operation of Spin Qubits based on Silicon Tunnel Field-Effect Transistors, arXiv:1804.03364, Scientific reports, in print.
[2] K. Ono, S. N. Shevchenko, T. Mori, S. Moriyama, Franco Nori, Quantum interferometry with a high-temperature single-spin qubit, arXiv:1809.02326.

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