Silicon quantum processor unit cell operation above one Kelvin

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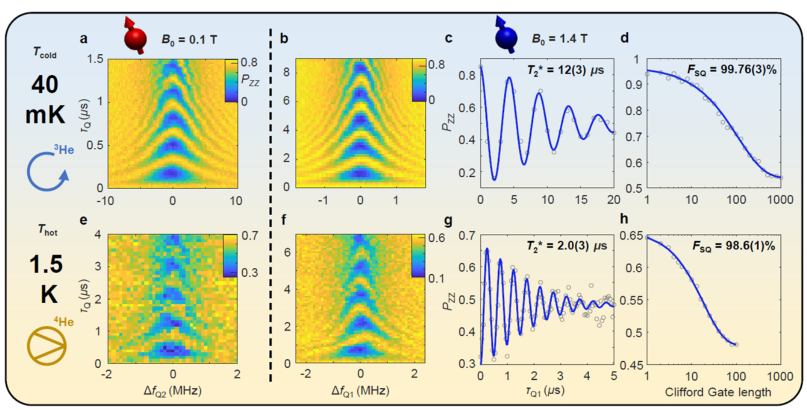
Quantum computers are expected to outperform conventional computers for a range of important problems, once they can be scaled up to large numbers of quantum bits (qubits), typically millions [1]. For semiconductor qubit technologies, scaling poses a significant challenge as every additional qubit increases the heat generated, while the cooling power of dilution refrigerators is severely limited at their operating temperature below 100 mK. Furthermore, imperfections in the material disrupt the performance of each qubit. Here we demonstrate operation of a scalable silicon quantum processor unit cell, comprising two qubits confined to quantum dots (QDs) at ~1.5 Kelvin. We achieve this by isolating the QDs from the electron reservoir, initialising and reading the qubits solely via tunnelling of electrons between the two QDs [2]. We coherently control the qubits using electrically-driven spin resonance (EDSR) in isotopically enriched silicon ^{28}Si, attaining single-qubit gate fidelities of 98.6% and coherence time T_2^* = 2 μs during 'hot' operation. We also present an electrostatically defined quantum dot that is robust to disorder, revealing a well defined shell structure [3]. We explore various fillings consisting of a single valence electron – namely 1, 5, 13 and 25 electrons – as potential qubits [4], and we identify fillings that yield a total spin-1 on the dot. Higher shell states are shown to be more susceptible to the driving field, leading to faster Rabi rotations of the qubit. Our work indicates that coherent control of electron quantum dot at higher shell states opens the possibility of an array of high fidelity qubits, while the fact that a spin-based quantum computer could be operated at elevated temperatures offers orders of magnitude higher cooling power than dilution refrigerators, potentially enabling classical control electronics to be integrated with the qubit array. [5]



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