Spin Qubits and Qubit Gates with Quantum Dots

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To date electron spin qubits have been demonstrated using various techniques with quantum dots (QDs), and it is now getting crucial to prepare multiple qubit systems and perform gate operation as the next step. We have recently developed a micro-magnet technique for making spin qubits with double QDs, which might suit the qubit multiplication and logical gate operations. I will show this technique is useful to realize multiple qubits, entanglement modulation, and non-destructive readout.
Electron spin resonance (ESR) is the fundamental concept of spin qubits, in which two Zeeman states are superposed by an ac magnetic field normal to the Zeeman field. A micro-magnet placed on top of a double QD imposes an out-of plane field gradient local to each QD under an in-pane external field. By laterally oscillating an electron in each QD with a microwave field, ESR local to each QD can be established. We first demonstrate two individual spin rotations using this technique, and then combine it with a pulsed operation of spin exchange coupling to modulate the spin singlet-state as a partial entangled state. We propose that the inhomogeneous magnetic field across the double QD can provide novel concepts of z-rotation gates and fidelity control of SWAP and sqrt(SWAP). We also show that the micro-magnet technique is useful for spin readout in a nondestructive manner.

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