Performing Joint Measurements on Electron Spin Qubits by Measuring Current through a Nearby Conductance Channel

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Advances in the manufacturing of semiconductor structures have allowed the observation of electron spins which are potentially useful for the construction of quantum computers. This project opens a new direction by theoretically exploring the procedure to perform joint measurements on spatially separated spin qubits through measuring the current in a nearby conductance channel. A joint measurement on multiple qubits gives information on the state of the system without revealing the individual state of each qubit. These joint measurements can be used to facilitate entanglement and form the basis of fault-tolerant error correction procedures. The main concept is to use a singlet-triplet qubit formed by a double quantum dot with tunable bias such that the charge density shifts in a spin-dependent way. As a result, electrostatic coupling between the qubits and conductance channel creates a scattering potential that depends on the spin states of the trapped electrons. Theoretical conditions must be taken into account before this can actually be implemented in experiment. In modelling this procedure through a transfer matrix approach, it is demonstrated that such joint measurements can be performed in principle although there are experimental limitations due to increasing sensitivity in barrier parameters and noise.