MAR07-2006-003358

Abstract for an Invited Paper
for the MAR07 Meeting of
the American Physical Society

Coherent electron spin transport and fault-tolerant semiconductor-based quantum computer architectures.[1]

LLOYD HOLLENBERG, Centre for Quantum Computer Technology, School of Physics, University of Melbourne

The recent progress in single atom fabrication techniques for discrete gated donor systems in semiconductors offer new opportunities for coherent quantum technology applications. We review a new scheme for coherent electron spin transport by adiabatic passage (CTAP) particularly suited to atomic and solid-state systems. In a semiconductor implementation, CTAP based transport is a highly robust mechanism for shuttling electron spin states coherently along pathways defined by ionised donors spaced 20-30 nm apart. Such novel discrete transport of electrons may lead to new applications in semiconductor technology, however, as a transport mechanism for spin-encoded quantum information it is an essential development for the successful design of a strongly scalable quantum computer architecture. Using phosphorous donor electron spins in silicon as a model system, the tunnelling rates, transfer times, and effects of decoherence are calculated. The introduction of electron spin transport leads to a scalable 2D quantum computer architecture for Si:P with spatially separated interaction, storage and readout regions and incorporates non-nearest-neighbour interactions between qubits. The transport rails which provide these non-local interactions, also provide alternative pathways to avoid non-functioning regions. The fault-tolerant operation of such an architecture using CTAP for qubit transport is considered in detail.

[1]This work was supported by the Australian Research Council, the Australian Government, the US National Security Agency (NSA), Advanced Research and Development Activity (ARDA), and the Army Research Office (ARO) under contract number W911NF-04-1- 0290.