Physics Department Colloquium

"Silicon-based Quantum Computation"

by

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Silicon - the semiconductor that is the mainstay of the contemporary computer industry - also has many attractive properties for future quantum logical devices. Specifically, both electron and nuclear spins situated in Si can have extremely long lifetimes ($t_1 \cong 1$ hour), and are consequently highly immune from decoherence induced by environmental noise.

A Si-based quantum computer will require the development of devices capable of performing one and two qubit logical operations, as well as the initialization and measurement of single spin qubits. I will describe a quantum computer architecture in which the nuclear spin qubits are situated on ^{31}P donors in a Si host, located beneath metal gates capable of performing the required quantum logical operations. Qubit measurement is performed by first transferring the nuclear spin to an electron and then measuring the electron spin. The Pauli Principle requires that the charge configuration of a two-electron system must depend on whether the electrons are in a mutual singlet or triplet spin state. Thus, sensitive electronic probes of a two-electron system (single electron transistors for example) can be used to infer the spin state of the electrons under appropriate circumstances.

I will describe the experimental program currently underway in my laboratory to develop devices to demonstrate the ideas presented above, particularly devices for measuring single electron spins. Finally, I will discuss what I consider to be the most promising approaches to the eventual development of a large-scale quantum computer in Si.

Thursday, January 9, 2003
4:00 PM in 102 JFB
Refreshments at 3:30 PM in 219 JFB