Inside Science Research — Physics News Update

Number 662 #2, November 18, 2003 by Phil Schewe, James Riordon, and Ben Stein

Electron Spins Can Control Nuclear Spins

Electron spins can control nuclear spins in a semiconductor when trapped in a very confined space, a recent experimental development which calls upon laser science, solid-state physics, and nuclear magnetic resonance. David Awschalom and his colleagues at the Center for Spintronics and Quantum Computation at UC Santa Barbara begin by lithographically creating a quantum well, an extremely thin, practically two-dimensional region inside a semiconductor capable of trapping electrons. First, a laser pulse injects polarized electrons (their spins have a definite orientation determined by the laser's polarization) into the well. Once in the well, the tiny disk of electrons (with a radius of about 20 microns but a thickness of only 20 nm) can be controllably moved along one axis, much as an abacus bead can be slid along a wire, by simply changing a voltage. In this case, the disk can be positioned with nm-accuracy. The nuclei of atoms residing within the thin volume occupied by the spin-polarized electrons will in turn be polarized; that is, the spin of these nuclei will tend to align themselves with the spin of the electrons. The result is an extremely thin---equivalent to the thickness of several tens of atoms--- region of polarized nuclei which can be precisely positioned by changing a single voltage. These thin sheets of nuclear polarization could constitute the basic elements of an information storage device in which nuclear spin determines the logical state of the system. One may ask, why not take out the "middle man" and just use the electron spin to encode information? The answer: nuclear spins have a weaker interaction with the surrounding environment than electron spins. While harder to flip, once oriented, nuclear spins preserve their state longer than do electrons. One may also wonder, why not just use some large magnet to orient the nuclear spins? Why use electrons as intermediaries? The answer: all-electronic control of spin is desirable because electric fields are so much easier to control and create on a small scale than magnetic fields. They are scalable and easy to implement, while it is notoriously hard to produce large and localized magnetic fields. In addition, all of our current integrated circuit technology is based on charge and electric field; it would certainly be helpful to manipulate spin using "knobs" which are well developed and familiar to engineers. **Awschalom (mailto:awsch@physics.ucsb.edu)** (805-893-2121) believes this current result is the first step toward the establishment of an all-electrical manipulation of countable numbers of nuclear spins.(**Poggio *et al.* (http://link.aps.org/abstract/PRL/v91/e207602)**, *Physical Review Letters*, 14 November 2003)