MAR09-2008-000753

Abstract for an Invited Paper
for the MAR09 Meeting of
the American Physical Society

Optical Spin Initialization and Non-Destructive Measurement in a Quantum Dot Molecule

DANNY KIM, Naval Research Laboratory

The spin of an electron is an ideal two level system for realizing a quantum bit. Spatial confinement in a self-assembled InAs quantum dot greatly extends its spin coherence times as well as making them optically addressable. Through the excited trion state the electron can be initialized, coherently manipulated, and read out: the essential operations for quantum information processing. For single quantum dots, initialization of the spin requires a transverse magnetic field in order to turn on the normally forbidden transitions, which breaks the symmetry of the system. A major drawback is that this precludes the use of sensitive 2-level cycling transitions. In a cycling transition measurement the system repeatedly returns to the same spin eigenstate because of selection rules, and in this sense is non-destructive. Cycling transition measurements are the established method of eigenstate readout as in the case of ion qubits. Spin initialization and non-destructive cycling transition read out are incompatible in single quantum dots. In this talk I show how we overcome this fundamental limitation by using a pair of quantum dots that are coupled through coherent tunneling. The electron is isolated in one quantum dot whose spin is initialized or read out by the optical creation of an electron-hole pair in the other quantum dot, forming a molecular trion. The unique energy level structure of a molecular trion eliminates the need for a transverse magnetic field. Instead a longitudinal magnetic field is used to tune two of the trion states into resonance such that an exchange interaction permits a spin-flip Raman process. At the same time other trion states maintain strict selection rules and are used for cycling transition measurements. Overall the singly charged quantum dot molecule forms a "W" energy level system which is comprised of a Lambda system and two two-level cycling transitions. Two-laser transmission spectroscopy is used demonstrate initialization and non-destructive measurement, simultaneously.

[1] D. Kim et al. Phys. Rev. Lett, **101** (2008)