Condensed Matter Theory Center Seminar

Thursday, February 10
11am-12pm
2205 Physics Building

All are welcome to attend.

Luke Cywinski, Institute of Physics, Poland

"Decoherence of an electron spin coupled to a nuclear spin bath: dipolar and hyperfine dynamics"

Coherently controlled electron spins embedded in a semiconductor environment could be used as qubits or as very sensitive magnetometers. In recent years a large progress has been made in coherent control of spins in III-V materials such as GaAs and InGaAs. In these semiconductors all the nuclei are spinful, and the hyperfine interaction of the electron spin with the nuclear spins is the main factor affecting the qubit coherence time.

I will outline the well-established solution to the problem of electron spin decoherence caused by the dipolarly-driven nuclear dynamics (the so-called spectral diffusion problem). This theory successfully explains decoherence in Si:P and in GaAs at high magnetic fields. In the case of lower magnetic fields (smaller than a Tesla in GaAs), decoherence can be described with a theory based on an effective Hamiltonian approach (containing so-called hyperfine-mediated interactions). This method, while being approximate, offers an appealing physical picture of the decoherence process, and allows one to do calculations which had given predictions (recently experimentally confirmed) for spin echo experiments in GaAs at low B fields. I will discuss the analytical solutions for spin dephasing obtained with this approach, compare them with exact numerical results obtained for small baths, and explain the details of the application of this theory to the singlet-triplet qubit in a double quantum dot. Finally, I will discuss some open theoretical problems related to the long-time asymptotics of the spin coherence decay and the physics of sparse nuclear baths.

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