Name	**Dieter Suter (Dr.Jeong Hyun Shim)**
Organization	**Technical University of Dortmund**
Division/Department	**Exp. Phys III**
Title	**Prof. Dr.**

Presentation Title

Dynamical decoupling of single spins in diamond

Abstract

TU Dortmund did not have a setup for studying defect centers in diamond. Establishing this setup was the first and main task for the Dortmund group. The setup is now mostly finished, it allows the identification of single defect centers and the generation of very flexible microwave excitation sequences. We have tested the setup by measuring the spectra of many different centers and identified several multiqubit systems with single electron spins and multiple nuclear spins. We recently installed a magnet control system that allows the application of arbitrary magnetic field vectors with amplitudes of up to 100 mT. Microwave excitation fields are generated by mixing the output of an arbitrary waveform generator with the monochromatic output of a microwave synthesizer to generate arbitrary waveforms over a frequency range of ~1 GHz for driving the electron spins.

Increasing coherence lifetimes

The loss of coherence is the limiting factor for most implementations of quantum information processing. In the case of the NV centers, decoherence of the electron spin qubits is dominated by the interaction with the ^{13}C nuclear spins. An efficient way of suppressing this environmental perturbation consists in applying sequences of inversion pulses to the electron spin qubit, thereby refocusing the interaction with the environment. We have this technique, which is known as “dynamic decoupling” and found that we are able to increase the coherence lifetime by several orders of magnitude. Working with natural abundance samples, we could increase the electron spin coherence lifetime up to 1.8 ms. Particular care was taken to test that this effect works for arbitrary initial states – an essential requirement for quantum information processing. Working together with the solid-state NMR QIP group, we successfully tested sequences that work virtually perfectly for arbitrary initial conditions.

Future directions

Combining gate operations with DD

So far, we implemented dynamic decoupling for memory applications, i.e. we tried to conserve the input state. In the future, we will combine this approach with quantum logical gate operations. One possible approach is to implement synchronized dynamical decoupling sequences to a pair of electron spin qubits and the necessary single qubit rotations in the gaps between the DD pulses. In addition, we plan to implement electron-nuclear multi-qubit gate operations. The specific challenge here is that the interaction of the nuclear spin with the magnetic field is roughly four orders of magnitude weaker than that of the electron spin qubit.

Combining isotopic dilution with DD

We expect that we will be able to extend the preservation of coherence by dynamic decoupling to several ms. However, we were also able to show that centers with few neighboring ^{13}C nuclei, which show longer coherence times even in the absence of dynamic decoupling, also respond better to DD sequences. We expect therefore that we should be able to increase the coherence lifetime in isotopically enriched crystals to a range of 10-100 ms. This would provide excellent opportunities for high-fidelity control of pairs of NV centers, even if they are separated by > 10 nm.