HL 38: Focused Session: Different realizations of quantum registers

Time: Thursday 9:30–11:45 Location: HSZ 01

Topical Talk HL 38.1 Thu 9:30 HSZ 01

Quantum control of spins and photons in diamond — •Mikhail Lukin — Physics Department, Harvard University, Cambridge, MA, 02138, USA

We will discuss our recent work involving quantum control of spins and photons in diamond. Potential applications of these techniques to realization of quantum networks, nanoscale magnetic sensors and single photon switches will be discussed as well as the recent progress towards their implementation.

Topical Talk HL 38.2 Thu 10:00 HSZ 01

Quantum Information processing in diamond — •Fedor Jelezko and Jörg Wrachtrup — 3. Physcal Instutute, University of Stuttgart

Quantum Information processing in diamond Solid state quantum information processing often requires important breakthrough in material science. While classical semiconductor materials have had several decades of development with respect to purity and structure, carbon based materials are a relatively new class of substances to this field. Research on carbon systems, like, fullerenes, nanotubes, graphene or recently diamond is often driven by the requirements of having a spin-free lattice. In this talk we will focus on exceptional optical and spin properties associated with single color centers. Such optically active defects have been identified as a prominent candidate for quantum information processing and quantum cryptography a few years ago, but technology for controlling single spins was developed only recently. Here we show that being placed in a spin free lattice, single electron spins show the longest room temperature spin dephasing times ever observed in solid state systems. This benchmark will potentially allow observation of coherent coupling between spins separated by a few tens of nanometres, making it a versatile material for room temperature quantum information processing devices. We also show that single electron spins can be used to detect external magnetic fields with a sensitivity reaching nanotesla and sub-nanometre spatial resolution. References: Balasubramanian et al. Nature 455, 648-651 (2008), Neumann, et al. Science 320, 1326-1329 (2008).

15 min. break

Topical Talk HL 38.3 Thu 10:45 HSZ 01

Coherence of a single spin in a tunable environment — •Ronald Hanson — Kavli Institute of Nanoscience, Delft University of Technology

Diamond-based materials have recently emerged as a unique platform for quantum science and engineering. Spins of Nitrogen-Vacancy (NV) color centers in diamond can be optically imaged and read out, and exhibit long coherence times. Moreover, the dynamics of the spin environment can be adjusted in situ, providing an excellent system for controlled studies of decoherence in the solid state.

We use high-fidelity quantum control of single NV center spins to study the loss of spin coherence due to interactions with the surrounding bath of electron spins. By tuning the internal bath dynamics as well as the coupling between the bath and the NV spin, we gain access to regimes with strikingly different behaviour [1]. Furthermore, we measure the NV spin coherence time T_2 from room temperature down to 1.3 K. We find that T_2 increases sharply when the Zeeman energy exceeds the thermal energy, demonstrating that the fluctuations in the spin bath can be fully eliminated through polarization [2]. We will discuss these insights along with our latest results on counteracting decoherence.

[1] R. Hanson et al., Science **320**, 352 (2008).
[2] S. Takahashi et al., Phys. Rev. Lett. **101**, 047601 (2008).

Topical Talk HL 38.4 Thu 11:15 HSZ 01

Spectroscopy and Coherent Control of Single Spins — •Gregory Fuchs — Center for Spintronics and Quantum Computation, University of California, Santa Barbara, CA, USA

Nitrogen Vacancy (NV) defect centers in diamond are a promising system for spin-based applications in quantum information and communication at room temperature. Using a combination of optical microscopy and spin resonance, the spin of individual NV centers can be initialized, manipulated and read out. There remain significant challenges, however, both in understanding the physics of these defects as well as the development of technologies based on their quantum properties. In particular, knowledge of the detailed structure of the orbital excited-state, which continues to be an active research area, is critical to ultra-fast quantum control schemes. Here we present recent experiments using single-spin resonant spectroscopy of the excited-state of an NV center at room temperature[1]. We observe these spin levels over a broad range of magnetic fields allowing for a direct measurement of the zero-field splitting, g-factor and transverse anisotropy splitting. The latter of these is nearly zero in the ground-state spin levels, but plays an important role in the excited-state. In addition, we find strong hyperfine coupling between the nitrogen nuclear spin and the NV electronic spin in the excited-state. These findings will be discussed in the context of quantum control of single and coupled spins in diamond.

[1] G. D. Fuchs, V. V. Dobrovitski, R. Hanson, A. Batra, C. D. Weis, T. Schenkel, and D. D. Awschalom, Phys. Rev. Lett 101, 117601 (2008).