Seminar

Nano-scale MRI: Optically Detected Magnetic Resonance using Nitrogen-Vacancy centers in diamond

Vidya Praveen Bhallamudi

The Ohio State University, Columbus

Nitrogen-vacancy (NV) defect centers in diamond have emerged as one of the most promising tools for magnetic resonance studies at the nanoscale, and at the single molecular and single cellular level. A potent combination of optical and magnetic properties makes the intensity of their fluorescence dependent on their spin state, and enables Optically Detected Magnetic resonance (ODMR). NV's spin resonance and changes to it due to magnetic fields from nearby target paramagnetic spins or ferromagnetic magnetization can be measured extremely sensitively using ODMR. The NV centers can achieve magnetic field sensitivity of sub-nT/Hz1/2 and a spatial resolution that is ultimately limited only by their atomic size. This extreme sensitivity has allowed detection of just a few resonant nuclear spins and nuclear magnetic resonance imaging with resolution of ~10 nm. Remarkably this has been demonstrated under ambient conditions and at room temperature.

I will briefly discuss the basics of ODMR and the unique set of properties that make NV center an excellent material for pursuing nanoscale MRI, and provide an overview of the current state of the art for NV-based magnetic resonance detection and imaging. I will then discuss two recent NV-based ODMR projects in our group. In a proof-of-concept experiment, among the first of its kind, we show site-specific labeling of DNA molecules with individual nanodiamonds. We measured a spectrum of the NV centers in the nanodiamond showing the motion of a single nanodiamond-DNA complex in a microfluidic channel. We have also been developing an alternate spin-relaxation based modality for detecting magnetic resonance of target spins or magnetization that does not require any resonant manipulation of the NV centers themselves. Our approach exploits a straightforward continuous wave detection scheme using readily available diamond detectors that makes it easily implementable. Such approach has advantages for nanoscale MRI by relaxing some of the constraints needed for ODMR based on resonant manipulations of NV spin. Our research highlights the potential of NV-based ODMR for studying single molecular dynamics, and in understanding spin transport and relaxation at the nanoscale.

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4:00 PM (Tea/Coffee at 3:45 PM)

Seminar Hall, TCIS