IBS Center for Molecular Spectroscopy and Dynamics

COLLOQUIUM

□ SPEAKER

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□ TITLE

Single spin probes towards optical magnetic imaging in nanoscale

□ ABSTRACT

Single point defects in solids can be used as sensitive probes in nanoscale. The nitrogen-vacancy (NV) center in diamond is a well-known example which is an atomic scale defect emitting photons in VIS range with a fast emission rate, thus called a color center. Its strong PL emission rate at room temperature makes it one of the most efficient solid-state single photon sources, which will be useful even for quantum communication [1]. The strong spin dependent recombination also allows optical detection of single spins embedded in single NV centers at ambient conditions [2]. Such robust quantum properties have mostly been investigated to realize quantum bits, especially when they are strongly coupled to nuclear spins, the quantum memory [3]. Phenomenal progress so far includes quantum registers [4], quantum error correction [5], and spin-photon interfaces [6], to name but a few. Recently, we have reported creation and spin detection of single color centers in a new platform, silicon carbide [7]. It is, thanks to its similarity to silicon, considered as industry-friendly platform, thus practical quantum devices are expected to be emerging.

Researchers also have found that color centers can be used for various quantum applications. When they are confined in nanoscale particles, fluorescent nanocrystals can be used as biomarkers, which are stable and non-toxic since both diamond and silicon carbide are known to be biocompatible [8,9]. We also reported molecular-sized fluorescence diamond nanoparticles, which will be useful for cell biology [10]. Because the incorporated spins are sensitive to environment, and the perturbed spin states can be projected to a photon flux, quantum metrology also becomes promising. This include magnetometry, thermometry, electric field sensing and pressure sensing in nanoscale [8]. Among

them, magnetometry is especially attracting since spins can be efficiently coupled to external magnetic fields. When this is combined with high spatial resolution optical imaging techniques, e.g. super-resolution microscopy, nanoscale magnetic imaging becomes possible [11]. The best sensitivity is found from AC magnetic field sensing by utilizing quantum lock-in type measurements. Since they can detect alternating magnetic fields originating from Larmor precession of nuclear spins at the distance of □ 10 nm, nano NMR is feasible [12].

In this presentation, I will introduce our recent progress for realizing □ 100 Hz resolution of nano NMR based on a single NV center electron spin at ambient conditions utilizing quantum entanglement [13], one of the most absurd quantum mechanical phenomena, which allows "spooky action at a distance" [14] among spins in atomic scale defects, and an essential part for quantum computing as well. The next step is to realize □ 1 Hz resolution comparable to that of conventional NMR. This will provide a new way for optical magnetic imaging and NMR spectroscopy of small specimens such as cellular structures and single molecules, and even their dynamics.

□ DATE AND VENUE

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