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Magnetic field imaging using quantum sensors for condensed matter physics

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Abstract

Exploring the magnetic properties of various materials is one of the central topics in condensed matter physics. Diverse local magnetic field (magnetization) measurement methods have been developed.
Recently, there has been considerable interest in using nitrogen-vacancy centers (NV centers) in diamonds as quantum magnetic sensors. As they have unique electron spin-dependent optical excitation and relaxation processes, the spin state of a single NV center can be optically read out by combining microwaves. This technique is called optically detected magnetic resonance (ODMR). As the ODMR spectrum of an NV center in a magnetic field shows a Zeeman splitting, the magnetic field felt by the NV center can be measured by analyzing the spectrum. In 2020, it was revealed that similar magnetic field measurements can be made using boron vacancy defects in hexagonal boron nitride (hBN).
We aim to use these diamond and hBN quantum sensors to measure the magnetic properties of various materials locally. This talk will introduce our recent achievements, such as real-space observation of superconducting magnetic vortex, precise magnetic field measurement aided by machine learning, and hBN quantum sensor nanoarray. These will be fundamental techniques for future quantum sensor-based precision physical property measurements.