RICE QUANTUM GROUP MEETING SEMINAR SERIES

The development and application of scanning quantum sensing microscope

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Dr. Wentian Zheng received his PhD in 2021 from Peking University (PKU), China, under the supervision of Prof. Ying Jiang. During his PhD, Dr. Zheng focused on the development and application of a novel scanning quantum sensing microscope, which combined qPlus atomic force microscopy (AFM) with NV-based sensing techniques. After completing two years of postdoctoral research, Dr. Zheng joined Prof. Yonglong Xie's group at Rice University in 2024 as Smalley-Curl (SCI) Postdoctoral Fellow. He is currently working on scanning single-electron transistors (SET) on low-dimensional quantum materials to explore emergent quantum states. His research interests include scanning NV magnetometry on 2D materials, nanoscale NMR detection, and scanning SET techniques for quantum materials..

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ABSTRACT

The nitrogen-vacancy (NV) center in diamond has emerged as one of the most promising solid-state qubit platforms, offering remarkable potential for both quantum sensing and quantum computing applications. As a highly sensitive nanoscale magnetometer, the NV center has already demonstrated its capabilities, and the introduction of dynamical decoupling sequences has further extended its utility to nanoscale nuclear magnetic resonance (NMR) and magnetic resonance imaging (MRI). In this study, we present a novel integration of qPlus atomic force microscopy (AFM) with NV sensing techniques, enabling the first-ever demonstration of scanning electrometry at the nanoscale. Additionally, by leveraging the AFM tip as a precise local handle, we successfully enhance the coherence of the NV center through targeted manipulation of nearby electron spins, paving the way for improved qubit functionality in quantum systems. Furthermore, we utilize NV-NMR spectroscopy to uncover critical insights into the phase transition of confined water from liquid to solid at room temperature. These findings not only provide compelling evidence for nanoscale phase transitions but also introduce a versatile toolkit for high-resolution structural analysis at nanoscale level, with broad implications for materials science and quantum technologies.

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