Quantum Sensing at the Atomically Thin Limit

Solid-state spin defects have revolutionized quantum sensing by enabling nanoscale measurements with subwavelength spatial resolution and sensitivity to diverse physical signals. To fully harness these capabilities, one must minimize both the distance between the sensor and the target, as well as the smallest detectable signal. However, established systems such as nitrogen-vacancy centers in diamond often face limitations when operated close to surfaces or confined to nanoscale volumes, motivating the exploration of spin-active defects in novel, atomically thin materials.

In this talk, I will present an experimental framework for studying a new two-dimensional spin ensemble hosted in hexagonal boron nitride (hBN). I will discuss how we probe the spin Hamiltonian, characterize coherent sensing dynamics, and identify the noise environment of this 2D platform. By precisely mapping hyperfine interactions with nearby nuclear spins, we demonstrate controllable switching between magnetic and electric field sensing, as well as develop strategies to build atomic registers. I will also introduce a new method for reconstructing the local noise spectrum that directly accounts for imperfections in quantum control.

Our measurements reveal a coherence time of up to 0.1 milliseconds and AC magnetic sensitivities at the nanotesla level for targets only 10 nanometers away – approaching the regime needed to detect single nuclear spins. These advances, together with the design flexibility of atomically thin hosts like hBN, open pathways toward next-generation quantum sensors that combine ultrahigh sensitivity, tunable noise selectivity, and reconfigurable quantum functionalities.

Bio: Souvik Biswas is an Assistant Professor at the University of Michigan, Electrical Engineering and Computer Science. Previously, he was a postdoctoral research affiliate at Stanford University in Electrical Engineering. His research focuses on developing high-fidelity, scalable quantum systems by leveraging solid-state spin-photon interfaces, including low-dimensional materials, diamond, and silicon carbide. He received his Ph.D. in Applied Physics from the California Institute of Technology, where he focused on spectroscopic studies of engineered excitons in two-dimensional materials and the development of atomically thin reconfigurable nanophotonics. His work has been recognized by 2024 LSA Rising Stars of Light, 2024 Rising Stars in MSE, and 2022 MRS Graduate Student Gold Award.