Quantum Information Science Focus Topic
Room Ballroom A - Session QS-ThP

Quantum Information Science Poster Session

QS-ThP-2 Creating, Controlling, and Characterizing Quantum Emission in Hexagonal Boron Nitride*, **Annemarie Exarhos,*** Lafayette College*; D. Hopper, R. Patel, R. Grote,* University of Pennsylvania*; A. Alkauskas,* Center for Physical Sciences and Technology, Lithuania*; M. Doherty,* Australian National University, Australia*; L. Bassett,* University of Pennsylvania

Optically addressable spins associated with localized defects in wide-bandgap semiconductors are the basis for rapidly expanding quantum technologies in nanoscale sensing and quantum information processing. Most research has focused on three-dimensional host materials such as diamond and silicon carbide, but more recent reports of single-photon emission – also known as quantum emission - from van der Waals materials has led to an increasingly active area of research focused on these systems. Within the family of two-dimensional materials, hexagonal boron nitride (hBN) has emerged as a robust host for bright, stable, room-temperature quantum emitters. However, many questions persist regarding the chemical and electronic structure of the defects responsible for emission as well as the potential role of spin-related effects. Significantly complicating the identification is the heterogeneity of optical characteristics observed for these quantum emitters.

Our studies focus on identifying and characterizing the optical and magnetic properties of quantum emitters in suspended hBN films in ambient conditions, via confocal fluorescence microscopy. Some qualitative similarities in optical dipole orientation, spectral shape, and emission statistics are evident among quantum emitters in hBN, even for large variations in emission energy, though some emitters exhibit significantly different behavior, suggesting that quantum emission in hBN may result from chemically different types of defects, different charge states of the same defect, or as the result of strong local perturbations [1]. Significantly, a small percentage of observed quantum emitters exhibit strongly anisotropic photoluminescence modulation in response to an applied magnetic field at room temperature [2]. The magnetic-field-induced modulation is consistent with an electronic model featuring a spin-dependent inter-system crossing between triplet and singlet manifolds, suggesting that these defects host optically addressable spin states. This discovery represents a critical step towards the realization of spin-based quantum technologies using van der Waals heterostructures. More broadly, the experimental considerations and techniques involved in this work provide a roadmap for the future experimental identification of quantum emitters in other wide-bandgap structures, paving the way for the discovery of quantum emitters with varying properties in a variety of hosts for use in future quantum technologies.

[1] Exarhos et al., ACS Nano 11, 3328 (2017).

[2] Exarhos et al., Nature Communications 10, 222 (2019).

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