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GRAPHENE AND BEYOND
From Atoms to Applications

Optical and spin dynamics of visible quantum emitters in hexagonal boron nitride

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Abstract

Hexagonal boron nitride (h-BN) hosts visible-wavelength quantum point defects (QPDs) that exhibit bright single-photon emission, magnetic-field dependent photoluminescence, and optically detected magnetic resonance at room temperature. In contrast to three-dimensional hosts, two-dimensional materials such as h-BN present opportunities to locate quantum emitters precisely at surfaces, and they can be easily heterointegrated with other materials for applications in quantum sensing and quantum photonics. However, the chemical and electronic structure of h-BN's QPDs remain unknown, as do key details of their orbital, spin, and charge dynamics under optical excitation. In this talk I will discuss experimental evidence for complex optical and spin dynamics in h-BN's visible quantum emitters, involving multiple dark electronic states in both optical excitation and emission [1]. We particularly utilize photon emission correlation spectroscopy [2] to study the variation of the emitters' optical dynamics as a function of optical excitation power and applied magnetic fields. Aided by quantitative theoretical simulations, we develop an empirical model of the QPDs' electronic structure. Such understanding is a prerequisite to designing quantum control protocols that will facilitate their use in quantum technologies.

[1] R. N. Patel, D. A. Hopper, J. A. Gusdorff, M. E. Turiansky, T-Y. Huang, R. E. K. Fishman, B. Porat, C. G. Van de Walle, and L. C. Bassett, "Probing the Optical Dynamics of Quantum Emitters in Hexagonal Boron Nitride," *PRX Quantum* **3**, 030331 (2022).

[2] R. E. K. Fishman, R. N. Patel, D. A. Hopper, T.-Y. Huang, and L. C. Bassett, "Photon emission correlation spectroscopy as an analytical tool for quantum defects." *PRX Quantum* **4**, 010202 (2023).