Quantum Sensing Using Two-dimensional Hexagonal Boron Nitride

Hailong Wang

School of Physics, Georgia Institute of Technology, Atlanta, Georgia 30332

Emergent color centers with optically accessible spins have attracted tremendous research interest in recent years due to their significant potential for implementing transformative quantum sensing technologies. Spin defects hosted by hexagonal boron nitride (hBN) are emerging candidates in this catalog due to their remarkable compatibility with solid-state nano device integration and multimodal sensing of proximal two-dimensional quantum materials/devices [1]. Taking advantage of boron vacancy spin defects in hBN, we report nanoscale quantum imaging of low-dimensional ferromagnetism sustained in Fe_3GeTe_2/hBN van der Waals heterostructures [2]. Exploiting quantum spin relaxometry methods, we have observed spatially varying magnetic fluctuations in exfoliated Fe_3GeTe_2 nanoflakes, whose magnitude reaches a peak value around the Curie temperature. Using optically detected magnetic resonance measurements, we further show that ferromagnetic resonance and parametric spin excitations in a magnetic insulator $Y_3Fe_5O_{12}$ (YIG) can be effectively detected by boron vacancy spin defects under various experimental conditions through the off-resonant dipole interaction between YIG magnons and boron vacancy spin defects [3]. Our results highlight the opportunities offered by novel quantum spin defects in layered vdW materials for investigating microscopic spin behaviors in magnetic solid-state matters.

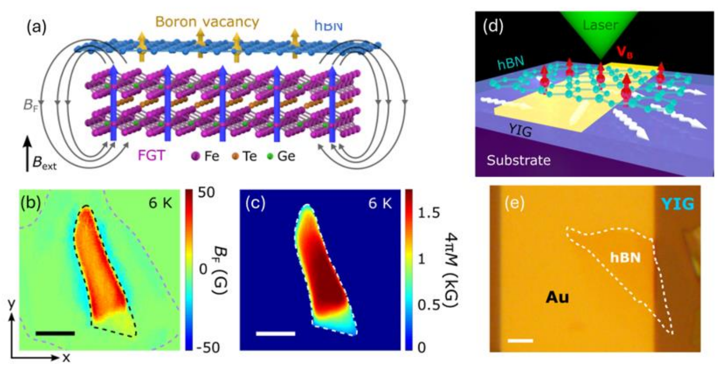

Figure 1. (a)-(c) hBN-based quantum wide-field imaging of 2D magnet Fe_3GeTe_2. (d)-(e) hBN quantum sensing of spin waves in magnetic insulator $Y_3Fe_5O_{12}$.

[1] A. Gottscholl et al., Nature Materials **19**, 540 (2020).
[2] M. Huang et al., Nature Communications **14**, 5259 (2023).
[3] J. Zhou et al., Science Advances **10**, eadk8495 (2024).