Study of static and dynamical properties of topological magnetic vortices with spin centers in hBN.

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Spin centers defects in solid-state systems have emerged as a promising platform for different quantum technologies, including qubits and quantum sensors. Their frequency in the GHz range, together with their response to magnetic fields, has promoted magnetic hybrid quantum systems – composed of spin centers and magnets – as a novel platform for coherently controlling spin centers in diamond via magnon modes [1] and for generating magnon-mediated entanglement between spin centers at optically addressable distances [2-4]. Despite recent advances in magnonic hybrid systems, interfacing the spin center with topological magnetic structures and excitations remains largely unexplored. In this talk, we will present recent combined theoretical-experimental development on the study of spin centers coupled to topological magnetic entities, e.g., topological magnons, skyrmions, and soliton-magnetic vortices.

Our system of study consists of hBN hosting spin centers atop a NiFe thin film prepared with a topological-vortex magnetization profile. We first establish the capability of these spin centers to quantitatively reconstruct the static vortex-induced stray-field distribution via optically detected magnetic resonance, and we validate the measurements against theoretical predictions with micromagnetic simulations (MuMax3) and a self-consistent, home-built ODMR simulation of the spin center (See Fig. 1).

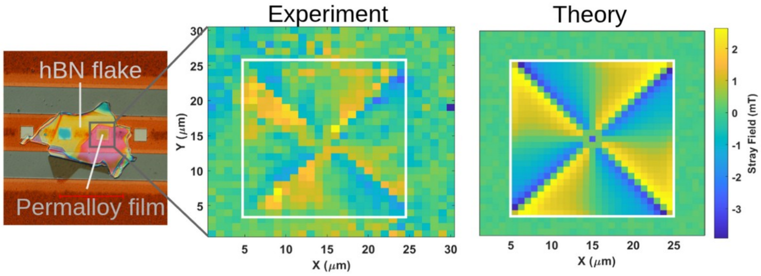

Fig. 1. Experimentl and Theoretical Magnanetometry of Permalloy films using hBN flakes. Color code shows the static stray field produced by the Py films.

Having verified the vortex configuration, we then use spin centers to experimentally study the dynamics of magnetic vortices. Interestingly, we demonstrate that driving the system with ~0.1 GHz microwave fields induces a change in the optical contrast, indicating that the gyration mode of the vortex core that generates dynamical fringe fields resonant with the spin-center frequency transitions in the GHz regime. Interestingly, this nonlinear excitation of the spin centers occurs only above a threshold microwave power. All of our experimental results are quantitavely explained and consistent with theoretical modeling of vortex magnetic dynamics via both micromagnetic simulations and analytical models combined with ODMR simulations.

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