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Coupling a driven magnetic vortex to individual nitrogen-vacancy spins for fast, nanoscale addressability and coherent manipulation[1]

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The core of a ferromagnetic (FM) vortex domain creates a strong, localized magnetic field which can be manipulated on nanosecond timescales using small magnetic fields, or electrical currents. These capabilities present opportunities for nanoscale spin-based devices. Here, we demonstrate how these FM vortex properties can be used in a room temperature, integrated device by coupling a FM vortex to nitrogen-vacancy (NV) center spins in diamond [1]. Measurements are carried out using a combined magneto-optical microscopy and optically-detected spin resonance technique. We show that the FM vortex can be driven into proximity with an NV, inducing significant NV spin splitting and sufficiently large magnetic field gradient to address spins separated by nanometer length scales. By applying a microwave-frequency magnetic field, we drive both the vortex and the NV spins, resulting in enhanced coherent rotation of the spin state. Finally we demonstrate that by driving the vortex on fast timescales, sequential addressing and coherent manipulation of spins is possible on 100 ns timescales, while driving on faster timescales results in non-trivial coherent dynamics of the coupled vortex/NV system. [1] Wolf, M.S., Badea, R., and Berezovsky, J., cond-mat/1510.07073, (2015)

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