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Dynamics of a pinned magnetic vortex¹

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Disks patterned from soft ferromagnetic films typically form a single magnetic vortex for diameters on the order of a few microns or less. The vortex dynamics include both ordinary spin waves and a gyrotropic mode, in which the vortex core undergoes circular motion about its equilibrium position [1, 2]. This mode has sub-GHz frequencies which ideally depend only on the aspect ratio (diameter over thickness) of the disk [2, 3]. We have used time-resolved Kerr microscopy to investigate the gyrotropic mode as a function of the equilibrium position of the core, which can be tuned by an applied field with a sensitivity of ~ 1 nm/Oe. In the limit of high excitation amplitude, the gyrotropic frequency f_G is independent of the vortex core position, as previously predicted and observed [1, 3]. For small amplitudes, however, we observe unexpected fluctuations in f_G as a function of the applied field. The average core displacement between consecutive frequency peaks, as well as the average frequency shift, is observed to be independent of disk diameter. These observations indicate that the fluctuations are due to a distribution of nanoscale defects that pin the vortex core by lowering its energy [4]. Furthermore, they are consistent with a model in which the frequency shift for a particular fluctuation is a direct measure of the interaction energy of the vortex core with one defect. By mapping f_G as a function of orthogonal in-plane static fields, we image the 2D spatial distribution of defects with nanoscale resolution.

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