Propagation and control of nanoscale magnetic-droplet solitons

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Recent results on propagating, solitary magnetic wave solutions of the Landau-Lifshitz equation with uniaxial, easy-axis anisotropy in thin (two-dimensional) magnetic films will be illustrated. These localized, nontopological wave structures, parametrized by their precessional frequency and propagation speed, extend the stationary, coherently precessing "magnon droplet" to the moving frame, a non-trivial generalization due to the lack of Galilean invariance. Propagating droplets move on a spin wave background with a nonlinear droplet dispersion relation that yields a limited range of allowable droplet speeds and frequencies. The droplet is found to propagate as a Nonlinear Schroedinger bright soliton in the weakly nonlinear regime [1]. Using spin transfer torque underneath a nanocontact on a magnetic thin film with perpendicular magnetic anisotropy (PMA), the generation of dissipative magnetic droplet solitons was announced this year for the first time, following its theoretical prediction [2]. Rich dynamical properties (including droplet oscillatory motion, droplet spinning, and droplet breather states) have been experimentally observed and reported. After reviewing the conservative magnetic droplet, some properties of the soliton in a lossy medium will be discussed [3]. In particular, it will be shown that the propagation of the dissipative droplet can be accelerated and controlled by means of an external magnetic field. Soliton perturbation theory corroborated by two-dimensional micromagnetic simulations predicts several intriguing physical effects, including the acceleration of a stationary soliton by a magnetic field gradient, the stabilization of a stationary droplet by a uniform control field in the absence of spin torque, and the ability to control the solitons speed by use of a time-varying, spatially uniform external field. Soliton propagation distances approach 10 μm in low-loss media, suggesting that droplet solitons could be viable information carriers in future spintronic applications, analogous to optical solitons in fiber optic communications.

References

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