총회 초청강연

Magnetic Vortex State Stability and Dynamics in Small Magnetic Particles

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Understanding fundamentals of magnetization dynamics in systems with a reduced dimensionality is essential in the future advancements of the field of nanomagnetism and spintronics. Thus, it becomes important to calculate and observe the eigenfrequencies and eigenmodes of magnetization oscillations of sub-micron magnetic particles.

The magnetization distribution in small ferromagnetic particles (dots) depends on their size and shape. For mesoscopic sizes and non-elliptical shapes, non-uniform magnetization distributions with zero remanence ("vortex" state) are often observed. These states can be stable within a wide range of dot sizes from a few tens of nm up to a few tens of microns. Vortex phenomena offer insight into magnetization dynamics on a fundamental level, and also govern magnetization reversal.

In this talk I will present a review of calculations and measurements of the low-frequency (sub-GHz range) and high-frequency (above 1 GHz) vortex dynamic excitations in soft magnetic dots. Particular cases of the circular [1-4], elliptic [5] dots and tri-layer ferromagnet/spacer/ferromagnet [6] dots will be considered. The vortex eigenfrequencies are quantized due to the geometrical confinement and depend on the dot size and geometry. The observed low-frequency oscillations of the vortex core position are described as the gyrotropic modes of the magnetic vortex motions around the equilibrium positions induced by a gyroforce and dynamic magnetostatic restoring forces. The equation of motion for the vortex core position in the form suggested by A. Thiele is applied to the low-frequency vortex dynamics. The role of the vortex topological charges in the magnetization dynamics will be discussed. The topological charges determining the vortex gyrovectors are especially important for the case of dynamics of coupled vortices [5, 6]. The high-frequency modes can be described as radial or azimuthal spin waves over the vortex ground state [1, 7] with strong pinning on the dot circumference.

The dependencies of the vortex dynamic susceptibility and resonance linewidth on geometrical parameters of the dot are calculated and compared with experiment. The dynamical susceptibility has a form that is similar to that for ferromagnetic resonance in an infinite ferromagnet. However, the parameters of the susceptibility, which determine the resonance line position, intensity and shape, depend on the geometrical size of the dots [4]. This work was supported by Creative Research Initiatives(Reserach Center for Spin Dynamics & Spin-Wave Devices) of MOST/KOSEF.

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