Magnetic Vortex Oscillators

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Since spin-polarized dc-current driven magnetic vortex oscillators (MVOs) were experimentally demonstrated using nanoscale spin valve structures[1], such MVOs have begun to attract considerable attractions. These MVOs have several advantages over conventional spin-transfer-torque (STT) driven magnetization precessional oscillators[2]. In recent studies, several groups have reported excitations of vortex oscillations in different types of nanostructures by using out-of-plane dc currents[1-6]. Although these previous studies have proposed and demonstrated a new concept of nano-oscillators based on vortex translation mode excited in magnetic nanodisks, quantitative understandings of the underlying physics of this phenomenon and associated phenomena have been lacking.

In this presentation, we are going to report quantitative interpretations and results of vortex oscillations in a free standing soft magnetic nanodisk driven by spin-polarized out-of-plane dc current[7]. We conducted analytical calculations and numerical simulations, considering both the STT effect of the spin-polarized current acting directly on a given vortex state and comparable Oersted field effects induced by the current flow. To obtain key parameters for the control of the eigenfrequency and radius amplitude of single vortex core motions in nanodisks of a different vortex polarization p and chirality c configuration, we analytically derived vortex core motions using the linearized Thiele's equation of motion, taking the STT terminto account. It was found from the derivation that the eigenfrequency and the radius amplitude are controllable with only the external driving parameters of the current density and its direction, for a given vortex state characterized by p and c, and the magnetization direction of the perpendicular polarizer. We also numerically calculated both the critical current densities and eigenfrequencies at the corresponding current densities as a function of the dot dimensions. These constructed phase diagrams can offer how to design dot dimensions and select a proper material for controlling persistent vortex oscillations and their eigenfrequencies.

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