Perpendicular-bias-field control of coupled-vortex oscillations in nanodot networks

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We studied, by combined micromagnetic numerical simulations and analytical derivations, coupled vortex dynamics in one-dimensional (1D) arrays composed of two or more dipolar coupled-vortex-state disks under perpendicular bias fields. We derived explicitly analytical expressions that could provide physical insights into the observed dynamic behaviors. The effects of perpendicular bias fields on the interaction strengths between the coupled-vortex oscillators and their characteristic band structures were solved in terms of field strength and direction; the implication here was that the normal modes and dispersion relations of collective vortex gyration as well as the signal-transfer rate can be tailored according to the derived explicit forms. The band width and gap of 1D coupledvortex oscillator magnonic crystals, for example, are essential to the control of gyration-signal transfer in vortexstate dot networks. All of the analytical calculation results showed quantitatively good agreement with the micromagnetic simulation results, indicating that the perpendicular-bias-field dependence of coupled-vortex gyrations can be expressed simply as a function of the dynamic parameters under the zero field, and the field strength and direction. This work provides not only a fundamental understanding of the effects of perpendicular bias fields on coupled-vortex oscillators but also an efficient practical means of dynamic manipulation of collective vortex gyrations.

References

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