MAR11-2010-001562

Abstract for an Invited Paper
for the MAR11 Meeting of
the American Physical Society

Dynamical Magnetoelectric Phenomena in the Multiferroic Mn Perovskites

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Electric manipulation of magnetic structures is an urgent issue in the field of spintronics. Concurrently magnetic and ferroelectric materials, i.e., multiferroics offers a promising route to attain this goal, and its dynamical aspects are now attracting a great deal of interest. In this talk, we will discuss the recent progress of theoretical study on the dynamical magnetoelectric phenomena in the multiferroic Mn perovskites $R\mathrm{MnO}_3$ (R=Tb, Dy, $\mathrm{Eu}_{1-x}\mathrm{Y}_x$, ...). In these materials, a spiral order of the Mn spins induces spontaneous electric polarization through breaking the inversion symmetry, and thus the strong coupling between electric and magnetic dipoles is realized. Using an accurate spin Hamiltonian describing $R\mathrm{MnO}_3$, we first study the electromagnon excitation in these materials at THz frequencies, i.e., collective motion of spins with oscillating electric dipoles activated by the electric-field component of light. The optical spectra with two specific peaks are explained by a symmetric magnetostriction model for the spiral spin order with higher harmonic components. After clarification of its mechanism and nature, we then study the nonlinear dynamical processes of magnetic system caused by the intense electromagnon excitations through the optical pumping. The excitation by the electric field can be more intense and faster than that by the magnetic field. This necessarily leads to novel and intriguing phenomena which can never be expected in the conventional magnetic-field-induced magnon excitation. As one of the most interesting phenomena, we will theoretically propose a picosecond optical switching of spin chirality in $R\mathrm{MnO}_3$. We will demonstrate that by tuning strength, shape and length of the optical pulse, we can control the spin chirality at will. This proposal will pave a new way to control the magnetism in the picosecond/THz time domain.

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