Theories of Dynamical Magnetoelectric Phenomena in Multiferroic *R*MnO_3

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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 offer a promising route to attain this goal, and its dynamical aspects are now attracting enourmous interest. We will discuss the recent progress of theoretical study on the dynamical magnetoelectric phenomena in the multiferroic Mn perovskites *R*MnO_3 (*R*=Tb, Dy, $Eu_{1-x}Y_x$, ...)[1,2]. 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*MnO_3[3,4], we first study the nature of magnetoelectric coupling[5] as well as the electromagnon excitation in these materials at THz frequencies[1], 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 the mechanism and nature of the electromagnon excitation in *R*MnO_3, we then study the nonlinear dynamics of magnetic system caused by intense electromagnon excitations through the optical pumping.

As one of the interesting phenomena, we theoretically propose a picosecond optical switching of spin chirality in *R*MnO_3[2]. We 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.

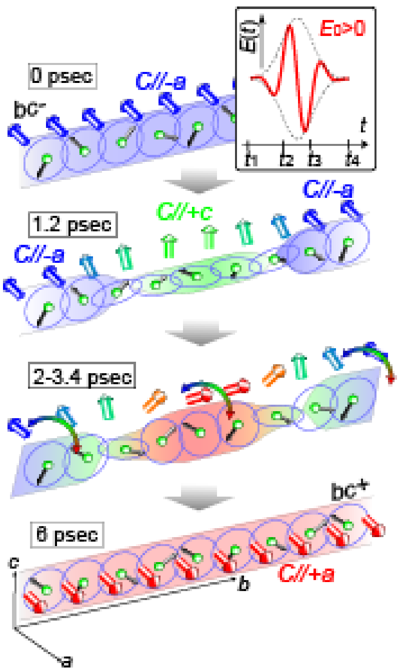

Figure: Spin-chirality switching process after irradiation of an intense THz laser pulse.

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[5]: M. Mochizuki and N. Furukawa, Phys. Rev. Lett. 105, 187601 (2010).