Dynamical aspects of multiferroics

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The real-time dynamics of the correlated electronic systems is an important but difficult problem for theories, and has denied the full understanding. Especially, even though the optical activity of the magnetic systems has been the subject since long ago, the optical manipulation of magnetism is the topic of intense interest only recently.
In this talk, I will discuss some of our recent works related to the real-time dynamics of the correlated systems.

(i) Photo-induced chirality switch in multiferroics RMnO3

In RMnO3, the ferroelectricity associated with the non-collinear magnetic structure is realized, and its dynamical properties including the electromagnon have been studied. We have developed the quantitative theory of electromagnon optical spectra (OS) by constructing the detailed microscopic spin Hamiltonian consistent with the phase diagram. It turned out that the nonlinear interactions play important role to reproduce the observed OS. Based on this spin Hamiltonian, we study numerically the effect of intense pico-second optical pulses on the magnetic system. It is found that the optical switching of the vector spin chirality is possible by tuning the pulse-width and intensity though the nonlinear electromagnon excitations.

(ii) Photo-induced metal-insulator transition in spin-electron coupled system

We present a model where the electrons are coupled to classical spins, i.e., double exchange model, to simulate the quantum real-time evolution of the electronic system combined with the classical spin dynamics. This model has the ferromagnetic metallic and antiferromagnetic insulating states as two nearly degenerate ground states. By this model, we analyze the real-time dynamics of the photo-induced metal-insulator transition including the nucleation process, non-adiabatic transitions, space-time pattern formation, and appearance of the spiral magnetic structure.

These works have been done in collaboration with M. Mochizuki, N. Furukawa,
and W. Koshibae.