Ultrafast manipulation of spin and orbital angular momenta by light pulses

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All-optical magnetization switching has been studied extensively in recent years. A typical form of non-thermal magnetization control is the inverse Faraday effect (IFE). It involves rotation of the linear polarization of a probe pulse induced by a circularly polarized pump pulse in a transparent medium. Spin precession accompanied by the IFE has been reported by Kimel *et al.* in iron compounds [1]. Spin precession is also observed with a linearly polarized pump pulse, in particular, a pulse polarized in a direction nonparallel to the crystal axes. This phenomenon is called the inverse Cotton-Mouton effect [2].

The IFE has also been observed even in pure antiferromagnetic (AFM) NiO with no net magnetic moment in the ground state [3]. The resonance frequencies of AFM materials reach the terahertz range, which is several orders of magnitude higher than that of FM materials. For that reason, AFM materials attract much attention in the context of ultrafast spin control. However, the mechanism of the observed spin oscillation by circularly polarized pulses remains unclear because of birefringence in the material. Here we discuss detailed mechanism using an NiO single domain which is optically isotropic [4].

Moreover, we report on the observation of coherent spin oscillations in AFM CoO in a pump-probe experiment. The orbital momentum of the Co^{2+} ion is not fully quenched by the crystalline field. We show that spin-orbit interaction as well as exchange interaction plays an important role for low-lying magnetic excitation [5].

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