Optical magnetoelectric effect with electromagnon resonance on multiferroics

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Magnetoelectric multiferroics exhibit the strong cross-coupling between the ferroelectricity and magnetism, leading to the novel functionalities of matter. An electromagnon, which is a magnon endowed with the electric activity, is the elementary excitation characteristic of the magnetoelectric multiferroics as indicated by the infrared absorptions in terahertz region [1]. For example, the helical spin orders always provides the spin-driven ferroelectricity as well as the electromagnon resonance irrespective of the underlying lattice as exemplified by various helimagnets. A unique character of the electromagnon is the resonanltly enhanced optical magnetoelectric effect, which is induced by the cross-coupled excitations of the electric polarizations P^{ω} and of the magnetizations M^{ω}. Consequently, the nonreciprocal optical responses, which are represented by the k^{ω}-dependent term in the optical constant, show up in the absorption and gyration of light. In fact, the nonreciprocal directional dichroism, which is the k^{ω}-dependent absorption of light, has been reported on the electromagnon resonance in the various multiferroic helimagnets.

We investigated the optical magnetoelectric effect with electromagnon resonance on the helimagnets by using the time-domain terahertz spectroscopy and polarimetry. In terms of the symmetry, the optical magnetoelectric effect is allowed under the simultaneous breaking of the time-reversal and space inversion symmetries. For example, the presence of static electric polarization *P* and magnetization *M* in matter ensures the directional dichroism for the light propagating parallel to $P \times M$. The cycloidal spin order, which produces the spin-driven ferroelectric polarization, turns into conical cycloidal spin state by external magnetic field, resulting in the presence of static P and M as shows in Fig. (a). In fact, the gigantic directional dichroism has been observed on the electromagnon resonance in perovskite manganite [3]. On the other hand, the chiral matter also shows the directional dichroism under the magnetic field, which is referred to as the magnetochiral effect, for the light propagating parallel to the magnetization. The proper screw spin order has the chirality, i.e. the right- and left-handed screw spins are distinguished, so that the magnetic field parallel to the screw axis allows the magnetochiral effect (Fig. (b)). The genuine spin-driven magnetochiral effect on the electromagnon resonance has been observed on the screw spin helimagnet [4].

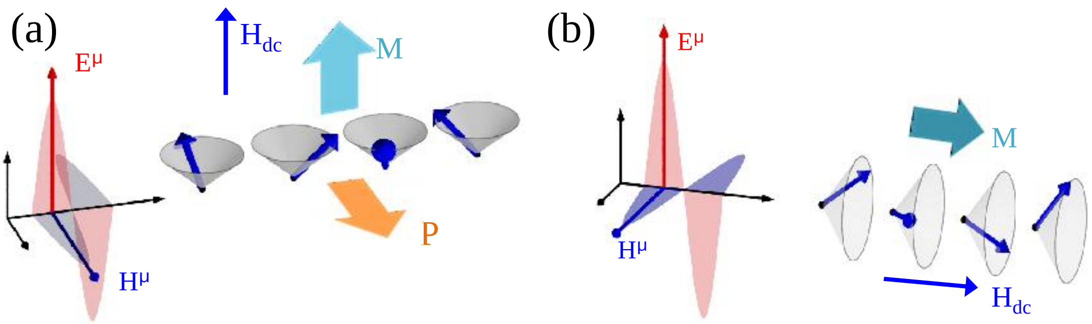

Figure. (a) Geometry of the nonreciprocal directional dichroism on the cycloidal helimagnet. (b) Magnetochiral effect on the screw spin helimagnet.

References

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