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Electromagnons in multiferroics

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Recent spectroscopic studies at THz frequencies for a variety of multiferroics endowed with both ferroelectric and magnetic orders have revealed the emergence of a new collective excitation, referred to as electromagnon.[1] It is magnetic origin, but it uniquely becomes active in response to the electric field component of light. Here we show our recent advance in the terahertz time-domain spectroscopy of electromagnons in multiferroics.[2] First, we extract general optical features in a variety of the spin ordered phases of perovskite manganites, $R\mathrm{MnO_3}$ (R=Gd, Tb, Dy, Eu, Y, and their solutions),[3–8] which are realized by tuning R, temperature, and magnetic field. In addition to the antiferromagnetic resonances driven by the magnetic field component of light, we clarify that the electromagnon appears only for light polarized along the a-axis, but independent of the direction of the spiral spin plane. A possible origin of the electromagnon is discussed with theoretical considerations based on Heisenberg model. Second, we show the recent finding of the electromagnon in $Ba_2Mg_2Fe_{12}O_{22}$ with conical (i.e., ferromagnetic plus spiral) spin order.[9] Reflecting the ferromagnetic nature of the compound, the conical spin state is completely modified to a large extent by magnetic fields, leading to a remarkable change (terahertz magneto-chromism) of the electromagnon spectrum. On the basis of the optical investigations presented here, we emphasize the particular role of the non-collinear spin order rather than the ferroelectric order as a source of electromagnons. This work was done in collaboration with S. Kumakura, Y. Takahashi, J. S. Lee, Y. Ikebe, R. Shimano, D. Okuyama, S. Ishiwata, M. Tokunaga, Y. Kaneko, Y. Yamsaki, Y. Taguchi, K. Iwasa, T. Arima, N. Nagaosa, and Y. Tokura [1]A. Pimonov *et al.,* Nat. Phys. **2**, 97 (2006). [2]N. Kida *et al.,* J. Opt. Soc. Am. B **26**, A35 (2009). [3]N. Kida *et al.,* Phys.Rev. B **78**, 104414 (2008). [4]N. Kida *et al.,* J. Phys. Soc. Jpn. **77**, 123704 (2008). [5]Y. Takahashi *et al.,* Phys. Rev. Lett. **101**, 187201 (2008). [6]J. S. Lee *et al.,* Phys. Rev. B **79**, 180403(R) (2009). [7]Y. Takahashi *et al.,* Phys. Rev. B **79**, 214431 (2009). [8]J. S. Lee *et al.,* Phys. Rev. B **80**, 134409 (2009). [9]N. Kida *et al.,* Phys. Rev. B (in press).