Optical Magnetoelectric Effects in Multiferroics

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Multiferroics show peculiar magneto-optical properties: Optical refractive index and absorption change with the reversal of the propagation vector $k$ of the electromagnetic wave. This magneto-optic effect is clearly distinct from the conventional magneto-optics like Faraday effect and named optical magneto-electric effect, because it can be considered as the high-frequency extension of the linear magneto-electric effect in multiferroics. We have recently succeeded in detecting the optical/x-ray magneto-electric effect in a polar ferrimagnet GaFeO$_3$, where spontaneous polarization $P_0$ and magnetization $M_0$ are parallel to the $b$ and $c$ axes, respectively. Optical magneto-electric effects are expected to show up for the electromagnetic wave with $k//a$, as the difference in absorption and refractive index with the sign reversal of the triple product of $P_0$, $M_0$, and $k$. X-ray magneto-electric absorption shows large enhancement at Fe 1s-3d transition. The obtained spectra are well explained by the interference between electric dipole and electric quadrupole transitions of Fe 1s electrons in an FeO$_6$ cluster. Optical magneto-electric absorption of the order of $10^{-3}$ was observed at around Fe intra-atomic d-d transition. *Measurements of x-ray spectroscopy were performed at BL-1A, KEK-PF, Japan. 1M. Kubota et al., Phys. Rev. Lett. 92 (2004) 137401. 2J. H. Jung et al., Phys. Rev. Lett. 93 (2004) 037403.

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