Record-high spin-driven polarization and light-matter interactions in $BiFeO_3$

Jun Hee Lee*
Ulsan National Institute of Science & Technology, Ulsan, Korea

Although $BiFeO_3$ is one of the most investigated multiferroics, its magnetoelectric couplings are barely understood on an atomic level. By combining a first-principles approach with a spin-cycloid model, we report hidden but huge spin-driven polarizations at room temperature in bulk $BiFeO_3$. One of the ferroelectric polarizations reaches ~3.0 $\mu C/cm^2$, which is larger than any other spin-driven polarization in a bulk material by one order of magnitude [1]. The broken inversion symmetries of the *R*3c $BiFeO_3$ induce the strong response of the magnetic interactions to an electric field and are responsible for the associated huge spin-driven polarizations. Second, we show strong THz non-reciprocal directional dichroism induced by the spin-driven polarizations [2]. The broken inversion symmetries of the *R*3c structure are responsible for the huge spin-driven polarizations and subsequent uni-directional light propagation at room temperature. Beyond the spin-current polarization governed by the inverse Dzyaloshinskii-Moriya interaction, various spin-current polarizations derived from both ferroelectric and antiferrodistortive distortions cooperatively produce the strong non-reciprocal directional dichroism or the asymmetry in the absorption of counter-propagating light in $BiFeO_3$. Our systematic approach can be generally applied to any multiferroic material, laying the foundation for exploiting optical magnetoelectric effects in the next generation of technological devices such as optical diodes [3,4].

References

[1] J. H. Lee* and R. Fishman, Physical Review Letters 115, 207203 (2015).
[2] R. Fishman, J. H. Lee*, *et al*., Physical Review B 92, 094422 (2015).
[3] I. Kezsmarki, U. Nagel, S. Bordacs, R. S. Fishman, J. H. Lee* *et al*., Physical Review Letters 115, 127203 (2015).
[4] J. H. Lee* and R. Fishman, New Journal of Physics 18, 043025 (2016).