Dispersion and scattering characteristics of electromagnetic waves in multiferroic heterostructures

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1 Extended Abstract

Realization of externally tunable chiral photonic sources and resonators is essential for studying and functionalizing chiral matter. Generation and control of chiral light is crucial for a number of applications in physics, chemistry, and biology such as its use for enantiomeric selectivity. An ability to control the enantiomeric ratio is, for example, important in medical drug production with increased therapeutic impact. Methods to generate chiral light include the use of nanostructured metasurfaces or the superposition of plane waves. Particularly useful are resonators with sizable chirality density that can be reversibly controlled by external fields with low-energy dissipation. Here, we exploit the spin-dependent scattering of light from the non-collinear spin texture in a helical multiferroic interface and show that a substantially large optical chiral density is formed between the interfaces. A suitable resonator material class was found to be dielectric multiferroic oxides with magnetically induced ferroelectricity such as RMn_2O_5 (R=Y,Ho,Bi), $DyMnO_3$, or $TbMnO_3$ [1].

In our studies, oxide-based stacks of helical multiferroic layers are shown to provide a suitable, electrically-controllable medium to efficiently trap and filter purely chiral photonic fields adding a new twist to the field of oxide and perovskite-based photonics. Structurally and electronically the discussed material class combines well with other ferroelastic or ferroelectric materials such as $BaTiO_3$ and exhibits multiple phases as a function of external parameters such as temperature, pressure and electric gates pointing to potential use in sensoric and material characterization. Using our originally developed analytical and rigorous coupled wave numerical method we simulate the dispersion and scattering characteristics of electromagnetic waves in multiferroic heterostructures. The results evidence that due to scattering from the spin helix texture, only the modes with a particular transverse wavenumber form standing chiral waves in the cavity, whereas all other modes leak out from the resonator [2]. An external static electric field enables a nonvolatile and energy-efficient control of the vector spin chirality associated with the oxide multilayers, which tunes the photonic chirality density in the resonator.

2 Acknowledgement

This work was supported by Shota Rustaveli National Science Foundation of Georgia (SRNSFG) [FR-23-249].

References

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