Magnetochiral effect of phonons

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The phonon magnetochiral effect is a nonreciprocal acoustic propagation arising due to the fundamental symmetry principles. Mirror symmetry breaking in chiral matters leads to natural optical or acoustic activity and time-reversal symmetry breaking by magnetic fields leads to magnetic optical or acoustic activity. When both symmetries are simultaneously broken, a nonreciprocal property appears - the magnetochiral effect.

We have observed the phonon magnetochiral effect in the chiral-lattice ferrimagnet Cu_2OSeO_3 below the magnetic ordering temperature $T_C \sim 58$ K [1]. Our high-resolution ultrasound experiments on this material have revealed that the sound velocity differs for parallel and antiparallel propagation with respect to the external magnetic field. The sign of the nonreciprocity depends on the chirality of the crystal in accordance with the selection rules of the magnetochiral effect. The nonreciprocity is enhanced nonlinearly towards higher ultrasound frequencies.

The underlying picture is that the acoustic phonons inherit the nonreciprocity from the asymmetric magnon excitations via a magnon-phonon band hybridization. This magnon-phonon hybridization results in a band repulsion or anticrossing, which deforms the linear dispersion of the phonons. For the origin of the magnon-phonon hybridization, we propose a chiral magnetoelastic coupling due to the modulation of the Dzyaloshinskii-Moriya interaction by shear strains. There is an overall agreement between the theory and experiment.

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[1] T. Nomura, X.-X. Zhang, S. Zherlitsyn, J. Wosnitza, Y. Tokura, N. Nagaosa, and S. Seki, Phys. Rev. Lett. **122**, 145901 (2019).