Shaking Topological Crystals with Chiral Phonons up to 30 Tesla

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The symmetries of crystals play an important role in the properties of their phonons. In particular, when the mirror symmetries are broken, the lattice ions can display circular motion with finite angular momentum. These modes, known as chiral phonons, have recently been demonstrated in both rotating and propagating lattice motions. Usually, phonons are insensitive to magnetic fields. On the contrary, chiral phonons carry magnetic moment and directly couple to magnetic fields [1].

Giant magnetic moments are predicted to result from electronic contributions to the magnetism of phonons. While such a mechanism establishes the possibility of connecting phonon chirality and electronic topology, no experimental evidence was reported …until now. In this talk, I will present the magnetic response of transverse optical phonons in a set of $Pb_{1-x}Sn_xTe$ thin films, which is a topological crystalline insulator for $x > 0.32$. We studied one sample in the trivial phase ($x = 0.24$) and two samples in the topological phase ($x = 0.42$ and 0.56). We observed the occurrence of a ferroelectric phase in all the samples at a composition-dependent critical temperature. Polarization-dependent terahertz magnetospectroscopy measurements revealed Zeeman splittings and diamagnetic shifts, demonstrating a large phonon magnetic moment. Films in the topological phase exhibited phonon magnetic moment values that were larger than those in the topologically trivial samples by two orders of magnitude. Furthermore, the sign of the effective phonon g-factor was opposite in the two phases, a signature of the topological transition according to our model. These results strongly indicate the existence of interplay between the magnetic properties of chiral phonons and the topology of the electronic band structure [2]. Our work opens new avenues for topology-based devices and applications through magnetic field-based phonon control of electronic states.

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