Effect of symmetry breaking on phonons in noncentrosymmetric magnets

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Symmetry breaking has been a fundamental concept in condensed matter physics related to the emergence of novel electronic states. In particular, spatial-inversion symmetry (SIS) and time-reversal symmetry (TRS) breaking lift the spin degeneracy of the electronic state. Therefore, novel spin-related electric phenomena such as Edelstein effect and the anomalous Hall effect emerge in symmetry-broken-materials. Here we have investigated the effect of SIS and TRS breaking on phononic bands in a chiral magnet MnSi using high-resolution inelastic X-ray scattering and first-principles calculations[1]. We find a momentum-transfer-dependent (q-dependent) splitting between transverse phonon bands having angular momentum parallel or antiparallel to q. This is an indication of the phononic version of spin-momentum locking owing to the SIS breaking. On the other hand, we observed no significant impact from TRS breaking induced by a magnetic field. This suggests the effect of time-reversal symmetry breaking is small or is restricted to a very low energy regime in this material, possibly due to small spin-orbit interaction. To observe the large impact of magnetism in phononic dispersion, some rare-earth compounds having larger spin-orbit coupling seems promising.

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