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Inherited Time-Reversal symmetry breaking in chiral phonons

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概　要

Chiral phonons carry angular momentum and are sensitive to perturbations that break time-reversal symmetry (TRS). In this talk, I will discuss how TRS breaking in the spin, orbital, or electronic sectors can be conveyed to chiral phonons. In many materials, these phonons exhibit Zeeman splitting with an effective phonon magnetic moment on the order of a few Bohr magnetons. This response far exceeds the predictions based on the circular motion of ions, and thus points towards an electronic contribution. Several distinct mechanisms have been identified for this enhanced magnetic response. One such mechanism is orbital-lattice coupling, in which low-energy electronic excitations on a magnetic ion hybridize with phonons, thereby endowing them with a large magnetic moment [1,2]. I will present a microscopic model for the effective magnetic moments of chiral phonons via this mechanism in selected f- and d-orbital magnets. Furthermore, chiral phonon splitting can also occur without external magnetic field, such as due to magnetic dipolar ordering [3]. We propose that chiral phonon splitting can also arise from other TRS-breaking orders, such as octupolar magnetic order [4] which often evade detection by conventional probes. Such splitting can be detected via helicity-resolved Raman spectroscopy, potentially providing a novel probe for such hidden orders. Finally, similar concepts can be extended to other systems in which TRS breaking manifests as non-trivial quantum geometry in the electronic bands [5].

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[3] Che, Mengqian et al., Phys. Rev, Lett. **134**, 196906 (2025)
[4] R. Sutcliffe, K. Hart, S. Chaudhary, and A. Paramekanti, arXiv:2506.18978 (2025)
[5] S. Chaudhary, and T. Oka, arXiv:2508.04132 (2025)

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