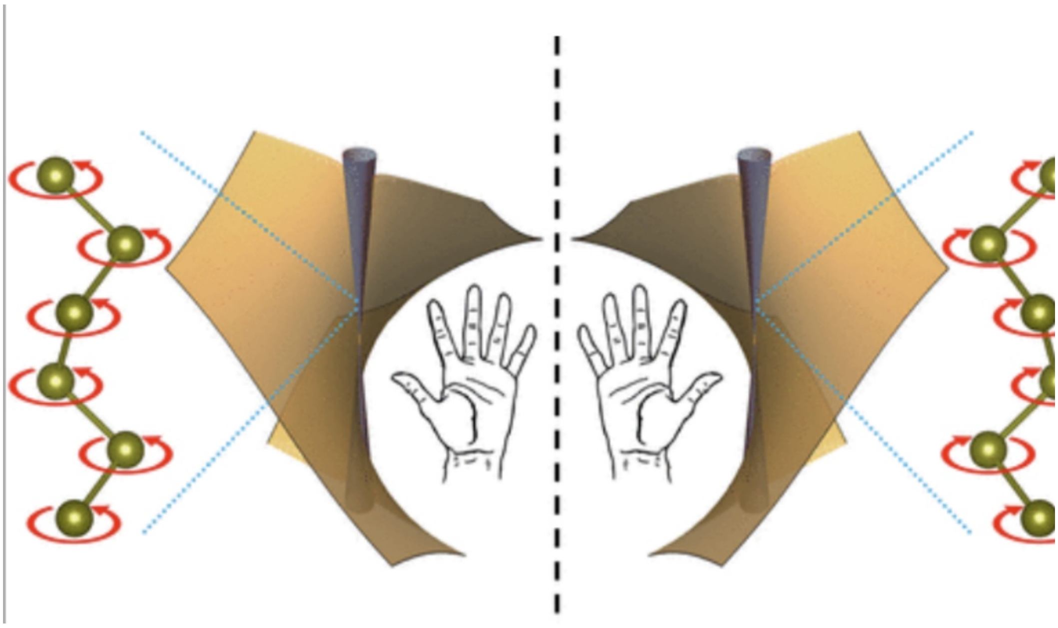
Theory, prediction and detection for topological and chiral phonons

In solids, there are various types of (quasi) particles. Among them, the "excitations" as lattice vibrations, phonons at the terahertz scale directly influence the transport properties, thermal conductivity, and other physical properties of solid materials, and play important roles in structural phase transitions, conventional superconductivity, and other physical mechanisms. However, the "zero spin" and electrically neutral properties make phonons difficult to control, limiting their involvement in the modulation and influence of physical processes. In recent years, with the successful introduction of the "topological" and "chiral" degrees of freedom in the terahertz-scale phonon spectrum, not only has it provided a "control handle" for phonons, but it has also provided new insights into understanding how phonons affect heat conduction, superconductivity, and other fundamental physical phenomena.

In the first half of the talk, I will introduce several classifications and diagnosis methods for topological phonons, as well as the prediction and experimental verification of related materials. Examples include the first topological phonon material FeSi [1-2], the Weyl phonon material BaPtGe with the highest Chern number for each phonon band in solids [3-4], and the nodal line phonon material MoB2 [5]. The second half of the talk will focus on the definition of chiral phonons and several related concepts, the connection and differences between chiral phonons and topological phonons, and how chiral phonons can be experimentally detected. Examples include chiral phonon theories in systems with nonsymmorphic and approximate rotationals symmetries [6-7], the observation of chiral phonons at the center of BZ with high group velocity in α-HgS and elemental Te [8-9], and the relationship between Weyl phonon and chiral phonon [9], as shown in the Figure blow.



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