**Ultrafast and coherence coupling between chiral phonons and spins**

**Abstract:** The electronic and magnetic properties of solids are fundamentally determined by the crystal structures. When the structure keeps evolving, the properties are usually determined by the instantaneous lattice configurations, but this may not always be true. When phonons are coherently excited in solids, the atoms oscillate back and forth around their equilibrium positions, and one would expect the perturbation on electronic properties to largely cancel out. But a qualitative change might be possible with atomic motions called "chiral phonons", which break time-reversal symmetry and have been predicted to cause unexpected magnetic, topological, and transport phenomena. Notably, chiral phonons with quantized angular momentum are simply guaranteed by multi-fold rotational symmetry, and thus are rather common in materials. In this talk, I will first briefly introduce the discovery of chiral phonons in two-dimensional (2D) semiconductors, which exhibit spin-valley locking and chiral electron-phonon coupling. I will then discuss the general properties of chiral phonons originating from time-reversal symmetry breaking, and give an example on the magnetic properties of chiral phonons in rare earth halides, and the ultrafast optical control of magnetization with an effective magnetic field on the order of 1 Tesla. Finally, I will introduce quantum coherent spin-phonon coupling in 2D antiferromagnets, leading to magnon-phonon hybridization, nontrivial topology, and possible chiral edge states. Together, these phenomena demonstrate a new paradigm of dynamic structural-property relationship in quantum materials.

**References:**

1. Luo et al, Science 382, 698 (2023)
2. Lin et al, ACS Photonics 11, 33 (2023)
3. Xu et al, Advanced Materials 35, 2302974 (2023)
4. Luo et al, Nano Letters 23, 2023 (2023)