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Terahertz-frequency magnons and chiral phonons in a kagome ferromagnetic Weyl semimetal

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Kagome lattice provides a rich platform for exploring novel quantum states, emerging from the interplay between its frustrated corner-sharing triangular geometry and intriguing electronic structure. Co3Sn2S2 is a kagome lattice ferromagnet, exhibiting a unique interplay between its electronic wavefunction topology and magnetic spin configuration. This interaction results in several intriguing properties, including Weyl points, a colossal anomalous Hall effect, and a pronounced magneto-optical response.
In the first part of the talk, I will discuss our recent ultrafast study of Co3Sn2S2 [1]. To our surprise, we directly observe two magnon modes in the terahertz range in the time domain. These frequencies exceed typical ferromagnetic resonance frequencies by 1-2 orders of magnitude. These dual modes originate from the strong coupling of localized spin and orbital magnetic moments. These findings unveil an unconventional category of magnons in a ferromagnet stemming from orbital magnetic moments, and position Co3Sn2S2 as a promising candidate for high-speed terahertz spintronic applications.
In the second part, I will report the discovery of chiral phonon modes in Co3Sn2S2 [2]. Using helicity-resolved magneto-Raman spectroscopy, we observe the spontaneous splitting of the doubly degenerate in-plane Eg modes into two distinct chiral phonon modes of opposite helicity when the sample is zero-field cooled below the Curie temperature, in the absence of an external magnetic field. As we sweep the out-of-plane magnetic field, this Eg phonon splitting exhibits a well-defined hysteresis loop directly correlated with the material's magnetization. Our findings highlight the role of the magnetic order in inducing chiral phonons, paving the way for novel methods to manipulate chiral phonons through magnetization and vice versa.
References:
[1] M. Che et al., Discovery of terahertz-frequency orbitally-coupled magnons in a kagome ferromagnet, Science Advances 11, eadw1182 (2025).
[2] M. Che et al., Magnetic order induced chiral phonons in a ferromagnetic Weyl semimetal, Physical Review Letters 134, 196906 (2025).

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