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Ultrafast Coherent THz Lattice Dynamics Coupled to Spins in the van der Waals Antiferromagnet $FePS_3$

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We employed the time-resolved magneto-optical setup described in [1] to study the optically driven lattice and spin dynamics of a 380 nm thick exfoliated flake of the antiferromagnetic van der Waals semiconductor $FePS_3$ as a function of excitation photon energy, sample temperature and external magnetic field [2]. We found evidence of a coherent optical lattice mode with a frequency of 3.2 THz.
The amplitude of the coherent signal vanishes as the phase transition to the paramagnetic phase occurs, revealing its close connection to the long-range magnetic order. The observed phonon mode is known to hybridize with a magnon mode in the presence of an external magnetic field [3], which we utilize to excite the hybridized phonon-magnon mode optically. These findings open a pathway towards the generation of coherent THz photomagnonic dynamics in a van der Waals antiferromagnet, possibly scalable down to thinner flakes. The talk will discuss the properties of the tabletop setup as well as the investigation of the phonon and phonon-magnon dynamics in $FePS_3$.

[1] F. Mertens et al., Review of Scientific Instruments 91 (2020)
[2] F. Mertens et al., Adv. Mater. 35 (2023)
[3] S. Liu et al., Phys. Rev. Lett. 127 (2021)

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