Polarized phonons carry angular momentum in ultrafast demagnetization

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Many laser-excited magnetic materials lose their magnetic order almost completely within femtosecond timescales, but where is the missing angular momentum in such a short time? Here we use ultrafast electron diffraction with THz-compressed electron pulses [1] to reveal in nickel an almost instantaneous, long-lasting, non-equilibrium population of anisotropic high-frequency phonons with an anisotropy plane that is perpendicular to the direction of the initial magnetization [2]. We explain these observations by means of circularly polarized phonons that quickly absorb the angular momentum of the spin system before macroscopic sample rotation [2]. The time that is needed for demagnetization is related to the time it takes to accelerate the atoms. These results provide an atomistic picture of the Einstein-de Haas effect and signify the general importance of polarized phonons and their fluctuations for non-equilibrium dynamics and phase transitions.

References:

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