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Ultrafast magnetic switching by resonant excitation of optical phonons

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Identifying an efficient pathway to change the order parameter via a subtle excitation of the coupled high-frequency mode is the ultimate goal of the field of ultrafast phase transitions. This is an especially interesting research direction in magnetism, where the coupling between spin and lattice excitations is required for magnetization reversal. Despite several attempts however, the switching between magnetic states via resonant pumping of phonon modes has yet to be demonstrated.

To provide strong resonant excitation of the phonon modes, we use pulses from FELIX (Free Electron Laser for Infrared eXperiments, Nijmegen, The Netherlands). The IR/THz light with photon energy ranging between 25 meV and 124 meV (wavelength 10-50 μm) is typically used, with pulse energy between 20 μJ in a single micropulse, and 150 μJ using cavity-dumping.

And thus we show how an ultrafast resonant excitation of LO phonons in magnetic garnet films switches magnetization into a peculiar quadrupolar magnetic domain pattern, unambiguously revealing the magneto-elastic mechanism of the switching. In contrast, the excitation of strongly absorbing TO modes results in thermal demagnetization only. The mechanism appears to be very universal, and is shown to work in samples with very different crystallographic symmetry and magnetic properties, such as antiferromagnets.

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