

Terahertz switching of antiferromagnetic order by Néel spin-orbit torque

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Ultrafast electric manipulation of magnetic order is a critical requirement for future terahertz data processing [1,2]. In suitable antiferromagnets, Néel spin-orbit torques [2,3] offer a fascinating mechanism for controlling the spin orientation by electric current pulses [4]. However, such switching has not been achieved on the ultrafast timescales of antiferromagnetic spin dynamics. Here, we demonstrate experimentally that phase-locked terahertz current pulses launch robust, directional and non-thermal rotation of the Néel vector \mathbf{L} by 90° in antiferromagnetic Mn_2Au [5]. The results are fully consistent with ultrafast Néel spin-orbit torque: First, we show by nonlinear optical imaging that opposite current-pulse polarity results in an opposite final orientation of \mathbf{L} . Second, transient optical birefringence reveals that the switching is completed in less than 15 picoseconds, which is in excellent agreement with atomistic spin-dynamics simulations. The switching speed surpasses ferromagnets by one order of magnitude, while involving comparable dissipated energy. Simulations indicate a minor role of thermal effects and routes for significant improvements in optimized sample systems. Our approach may further help to identify the mechanisms underlying ultrafast switching in a wider range of systems, including magneto-electric insulators and altermagnets. We expect that engineering of spin torques, resonance frequencies and read-out mechanisms will open up new pathways toward on-chip applications of terahertz antiferromagnetic spin-orbitronics.

References:

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