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# Ultrafast terahertz magnetometry

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A material's magnetic state and its dynamics are of great fundamental research interest and are also at the core of a wide plethora of modern technologies. However, reliable access to magnetization dynamics in materials and devices on the technologically relevant ultrafast timescale, and under realistic device-operation conditions, remains a challenge. Here, we demonstrate a method of ultrafast terahertz (THz) magnetometry, which gives direct access to the (sub-)picosecond magnetization dynamics even in encapsulated materials or devices in a contact-free fashion, in a fully calibrated manner, and under ambient conditions. As a showcase for this powerful method, we measure the ultrafast magnetization dynamics in a laser-excited encapsulated iron film. Our measurements reveal and disentangle distinct contributions originating from (i) incoherent hot-magnon-driven magnetization quenching and (ii) coherent acoustically-driven modulation of the exchange interaction in iron, paving the way to technologies utilizing ultrafast heat-free control of magnetism. High sensitivity and relative ease of experimental arrangement highlight the promise of ultrafast THz magnetometry for both fundamental studies and the technological applications of magnetism.

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