Ultrafast, Element-Specific, Demagnetization Dynamics Probed using Coherent High Harmonic Beams

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Element-specific magnetization dynamics on nanometer length scales and femtosecond timescales is a topic of intense current interest. Questions on, e.g., femtosecond magnetization processes, ultrafast dynamics of nanodomains, or ultrafast interaction in magnetic multilayer systems have motivated a variety of studies using magneto-optic effects probed by ultrafast light pulses. Magneto-optical dynamics studies currently make use of either ultrafast lasers or x-rays from large-scale synchrotrons. Ultrafast pulses from femtosecond lasers (∼20 fs) make high time resolution easily accessible, however, these studies lack element selectivity. X-rays from synchrotrons, on the other hand, enable element-specific probes using photons with energy near the absorption edges of ferromagnetic materials. Moreover, nanometer imaging capabilities are also possible using x-rays. However, the relatively poor time resolution available from x-ray facilities (∼100 fs using femtosecond slicing) to date has been too slow to resolve the fastest magnetization dynamics.

Ultrafast, coherent, table-top, x-ray sources based on high-harmonic upconversion of femtosecond lasers promise to overcome these limitations by providing a new tool to study how magnets work at the shortest time and length scales, with element specificity. In this work, we use few-femtosecond extreme ultraviolet (EUV) pulses from high harmonic generation (HHG) to extract demagnetization dynamics and hysteresis loops of a compound material for the first time [La-O-Vorakiat *et al.*, PRL 103, 257402 (2009)]. We measure the fastest, elementally-specific, demagnetization dynamics of any approach to date, with a time resolution of 55 fs.

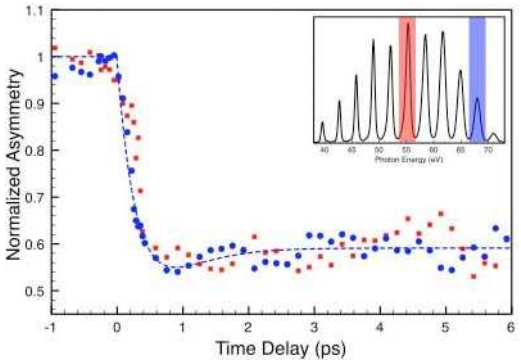

Figure 1: Time-resolved measurement of ultrafast demagnetization in a Permalloy film probed using few-fs high-harmonic beams around the Ni (blue circle) and Fe (red square) M-edge.