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Nanoscale Magnetic Gratings Generated and Probed by Femtosecond EUV Pulses

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The capability to conduct extreme ultraviolet (EUV) transient grating (TG) experiments at the TIMER beamline at FERMI opens multiple avenues for studying ultrafast dynamics of condensed matter on the nanoscale. In the first EUV TG experiments [1], the signal was dominated by the thermoelastic response of the sample. A very recent study [2] showed that with a probe wavelength tuned to an absorption edge of a transition metal element, TG measurements become sensitive to dynamics of the electronic and spin systems. In particular, Ref. [2] described the first observation of nanoscale transient gratings of magnetization. In this talk, we will discuss further experiments with magnetic transient gratings conducted at the TIMER beamline in summer 2020. Similarly to the initial experiment, we used a probe wavelength of 20.8 nm tuned to the M-edge of Co; the excitation wavelength was either 20.8 or 41.6 nm, yielding TG periods of 44 and 87 nm. By using a polarizing mirror placed behind the sample, we demonstrate that the diffraction signal from the magnetization grating is polarized orthogonally to the incident linearly polarized probe beam. Consequently, the magnetic TG signal can be separated from non-magnetic thermoelastic and electronic responses. Our measurements reveal drastic differences between the magnetic TG responses from Co-Ni and Co-Pt multilayers and those from a CoGd alloy. Furthermore, we observe a highly unusual dependence of the magnetic TG decay dynamics on the TG period and excitation energy. We also observe an unexpected dependence of the "coherent peak" on the magnetic field and the sense of the circular polarization of the excitation pulses, possibly suggesting a spin-sensitive nonlinear optics process.

[1] Bencivenga, F., *et al.* Nanoscale transient gratings excited and probed by extreme ultraviolet femtosecond pulses, Sci. Adv. **5**, *eaaw5805* (2019).
[2] Ksenzov, D., *et al.* Nanoscale Transient Magnetization Gratings Excited and Probed by Femtosecond Extreme Ultraviolet Pulses, arXiv:2009.13330 [cond-mat.mes-hall] (2020).

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