Laser-induced ultrafast demagnetization and perpendicular magnetic anisotropy reduction in a Co88Tb12 thin film with stripe domains

Marcel Hennes, Alaa El Dine Merhe, Xuan Liu, David Weder, Clemens von Korff Schmising, Michael Schneider, Christian Michael Günther, Benoît Mahieu, Grégory Malinowski, Michel Hehn, et al.

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[1]M. Hennes, [1]A. Merhe, [1]X. Liu, [2]D. Weder, [2]C. von Korff Schmising,[2]M. Schneider, [3]C. M. Günther,[4]B. Mahieu, [5]G. Malinowski, [5]M. Hehn, [5]D. Lacour, [6]F. Capotondi,

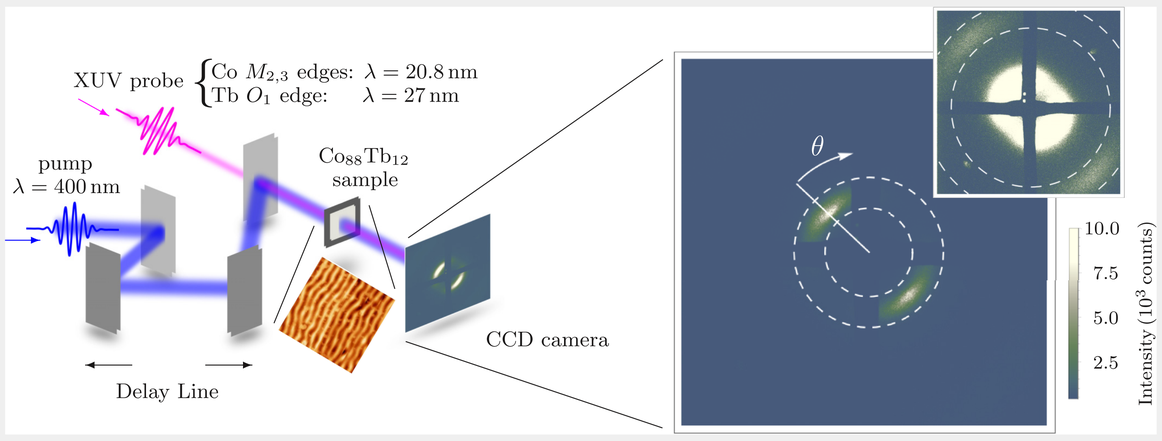
[6]E. Pedersoli , [6]I. P. Nikolov, [1]V. Chardonnet,[1]E. Jal ,[1]J. Lüning and [1]B. Vodungbo

[1]Laboratoire de Chimie Physique – Matière et Rayonnement, CNRS, Sorbonne Université, 75005 Paris, France
[2]Max Born Institut für Nichtlineare Optik und Kurzzeitspektroskopie, 12489 Berlin, Germany
[3]Institut für Optik und Atomare Physik, Technische Universität Berlin, 10623 Berlin, Germany
[4]Laboratoire d'Optique Appliquée, ENSTA ParisTech, CNRS, Ecole Polytechnique, Université Paris-Saclay, 91762 Palaiseau Cedex, France
[5]Institut Jean Lamour, CNRS, Université de Lorraine, 54000 Nancy, France
[6]FERMI, Elettra-Sincrotrone Trieste, 34149 Basovizza, Trieste, Italy

Abstract

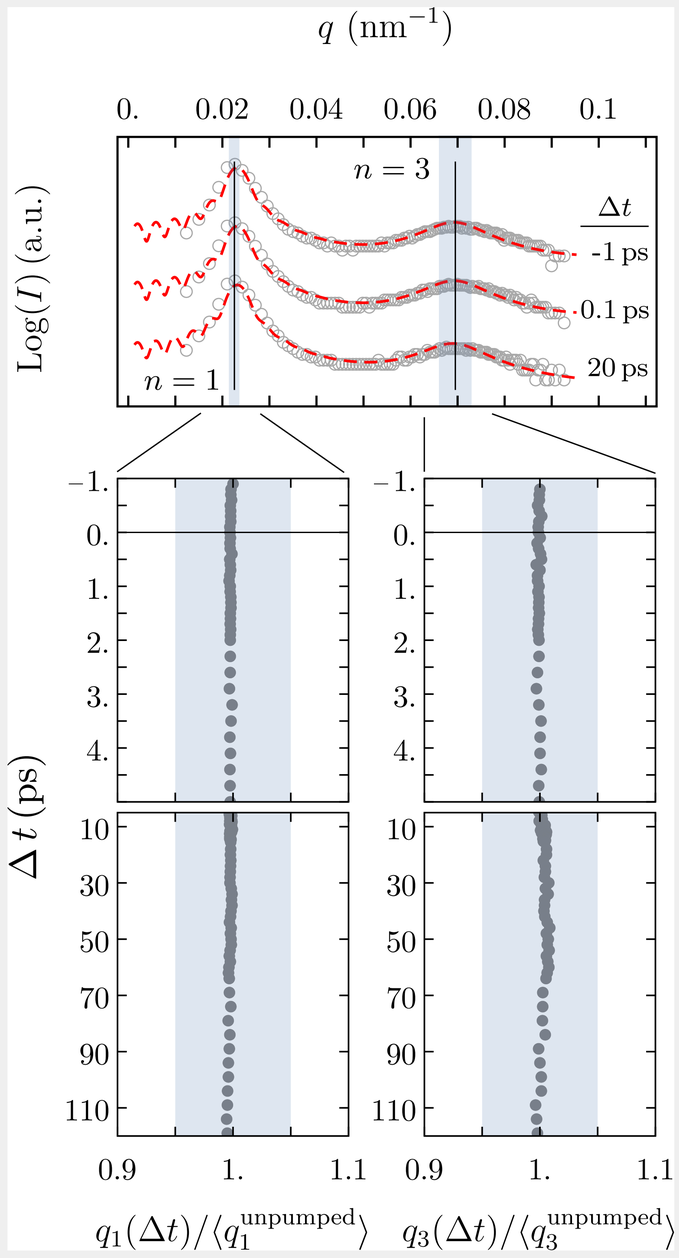
We use time-resolved x-ray resonant magnetic scattering (TR-XRMS) at the Co $M_{2,3}$ and Tb O_1 edges to studyultrafast demagnetization in an amorphous $Co_{88}Tb_{12}$ alloy with stripe domains. Combining the femtosecond temporal with nanometer spatial resolution of our experiment, we demonstrate that the equilibrium spin texture of the thin film remains unaltered by the optical pump pulse on ultrashort timescales (< 1 ps). However, after 4 ps, we observe the onset of a significant domain wall broadening, which we attribute to a reduction of the uniaxial magnetic anisotropy of the system, due to energy transfer to the lattice. Static temperature-dependent magnetometry measurements combined with analytical modeling of the magnetic structure of the thin film corroborate this interpretation.

X-ray resonant magnetic scattering [1]



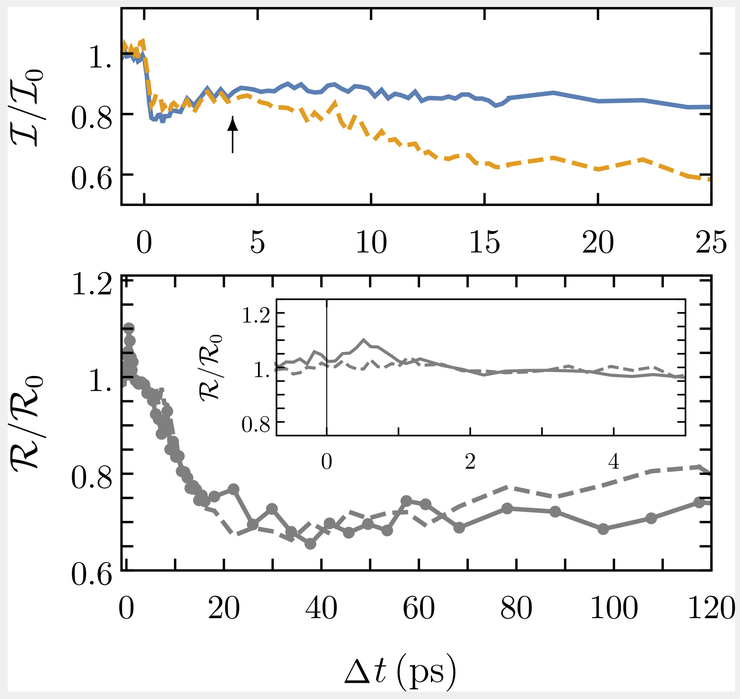
Experiment realized at FERMI free electrons laser
$Co_{88}Tb_{12}$ sample presenting a stripe domains structure
Observing intensity of scattering orders (1st and 3rd) as a function of time delay

Azimuthal integration of scattering pattern (along θ)



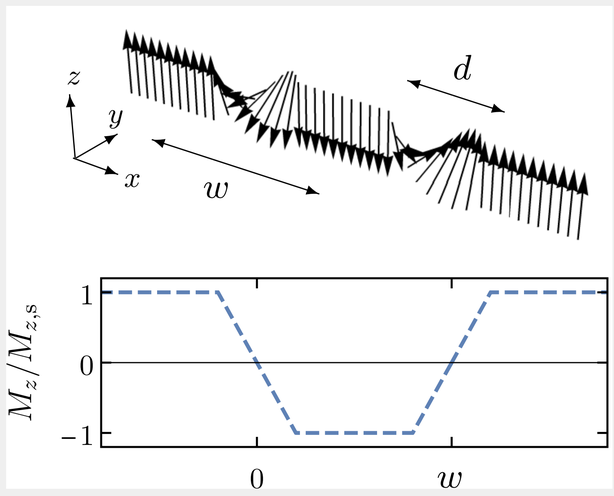
1st and 3rd peaks remain fixed as function of time
No modification of the domain structure periodicity

Scattering intensity as function of time delay

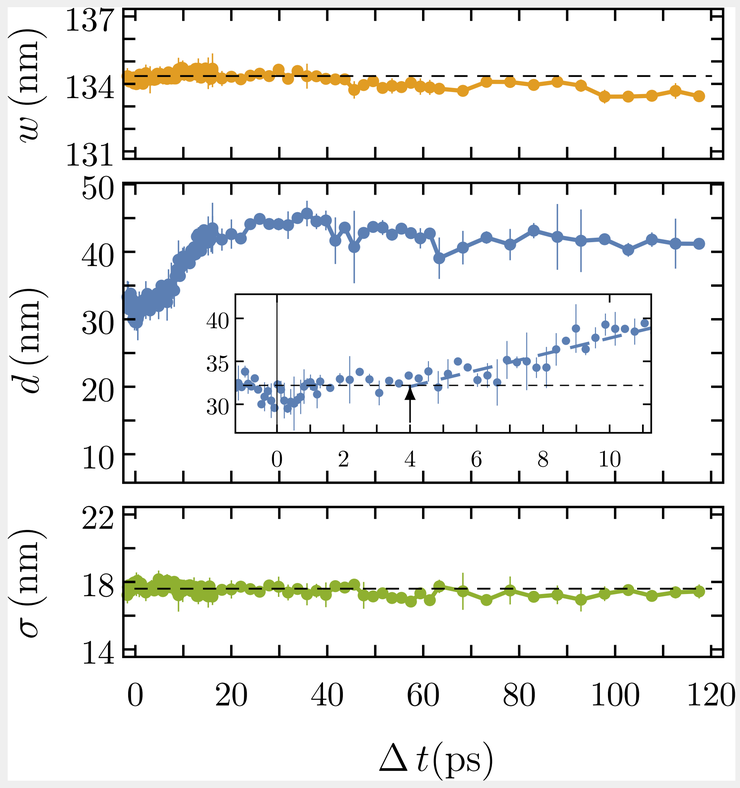


1st and 3rd orders intensity have very different dynamics
This reveals a modification of the domain wall region

Fit to domain wall model [2]



Magnetic domain structure describe with linear domain wall



The domain wall width increases on the picosecond timescales

Conclusion

We attribute this increase in domain wall width to a modification of the magnetic anisotropy since $d \propto \sqrt{\frac{A}{K_u}}$, where A is the exchange stiffness (which we suppose mostly constant) and K_u is the magnetic anisotropy.

References
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2 O. Hellwig et al., Phys. B: Condens. Matter 336, 136 (2003).
3 M. Hennes et al., Phys. Rev. B 102, 174437 (2020).