An Element-specific View on Ultrafast Magnetization Reversal of GdFeCo

I. Radu[1,2], K. Vahaplar[1], C. Stamm[2], T. Kachel[2], H. Dürr[2], T. Ostler[3], R. Chantrell[3], A. Tsukamoto[4], A. Itoh[4], A. Kirilyuk[1], Th. Rasing[1], A.V. Kimel[1]

[1]*IMM, Radboud University Nijmegen, Nijmegen, The Netherlands*
[2]*BESSY II, Helmholtz-Zentrum Berlin GmbH, Berlin, Germany*
[3]*Department of Physics, University of York, York, United Kingdom*
[4]*College of Science and Technology, Nihon University, Chiba, Japan*

Recent experiments have shown that femtosecond (fs) laser excitation is able to manipulate and even control spins in magnetic systems at unprecedented speeds [1,2]. In particular, a radical new approach in switching the magnetization using circularly polarized fs laser pulses has been recently demonstrated [2]. All these experiments have raised intriguing questions about ultrafast channels of angular momentum transfer from and to the spin system and microscopic processes governing the all-optical magnetization switching.

Here, we report on element- and time-resolved X-ray magnetic circular dichroism (TRXMCD) investigations of the fs laser-induced magnetization reversal of the ferrimagnetic GdFeCo alloy. We trigger the magnetization switching by driving the sample over its magnetization compensation temperature upon excitation with linearly polarized fs laser pulses. The subsequent dynamics of the Fe and Gd magnetic moments of the composite alloy is probed with 100 fs X-ray pulses. The TRXMCD data reveal a clearly distinct switching dynamics at the Fe and Gd sites: while Fe magnetic moment switches within 400 fs it takes around 2 ps for the Gd moment to reach the magnetization reversed state. This observation is highly intriguing since the expectation is to have identical dynamics for both sub-lattices accounting for the strong exchange interaction which governs their magnetic ordering. These results suggest a novel non-equilibrium state to be responsible for the genuine magnetization switching process where the elemental magnetic moments show a highly divergent transient behavior. The nature of the novel non-equilibrium state, its possible origins and the implications with respect to the all-optical magnetization switching mechanism will be discussed.

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[2] C.D. Stanciu et al., Phys. Rev. Lett. **99**, 047601 (2007).