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Distinguishing the ultrafast dynamics of orbital and spin magnetic moments in solids

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Ultrafast magnetization dynamics is an important issue for both fundamental science and for applications in order to optimize spin manipulation on a microscopic level. Since the first observation of laser induced spin dynamics,¹ the mechanisms of angular momentum dissipation at picosecond timescales have been widely debated. In order to progress in the understanding of such microscopic ultrafast mechanisms, it is now possible to probe absolute values of magnetization with a high temporal resolution (100 fs). In this context, we have used ultrashort optical laser pulses (60 fs duration) to induce changes of the magnetization in a ferromagnetic CoPd alloy film with perpendicular anisotropy. The dynamics was probed with ultrashort circularly polarized femtosecond X-ray pulses, measuring the X-ray magnetic circular dichroism (XMCD) at Co L_{2,3} edges.^{2,3} We observe that the two components of the magnetic moments (L and S) show different ultrafast dynamics and that the spin-orbit coupling related to the magneto-crystalline anisotropy in solids is strongly affected by fs laser pulses in the ultrashort time scales. These dynamics can be compared to the purely electronic effect at the CoL₃ edge. Electronic excitations and their response to the laser pump pulse will be discussed and related to the modifications in the spin-orbit coupling. We will compare our results with time resolved MOKE experiments recently performed on CoPd alloys.

¹Beaurepaire, E., Merle, J.C., Daunois, A., and Bigot, J.-Y. *Phys. Rev. Lett.* **76**, 4250 (1996).

²Stamm, C. Kachel, T., Pontius, N., Mitnzer, R., Quast, T., Holldack, Khan, S., Lupulescu, C., Aziz, E. F., Wietstruk, M., Dürr, H. A., and Eberhardt, W. *Nature Mater.* **6**, 740-743 (2007).

³C. Boeglin, E. Beaurepaire, V. Halté, V. Lopez-Flores, C. Stamm, N. Pontius, H. Dürr, J. -Y. Bigot “Observing how fast the spin-orbit interaction branches spin and orbital moments in solids” *Nature* 465, 458 (2010).