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Charges and spins dynamics induced by mid-infrared femtosecond laser pulses

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The question "How fast can the magnetization be manipulated?" is of crucial importance not only from a fundamental point of view but also for several industrial applications such as magnetic memories. In that context, femtosecond magneto optics is a powerful technique to induce and to study the ultrafast magneto optical processes resulting from an ultrashort optical excitation. It is well known that femtosecond laser pulses can demagnetize a ferromagnetic film during the thermalization of the charges [1], a process that follows a coherent coupling between the laser pulses and the spins [2]. In the "all optical" pump-probe experiments performed so far, the excitation energies were in the visible region of the electromagnetic spectrum. In that case, the absorption of a laser pulse excites electrons with high energies above the Fermi level, resulting both in intra and interband transitions. The aim of the present study is to show how the ultrafast demagnetization and how the subsequent rapid re-magnetization occurs when exciting a ferromagnetic material with low energy infrared pulses.

Towards that goal, we have developed and used an experimental set-up delivering mid-infrared femtosecond laser pulses (λ= 4.88µm) to excite $CoPt_3$ and Ni ferromagnetic thin films. The magneto-optical response is then probed in the visible (λ= 798nm). In such conditions of excitation, the fundamental state of the ferromagnetic nanostructure is only slightly perturbed with pumping photons having an excess energy of 0.254 eV above the Fermi level.

Our results (Fig. 1) show that even though only intraband transitions occur, the demagnetization [a) and d)] process and its subsequent relaxation to the lattice [b) and e)] and to the environment [c) and f)] are still the dominant processes involved in the magnetization dynamics. We also show that the material band structure is important to interpret the thermalization dynamics of the spins that occur before the heating of the lattice. For specific experimental configurations, we show that it is possible to induce a motion of precession of the magnetization around the effective magnetic field and observe it while it is damped.

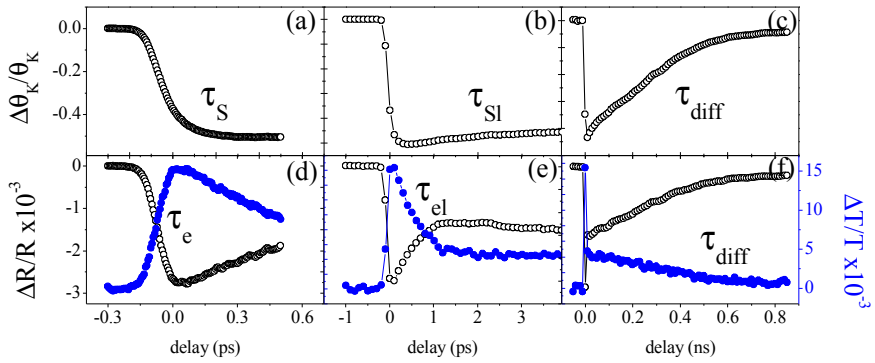

Fig. 1: *D*ynamics of spins a) b) and c) and charges d), e) and f) of 15 nm thick $CoPt_3$ film pumped in the mid infrared (4.88 µm) and probed in the visible (800 nm)

Références

[1] L. Guidoni, E. Beaurepaire, and J. -Y. Bigot, Phys.Rev.Lett. 89, 17401 (2002).
[2] J. -Y. Bigot, M.Vomir, and E. Beaurepaire, Nature Physics 5,515-520 (2009).

*Je souhaite concourir au prix « présentation orale » et je déclare être une chercheuse non-permanente n'ayant pas encore soutenu l*a thèse.