Groupe d'Etude de la Matière Condensée UVSQ CNRS

Séminaire

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Ultrafast magneto-acoustics: studying the dynamics of spin angular momentum

Manipulating the magnetization of materials with laser pulses is one of the driving research focus in the fields of Spintronics and Spinphotonics. Direct applications such as "Heat Assisted Magnetic Recording" are envisaged as well as fundamental studies of the spin-photon interaction, the excitation and propagation of magnons, the detection of element specific magnetic states using High Harmonic Generation, for example… Naturally the advantage of using laser pulses is the extremely accurate temporal resolution of a few femtoseconds which allows investigating the relaxation mechanisms leading to a change and to the recovery of the magnetization (spins thermalization, spin-lattice relaxation, precession of the magnetic vector around its effective field [1,2]).

Another interesting approach is to avoid heating the spins and charges by directly transferring angular momentum to the spins on the picosecond time scale using acoustic pulses as was demonstrated in the case of nickel films [3]. There are several advantages to use such technique: the magnetic material remains close to its fundamental state, the acoustic pulses can propagate over several microns, and moreover sequences of acoustic pulses can easily be generated in the acoustic transducer using the flexibility of optics [4]. In addition, since no radio-frequency cavity is necessary, one can probe local changes of the magnetization which are relevant to size of magnetic domains.

In this presentation I will describe the principles of ultrafast magneto-acoustics. After a brief review of the relaxation mechanisms associated to a direct laser excitation (heating of the spins) I will illustrate the advantages of acting only on the spin angular momentum, therefore bypassing thermal effects. I will also report about the observation of the motion of non-magnetic nanoparticles on top of an acoustic transducer, with extreme spatial resolution of ~1 Å in the longitudinal direction of excitation [5].

[1] J.−Y. Bigot, M. Vomir, E. Beaurepaire, *Nature Physics* **5**, 461 (2009).
[2] J.-Y. Bigot, M. Vomir, *Ultrafast magnetization dynamics of nanostructures*, *Annalen der Physik*, Review article **525**, No. 1–2, 2–30 (2013).
[3] J.-W. Kim, M. Vomir, and J.-Y. Bigot, *Phys. Rev. Lett.* **109**, 166601 (2012).
[4] J.-W. Kim, M. Vomir, and J.-Y. Bigot, *Scientific Reports* **5** : 8511 (2015).
[5] J.-W. Kim, O. Kovalenko, Y. Liu and J.-Y. Bigot, *ACS Nano* ***10*** (12), pp 10880–10886 (2016).

Jean-Yves Bigot is Research Director at CNRS. He received his PhD from the University of Strasbourg in 1984. After a post-doc at AT&T Bell Laboratories, he was staff scientist at Lawrence Berkeley Laboratory in the groups of Charles Shank and Daniel Chemla with whom he investigated the dynamics of excitons in Semiconductor Quantum Wells. In the 90^{ies} he developed a femtosecond lab in Strasbourg dedicated to the study of ultrafast processes in condensed matter physics. He has studied fundamental coherent and relaxation mechanisms such as the wave packet dynamics of polymer backbones, the surface plasmon dynamics in metallic nanoparticles, the transfer of protons in the protein GFP, the spins dynamics in ferromagnetic materials. He pioneered the field of Femtomagnetism which is his main current research activity. He has successively directed the Group of Nonlinear Optics at Ipcms, was deputy director of Ipcms and director of the Labex NIE "Nano-objects Interacting with their Environment". His actual research projects are focusing on time resolved processes in magnetic nanostructures and molecular magnets using femtosecond spectroscopy, High Harmonic Generation and picosecond magneto-acoustics. He is leading the Equipex UNION, a multi-usage facility dedicated to the study of Ultrafast Phenomena,
Awards: Silver medal of CNRS 2008; ERC advanced grant 2009 - Atomag project; 2000 Louis Ancel award from the SFP (Société Française de Physique). In 2016 he received the Ricard award from the SFP.

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