3 years PhD position on

Ultrafast All Optical Magnetization Switching in transition metal rare earth alloys

available at the Université Pierre et Marie Curie (Paris)

Scientific Context

The research group Strongly correlated and Magnetic Materials at the Laboratoire Chimie Physique – Matière et Rayonnement (LCPMR) has pioneered the investigation of ultrafast magnetization dynamics using time resolved resonant X-ray scattering techniques at femtosecond pulsed High Harmonic Generation (LOA, CEA) [1,2] and X-ray Free Electron Laser (FLASH, FERMI, LCLS) sources [3]. Thus combining femtosecond temporal with nanometer spatial resolution has given strong evidence for significant angular momentum transport by the IR pump laser excited spin polarized valence electrons [4,5,6].

Angular momentum transport has also been proposed [7] as the mechanism underlying the recently discovered all-optical switching phenomenon. This phenomenon has been thought to originate from the interplay between the antiferrimagnetically coupled magnetic sub-systems of transition metal – rare earth alloys [8]. Laser excitation was proposed to give rise to spin polarized currents between regions respectively rich in transition metal and rare earth elements. In view of the recent demonstration of all-optical switching in a variety of different materials, ranging from alloys to engineered complex heterostructures, this model is difficult to uphold and the quest for explaining the scientifically interesting and technologically relevant phenomenon of all-optical switching is once again opened.

Objectives and means

The goal of the here proposed thesis project is to apply advanced X-ray scattering and spectroscopy techniques to probe element selectively the magnetization dynamics of the individual components of complex heterostructures. In particular, the PhD student will have to develop magnetic spectroscopy techniques at the N and O absorption edges of rare earth elements. This will involve experimental work to design, realize and exploit X-ray pump/Infrared probe set-ups. The PhD student will have access to the state-of-the-art HHG source of the LOA and will have support from experience scientists for the optimization of the source. Specifically engineered sample will be produced either at LCPMR or at IJL, Nancy, a worldwide leading laboratory for the fabrication of complex magnetic samples [8]. In fact, this thesis project is part of an on-going collaboration between the IJL in Nancy, the LCPMR in Paris and the LOA located south of Paris in Palaiseau. The PhD student will also participate in complementary experiments at XFEL of the LCPMR group, which has an excellent track record in obtaining access to these novel X-ray sources.

Profile & requested skills

The candidate should have a Master degree in Physics, Material sciences or a related discipline. A background and strong interest in solid state physics, especially magnetism, is expected. Experience with X-ray spectroscopy, femtosecond pulsed laser sources, and general optics would be advantageous. Since part of the project will be realized within larger collaborations, excellent communication skills as well as the ability to work independently are crucial

Location

The PhD student will work at the LCPMR, ideally situated in the center of Paris. Sample preparation, characterization and data analysis will be conducted there. The HHG experiments will be conducted at LOA in Palaiseau, located 30' south of Paris. XFEL experiment will take place at FLASH (Hamburg, Germany), FERMI (Trieste, Italy) and LCLS(Stanford, USA).

Supervisors

Ass. Pr. Boris Vodungbo: boris.vodungbo@upmc.fr, +33 (0) 1 44 27 66 17
Pr. Jan Lüning: jan.luning@upmc.fr, +33 (0) 1 44 27 66 07

Application deadline

Candidates should send a detailed CV and a motivation letter to Dr. Boris Vodungbo (boris.vodungbo@upmc.fr) before 15th of June 2015. The position is supposed to be filled in fall 2015.

References

[1] Table-top resonant magnetic scattering with extreme ultraviolet light from high-order harmonic generation, B. Vodungbo et al., European Physics Letters 94, 54003 (2011).
[2] Towards enabling femtosecond helicity-dependent spectroscopy with high-harmonic sources, G. Lambert et al., Nature Communications 6, 6167 (2015).
[3] Ultrafast Dynamics of Magnetic Domain Structures Probed by Coherent Free-Electron Laser Light, L. Müller et al., Synch Rad News 26, 27 (2013).
[4] Laser-induced ultrafast demagnetization in the presence of a nanoscale magnetic domain network, B. Vodungbo et al., Nature Communications 3, 999 (2012).
[5] Ultrafast optical demagnetization manipulates nanoscale spin structure in domain walls, B. Pfau et al., Nature Communications 3, 1100 (2012).
[6] Imaging Ultrafast Demagnetization Dynamics after a Spatially Localized Optical Excitation, C. von Korff Schmising et al., Phys. Rev. Lett. 112, 217203 (2014).
[7] Nanoscale spin reversal by non-local angular momentum transfer following ultrafast laser excitation in ferrimagnetic GdFeCo, C. Graves et al., Nature Materials 12, 293 (2013).
[8] Engineered materials for all-optical helicity-dependent magnetic switching, S. Mangin et al., Nature Materials 13, 286 (2014).