CORE-CM SEMINAR
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Observation and manipulation of antiferromagnetic distributions in magneto-electric multiferroics

Antiferromagnets (AF) are currently in the limelight thanks to recent breakthroughs demonstrating the efficient effect of spin currents in interacting with the AF order parameter [1,2]. So far, due to the lack of net magnetization, controlling AF distributions has been rather challenging. Current-induced AF control also opens therefore new perspectives in Terahertz magnetization dynamics. On the materials side, antiferromagnets represent the large majority of magnetic materials and some of them show several simultaneous coupled ordered phases. They are commonly called 'multiferroics'. As a result, when the AF order is coupled to a net polarization, it may be controlled by applying a voltage. Multiferroic materials [3] are the focus of an intense research effort due to the significant technological interest of multifunctional materials as well as the rich fundamental physics lying in the coupling of various order parameters. Among all multiferroics, $BiFeO_3$ (BFO) is a material of choice because its two ordering temperatures (ferroelectric FE and AF) are well above room temperature. In addition, a large magnetoelectric coupling has been demonstrated in single crystals as well as in thin films. One downside of multiferroics is that these FE/AF textures can be rather challenging to assess. Second harmonic generation has proven to be a powerful and elegant way to image complex multiferroïc textures and to unentangle the different contributions at play [4]. In this presentation, I will present a study demonstrating the possibility to use second harmonic generation (SHG) to access the micron sized distribution of AF domain (Figure 1) in a multiferroic thin film [5]. Subsequently, we will study their ultrafast dynamics by assessing the time evolution of the multiferroic texture when subjected to an intense femtosecond light pulse. Eventually we will discuss how they could be efficiently manipulated by the internally optically rectified sub-picosecond electric fields which could open the door to an all-optical terahertz control the AF order, independently of the electric polarization, but still using the magnetoelectric effect. Another interesting consequence of this large magneto-electric coupling is the stabilization a spin cycloid. As topology is now playing a major role in spintronics, tailoring chiral antiferromagnetic features is therefore of significant relevance and in a last part I will discuss the observation and manipulation of these chiral objects in thin $BiFeO_3$ epitaxial layers [6,7].

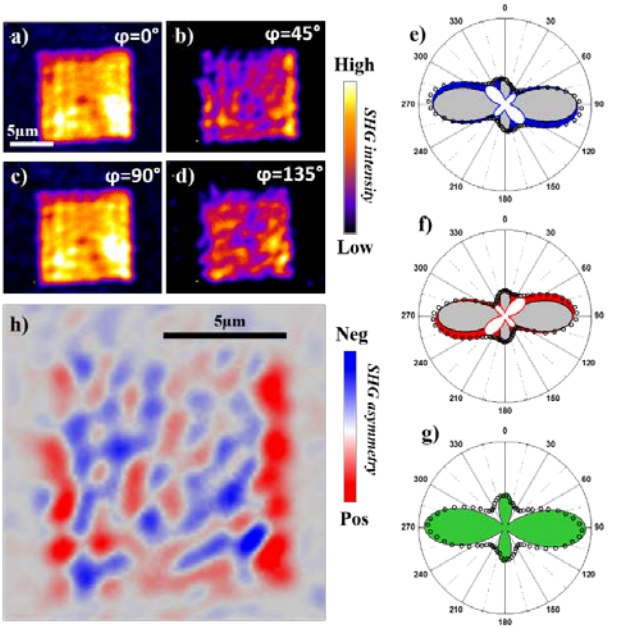

Figure 1 : SHG study of antiferromagnetic domains in BiFeO3 thin epitaxial layer. (a-d) SHG intensity images for different incident light polarization direction, ϕ. (e-g) 3 kind of Polarization angular dependence of the SHG intensity observed in the ferroelectric monodomain.(h) Reconstructed AF domains image [5].

References

[1] T. Jungwirth, X. Marti, P. Wadley and J. Wunderlich *Nature Nanotech*. **11**, 231 (2016) [2] P. Wadley and al. *Science* **351**, 587 (2016) [3] N. Spalding and M. Fiebig, *Science*, **309**, 391 (2005) [4] M. Fiebig & al., *Nature*, **419**, 818, (2002) [5] J.-Y. Chauleau & al., *Nature Materials*, **16**, 803, (2017) [6] I. Gross et al., Nature, **549**, 252, (2017) [7] J.-Y. Chauleau & al., *Nature Materials*, in press (2019)

Thursday, October 31, 2019
12:00 NOON
Room 1400 – Biomedical & Physical Sciences
Professor Tyler Cocker - Host