Investigating Spin Dynamics with Optical and X-ray Probes

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The dynamics of spins and spin ordering form the foundation of critical technologies and spin dynamics will play an important role in the emerging quantum information revolution. The spin dynamics in magnetically ordered materials (ferro-, ferri-, anti-ferromagnets) span many orders of magnitude in frequency space and it is also desirable to separate the spin dynamics of different constituents in a heterogeneous system. I will discuss different approaches to examining spin dynamics with various optical and x-ray probes. On the low energy side, we use a laser-based time-resolved magneto-optic Kerr effect (tr-MOKE) system to examine the spin dynamics of magnetic layers weakly coupled by a non magnetic layer. The tr-MOKE data reveal a mutual influence of the dynamics of one layer upon the other, even in the extreme case of no measurable coupling and when the second layer is driven well off the resonance of the first. A second technical approach directly reveals this mutual influence on the spin dynamics of layered magnetic structures by combining excitation of uniform precession modes (ferromagnetic resonance) with the power of core-level x-ray spectroscopy (x-ray magnetic circular dichroism or XMCD) to quantify the spins on different elements. Bridging these two techniques is a variation of tr-MOKE using extreme ultraviolet (EUV) photons termed high harmonic generation (HHG). With HHG we can also examine element-specific dynamics but with access to much higher frequencies (~1 THz and higher). I will discuss how these different techniques can be used to examine spin dynamics from the GHz to the THz range in magnetic multilayers, ferrimagnetic alloys, and oxide thin films.

Bio:
Dr. Arena earned a Ph.D. in physics from Rutgers, the State University of New Jersey, in 2000. He was a postdoc at Lawrence Livermore National Laboratory in California. Subsequently, he was awarded a National Research Council Research Fellowship in 2001, supporting his employment at the Naval Research Laboratory in Washington, D.C. while stationed at the National Synchrotron Light Source (NSLS). The NSLS was a scientific user facility at the U.S. Department of Energy's Brookhaven National Laboratory (BNL) in Upton, NY on Long Island. From 2003 – 2015, he was a Physicist at the NSLS and its successor facility NSLS-II. In 2015, Dr. Arena moved to the Department of Physics at the University of South Florida (USF) in Tampa, FL. Dr. Arena is the co-author of over 120 peer-reviewed scientific articles and is an Academic Editor of the open-access journal *AIP Advances*. He is a recipient of a Fulbright Core Fellowship for 2017 – 2019, for collaborative research at Uppsala University, Uppsala, Sweden.