Spin dynamics in antiferromagnets and its applications

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In-person: EEB248
Online: Zoom link:
https://usc.zoom.us/j/99956388667?pwd=UHZ2bEZSY0FuakM5dGFwcU1GcTB2QT09

Abstract: Antiferromagnets (AFM) materials have ordered spin moments that alternate between individual atomic sites, which gives them a vanishing macroscopic magnetic signature and picosecond intrinsic timescale. Traditionally, AFM materials have played a secondary role to ferromagnets, which are used as active elements in commercial spintronic devices like magnetic sensors and non-volatile magnetic memory. However, it was recently suggested that spin transfer torque could in principle be used to manipulate the magnetic order in AFMs, leading to either stable AFM order precessions for their use as high-frequency oscillators, or switching of the AFM order for their use as magnetic memories.

My presentation will focus on the physics and modeling of electrically driven spin dynamics in thin films of two unique AFMs: Cr_2O_3, a single-phase magnetoelectric material that can be manipulated solely with electric fields and the Weyl semi-metal Mn_3Sn in which spin torque can induce chiral spin rotations. Cr_2O_3- based ferromagnet-free random access memory has been experimentally demonstrated, while in the case of Mn_3Sn, spin torque driven dynamics were found to induce chiral oscillations, from the megahertz to the terahertz frequency range. These materials can overcome the central challenge of manipulating and reading the AFM's order parameter via microelectronics compatible circuitry, thus allowing us to develop antiferromagnetic spintronics along a similar route as ferromagnetic spintronics.

I will discuss my group's recent work in developing new analytic models and numerical techniques to handle the complex domain dynamics across many length scales and time scales in AFM structures. I will use these models to explain recent experimental findings and bridge the gap between physics and applications development. I will conclude my talk by summarizing the limits, challenges, and opportunities of AFM spintronics for future technologies such as high-density, secure nonvolatile memory, compact narrowband terahertz sources, and spike generators.

Biography: Shaloo Rakheja is currently an Assistant Professor in the Electrical and Computer Engineering (ECE) department at the University of Illinois at Urbana-Champaign. She is currently leading the Center for Aggressive Scaling by Advanced Processes for Electronics and Photonics (ASAP) – an Industry-University Cooperative Research Center, expected to be launched as a Phase 1 Center by the NSF in 2022. Shaloo is an expert in physics-based modeling of nanoelectronic and magnetic devices for energy-efficient computing and communication. She has developed multi-scale models, spanning from first-principles calculations to circuit-compatible implementations, for enabling materials-to-circuits co-design for a wide range of technologically relevant applications.

Hosted by Prof. J. Joshua Yang, Prof. Han Wang, Prof. Chongwu Zhou, Prof. Stephen Cronin, and Prof. Wei Wu.