TUESDAY, Dec 3, 3PM

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"Engineering topological magnetic phases in thin-film heterostructures and their properties"

Research in topological matter is an emerging and exciting field because it presents a test-bed to study novel fundamental physics that results from establishing non-trivial properties of condensed matter systems. The ability to access and control this new degree of material tunability provides a venue to engineer a new generation low dissipation, high sensitivity, high speed, and low cost sensors and information technologies that ultimately improves energy efficiency and performance compared to state-of-the-art technologies [1-5]. To date, the ability to design magnetic materials with non-trivial topology has already resulted in promising venues for future non-volatile information technologies that are based on particle-like magnetic spin textures termed skyrmions.

In this talk, I will focus on our recent developments [6-9] to engineer topological magnetic spin textures, such as chiral domain walls and skyrmions, in amorphous centrosymmetric and non-centrosymmetric thin-film heterostructures, as well as, demonstrate technology-relevant static and dynamic properties these magnetic spin textures can exhibit. First, I will show that zero-field ordered skyrmions can be realized in centrosymmetric Fe/Gd multilayers by carefully engineering the competition between magnetostatic and exchange energies [6] and precipitating magnetic-field induced long range magnetic order [7]. In the second part of my talk, I will present our recent observation of current-induced stripe-to-skyrmion generation in non-centrosymmetric Co/Ni/Pt multilayers [8] which shows that skyrmions can be stabilized in a broader material landscape than currently-known. Last, I will demonstrate that non-centrosymmetric magnets, of the form Fe/Gd/Fe/Pt/Ir multilayers, can exhibit the coexistence of opposite helicity chiral magnetic spin textures with unequal population distributions [9]. Overall, the ability to locally control material properties symmetrically and asymmetrically across different thin-film layers of a heterostructure presents a pathway to tailor unique chiral magnetic spin textures for building novel information and sensor devices.