Exploring Magnetization Dynamics in Thin-Film Magnetic Insulators

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Abstract

The pursuit of efficient and scalable spintronics and photonics devices has fueled significant interest in thin-film magnetic insulators. The absence of conduction electrons in magnetic insulators makes them ideal materials for spin waves propagation over relatively long distances (~0.1 mm) without significant attenuation. $Y_3Fe_5O_{12}$ (YIG) is one such magnetic insulator, known for its ultra-low damping and perpendicular magnetic anisotropy (when adequately substituted), which facilitate rapid domain wall dynamics. Although iron garnets have been extensively studied, ongoing theoretical and experimental efforts aim to further understand and optimize their fundamental properties for potential applications.

In this talk, I will discuss the magnetization dynamics of thin films of yttrium iron garnet (YIG), bismuth-doped YIG (Bi:YIG), and hexaferrites ($BaFe_{12}O_{19}$ and $SrFe_{12}O_{19}$), grown using pulsed laser deposition (PLD). We utilize ferromagnetic resonance (FMR) and Brillouin light scattering (BLS) to investigate the magnetization dynamics and interfacial Dzyaloshinskii-Moriya interactions (DMI) in these materials. Our findings reveal the impact of film thickness, substrate choice, and doping on magnetization dynamics, underscoring the potential of these materials for spintronics and photonics applications. Notably, Bi:YIG demonstrates enhanced magnetization dynamics, while hexaferrites exhibit unique properties tailored for high-frequency applications. This work provides valuable insights into designing and optimizing thin-film magnetic insulators for next-generation devices.

Additionally, I will present exciting results on perovskite iridates. Sr_2IrO_4 displays a novel ground state driven by strong spin-orbit coupling (SOC), resulting in a $J_{\mathbf{eff}}$ **= 1/2** Mott insulating state. This state is characterized by a distinctive magnetic structure and significant magnetic anisotropy. We have investigated the effects of doping on this ground state, uncovering fascinating modifications to the electronic and magnetic properties. Specifically, Cu, Ru, and Y doping induce changes in the SOC-driven ground state, leading to altered magnetic ordering, electrical transport, and quantum interference phenomena such as weak localization, alongside the emergence of several exotic phases. These findings provide deeper insights into the complex interplay between SOC, electron correlations, and doping in this remarkable class of materials.