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University of Miami, Physics Department Colloquium

Date: Wednesday, Oct 22, 2025
Time: 3:45 pm – 4:45 pm
Location: Physics Library – Rm 335, Knight Physics Building

Interplays of Structural Chirality, CISS, and Pure Spin Current Transport in Chiral Matters

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Abstract

Coupling of spin and charge currents from structural chirality in non-magnetic materials, referred to as the chirality-induced spin selectivity (CISS) effect, has shown promising applications for spintronic devices at room temperature. Recent convergence of magnons, phonons, photons, and their rich interactions between spin accumulation in the chiral matters offers alternative routes to uncover the CISS effect using pure spin current theme, such as the inverse CISS effect and anisotropic spin absorbers. In this talk, we will discuss the observations of the Onsager reciprocal to the CISS effect, i.e., the inverse CISS effect (ICISS) in a series of chiral π-conjugated polymers (PII2T) with tailored chirality and electrical properties using spin pumping techniques, from which the coefficient of the CISS effect can be precisely quantified as well as the spin relaxation time in the CISS channel. The sign of ICISS depends on the chirality of chiral PII2T with spin-to-charge conversion efficiency up to 0.05%. We conclude that distinct spin properties in the ICISS process are attributed to the unique electron-hopping induced spin relaxation process parallel to the chiral axis and the unconventional spin orbit coupling-induced spin-momentum locking in the electronic structure. Furthermore, under the pure spin current condition, the structural chirality enables us to realize colossal anisotropic absorption of non-local spin currents in chiral cobalt oxide thin films. The emergence of exceedingly large, colossal anisotropic non-local Gilbert damping factors (up to 1000%) was demonstrated. The Gilbert damping in the chiral cobalt oxide films is found to exhibit a maximum (minimum) value when the direction of the spin polarization is parallel (perpendicular) to the chiral axis. This effect has been attributed to the strong spin-flip process arising from chirality-induced band spin-splitting, a state where the chiral principal axis of the chiral metal oxide enables spin-selective transmission, consistent with the picture as conceptualized for the inverse CISS effect. Our studies herald a paradigm shift in design strategies for quantifying the performance of CISS-active spintronic devices, enabling faster magnetic switching and enhanced spin injection efficiency. These advancements pave the way for next-generation spintronic applications, including spin field-effect transistors, spintronic terahertz emitters, and beyond.

Biography

Dr. Sun's research interests are in spintronics and optoelectronics of organic semiconductors, magnetic thin films, and organic-inorganic hybrid perovskites. It includes the studies of organic spin valves, organic light-emitting diodes, hybrid perovskite optoelectronic/spintronics devices, and their device physics. The Sun Research Group at NC State focuses on exploring novel routes for spin injection and detection, magnetic field effect, spin Hall effect and their applications in molecules, polymers and newly emerged materials.