Topologically Protected Magnetic Quasi-Particles with Orbital Asymmetry in Advanced Magnetic Systems

Understanding the origins and interplay of magnetic energies—perpendicular magnetic anisotropy (PMA), Dzyaloshinskii-Moriya interaction (DMI), Zeeman energy, and dipolar energy—is crucial for developing next-generation spintronic devices. My research focuses on elucidating the microscopic origins of these energies, particularly emphasizing the critical role of spin-orbit coupling at atomic interfaces.

By fabricating atomically sharp metallic interfaces with maximized orbital asymmetry, I achieved giant interfacial PMA systems. Using X-ray magnetic circular dichroism, we demonstrated that the orbital structure of materials significantly influences interfacial DMI, underscoring the importance of orbital symmetry in engineering magnetic properties.

Further, I explored helical spin structures induced by DMI and magnetic octupole switching in non-collinear antiferromagnetic systems. Extending beyond interfacial phenomena, I uncovered bulk-type DMI in ABC-stacked superlattices, accompanied by Rashba-driven giant spin torque. Based on my research background, I will introduce some topologically protected cases which are extended to dynamics of a chiral soliton lattice with helical magnetism or magnetic multipoles in various magnetic systems.

Those results provide a pathway for designing magnetic systems with enhanced functionalities, bridging fundamental spin-related physics and quantum devices.