Abstract:

Spintronics is an essential upgradation of electronics where the quantum spin of electrons becomes a central quantity of interest. A prevailing pursuit of spintronics is to effectively control magnetism and magnetic dynamics through electrical stimuli, which can be realized in a heterostructure composed of a magnet and a non-magnetic driver operated by electric currents. This archetypal setup, however, suffers from two fundamental problems: 1) The transfer of spin angular momenta is greatly inhibited by the interface; 2) The input power is mostly dissipated through Joule heating, rendering the overall efficiency surprisingly low. The discovery of intrinsic magnetic topological insulators (iMTIs) opened a unique physical platform to address the above issues. Thanks to the intertwined topological electrons and magnetic ordering, an iMTI driven by electric fields can generate non-equilibrium spins on its own, which in turn drives its magnetic dynamics internally without the aid of other materials. Such a monostructural system can function as an electrical actuator and a magnetic oscillator simultaneously, obviating the undesirable interface in heterostructures. Furthermore, the spin generation and transfer processes do not rely on Ohm's currents but are instead enabled by the "adiabatic currents" arising from the Berry curvature crosslinking the crystal momentum and magnetic orientation. Because adiabatic currents do not incur Joule heating, they can convert 100% of the input electric power into magnetic dynamics, marking a transformative boost of operational efficiency compared to established approaches. In this presentation, I will introduce the intriguing physics underlying a series of compelling functionalities of monostructural spintronics based on iMTIs, which heralds a new paradigm featuring lossless power conversion in the absence of interfaces, heterostructures, and other common complications.

Biography：

Dr. Ran Cheng (程然) obtained his PhD degree in Physics from the University of Texas at Austin in 2014. He was a postdoctoral researcher at Carnegie Mellon University before joining the University of California, Riverside, as a faculty member in 2018. Dr. Cheng conducts theoretical research in condensed matter physics, focusing on spintronics, magnetism, and magnetic materials. He received the MURI award from the US Air Force, Office of Scientific Research, along with a cadre of physicists to study terahertz spintronics using antiferromagnetic insulators. Recently, he received the CAREER Award from the National Science Foundation to explore new fundamental spintronics in magnetic topological materials.