Oct 16, 2019

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Title: Intrinsic Hall effects and spin-orbit torques in two-dimensional systems

Abstract:

Spintronics is a field which aims to utilize the electrons' spin degrees of freedom for applications in information technology. To understand the physical principles of various spin-related transport and phenomena, we first discuss an intuitive real-space picture of intrinsic anomalous Hall effect, which is conventionally viewed as the consequence of Berry curvature describing the topological properties of the crystal band structure. We demonstrate that the inter-orbital coherence due to the interference between atomic orbital and the Bloch wave under the electric field facilitates the transverse current in the real space. We show that this real space charge density rotation could be used to image the valley Hall effect in the two-dimensional transition metal dichalcogenides(TMD). Next, we discuss spin-orbit torque in TMD/ferromagnet bilayers. Spin-orbit torque is an effect which enables the electric control of the magnetic orientation of a thin film ferromagnet, and can be the writing mechanism for nonvolatile magnetic memory. We use first principles calculations to illustrate an unconventional spin-orbit torque in 1T'-TMD/ferromagnet bilayers due to the reduced symmetry in TMD systems. We use a toy model to understand the relationship between the torque and inversion symmetry breaking direction. The convergence of spintronics with the zoo of two-dimensional systems opens up many opportunities in the broader field of condensed matter physics.