Nonlinear Hall Responses in Noncentrosymmetric Quantum Materials

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In this talk, we explore the novel and intriguing nonlinear Hall responses that emerge in noncentrosymmetric quantum materials, with a focus on two distinct material systems: two-dimensional (2D) PT-symmetric antiferromagnets and topological ZrTe5 films. First, we introduce the concept of intrinsic nonlinear Hall (INH) effects in 2D antiferromagnets, which enables efficient detection of the Néel vector. We show that the INH conductivity in monolayer manganese chalcogenides can achieve unexpectedly large values, significantly enhancing the detection of antiferromagnetic order even in the 2D limit. The INH effect exhibits a 2π-periodic dependence on the Néel vector orientation, offering a new avenue for the design of spintronic memory devices based on 2D antiferromagnets.

Next, we discuss the intriguing phenomenon of spontaneous inversion symmetry breaking in topological ZrTe5 films, which arises from interlayer sliding and intralayer distortion. This symmetry breaking induces Berry curvature and orbital magnetization, leading to significant nonlinear anomalous Hall effects (NAHE) and kinetic magnetoelectric effects (KME) in the system. Through a detailed study, we show how the sliding ferroelectricity directly couples with these nonreciprocal transport responses, opening exciting possibilities for tuning and controlling the nonreciprocal transport properties in van der Waals layered materials. Our findings provide valuable insights into the mechanisms behind inversion symmetry breaking and their potential applications in next-generation spintronic and quantum devices.

This talk will highlight the role of nonlinear Hall responses in these novel noncentrosymmetric systems, offering fresh perspectives on their applications in spintronic devices and quantum materials research.

References

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