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Uncovering Berry: The Role of Topology in the Anomalous Hall Effect of Amorphous Ferromagnetic Fe-Si and Antiferromagnetic Mn_3Ge

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The consideration of topology has recently led to the emergence of new exotic physics; topological insulators and Weyl semimetals are two classes of materials where unique properties arise due to the topology of the electronic band structure. Since its discovery, the Berry phase has helped explain diverse phenomena in condensed matter physics, with perhaps one of the most important breakthroughs being the reinterpretation of the intrinsic contribution to the anomalous Hall effect (AHE) in ferromagnets in terms of a Berry phase curvature in momentum space. Recent theoretical predictions have further suggested that the Berry phase can also give rise to an AHE in antiferromagnets with non-collinear spin structures. This talk will examine the role of the Berry phase on the AHE in both amorphous ferromagnets and non-collinear antiferromagnets. It will be shown that the anomalous Hall conductivity, when suitably normalized by magnetization and number of charge carriers, is independent of the longitudinal conductivity in a series of amorphous Fe-Si thin films. This observation suggests a primary dependence on an intrinsic mechanism, which is remarkable because it indicates a local atomic level description of a Berry phase, resulting in an intrinsic AHE in a system that lacks lattice periodicity. The second part of the talk will discuss the emergence of the AHE in the non-collinear antiferromagnet, Mn_3Ge. The AHE in ferromagnets generally scales with the magnetization, meaning that an antiferromagnet with no net magnetization should not exhibit an AHE. It will be shown that not only does Mn_3Ge exhibit an AHE but one that is comparable to that of ferromagnetic metals. Theoretical calculations will demonstrate that this effect originates from a non-vanishing Berry curvature, arising from the chiral spin structure.