Field tunable topological Hall effect in skyrmion crystals

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Abstract:

The topological Hall effect (THE) is the result of spin-asymmetric deflection of charge carriers flowing through a non-collinear spin system. Effective manipulation of the topological Hall conductivity (THC) in skyrmions is a topic of serious interest in the recent times as they have potential applications in spintronics. By examining a series of skyrmion crystals using tight-binding model Hamiltonians, we show that the band topology of the electrons, experiencing the emerging magnetic field of the skyrmions, can be tuned by changing the strength of the applied electric field driven SOC.This results in the change of the subband Chern numbers and a transition between ordinary insulator and Chern insulator as the Rashba SOC is varied. For partially filled subbands, the Rashba SOC can tune the THC and reverse its sign, so that the direction of the Hall current is flipped. The critical Rashba strength for this depends on the skyrmion type and the carrier density. We extend our analysis to the cases of Dresselhaus and Weyl SOC as well and show that they can be directly mapped to the Rashba SOC case. Our work suggests new avenues for the control of charge transport in skyrmion crystals. As an extension of our study, we show that THC quantization plateaus akin to quantum Hall effect can be realized.

References:

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