Quantum anomalous Hall effect in V-doped $(Bi,Sb)_2Te_3$

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The anomalous Hall effect [1], despite being more than a century old, remains of great interest for fundamental research purposes, especially in the context of novel magnetic materials such as magnetic topological insulators. Careful analysis of the anomalous Hall transport in a magnetic topological insulator, V-doped $(Bi,Sb)_2Te_3$, indicates the presence of two contributions of opposite sign. Their response to a variety of experimental parameters suggests that one contribution originates on the surface, and the other in the bulk of the magnetic topological insulator layer [2].

When the structural parameters of V (or Cr)-doped $(Bi,Sb)_2Te_3$ material are carefully optimized, at sufficiently low temperatures this ferromagnetic material is known to exhibit the quantum anomalous Hall effect [3], characterized by conduction through a single dissipationless chiral edge channel, even at zero external magnetic field. This perfect electronic transport quantization was quickly recognized as a promising platform for quantum metrology, as a zero field quantum resistance standard. Metrologically comprehensive experiments reveal a great precision of the anomalous Hall resistance quantization in our films [4].

Finally, careful analysis of the underlying fundamental physics reveals the existence of two distinct types of quantum anomalous Hall states, related to the systems' dimensionality. Both regimes are experimentally accessible by changing the layer thickness. Thinner films exhibit a conductivity tensor flow diagram equivalent to that of a two-dimensional electron gas, implying a fundamentally two-dimensional origin of the effect. When the film thickness is increased, a transition to the three-dimensional regime is observed. In the three-dimensional limit, the conductivity scaling changes to the one expected for electronic transport on two parallel topological interfaces, encapsulating a volume of distinct topology. This three-dimensional bulk supports axion electrodynamics, revealing the existence of an additional term in the Maxwell's equations, and a quantum state of matter called an "axion insulator" [5,6].

References:

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