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What is intrinsic and what is extrinsic in the spin Hall effect?[1]
EWELINA HANKIEWICZ, GIOVANNI VIGNALE, Univ. of Missouri-Columbia, MICHAEL FLATTÉ, University of Iowa — Two different forms of the spin Hall effect, intrinsic and extrinsic, have been recently proposed and observed in experiments. The intrinsic effect is caused by spin-orbit coupling in the band structure of the semiconductor and survives in the limit of zero disorder, whereas the extrinsic effect is caused by spin-orbit coupling between Bloch electrons and impurities. We treat both effects on equal footing within the framework of the exact Kubo linear response formalism. We show that the "side-jump" term, which is usually considered part of the extrinsic spin Hall effect, is really intrinsic, because it is independent of disorder. Furthermore, it is the only non-zero *intrinsic* contribution to the spin-Hall effect for the linear Rashba (or Dresselhaus) spin-orbit coupling model. On the other hand, the skew scattering term is the only *extrinsic* contribution to the spin-Hall effect within this model. The proof based on gauge invariance holds at all orders in disorder and electron-electron interactions and to first order in spin-orbit coupling, but does not apply to more complex spin-orbit coupled bands (e.g the Luttinger model). We also study many-body effects and predict that the spin Coulomb drag will reduce the spin Hall conductivity.

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