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Numerical Studies of Anomalous Spin and Charge Transport[1]

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In a crystal static electric fields can induce coherence between different Bloch bands. When spin-orbit interactions are included the coherence leads to spin currents that flow perpendicular to the electric field direction, and in the case of a ferromagnet to perpendicular charge currents as well. This anomalous transport thus makes a purely intrinsic contribution to the spin Hall effect, and for ferromagnets to the charge Hall effect. The robustness of these contributions in the presence of disorder has been questioned over the years, and recently for the case of the spin Hall effect of a two-dimensional electron system with Rashba spin-orbit interactions (R2DES) in particular. To address this question we have performed a numerically exact finite-size study of anomalous spin and charge transports currents for a R2DES with disorder. We find that the anomalous Hall currents are robust against disorder. In the case of a R2DES ferromagnet, the charge Hall current has additional contributions from changes in the occupation probabilities of states near the Fermi surface. We will discuss efforts to understand the total Hall conductivity of a R2DES ferromagnet in terms of intrinsic, side-jump, and skew-scattering contributions and efforts to achieve a general understanding of the circumstances under which the intrinsic contribution can dominate.

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