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Theory of Anomalous Hall Effect in Ferromagnets SHIGEKI ONODA, Spin Superstructure Project, ERATO, Japan Science and Technology Agency, NAOYUKI SUGIMOTO, NAOTO NAGAOSA, Department of Applied Physics, University of Tokyo — Mechanism of the anomalous Hall effect (AHE) in ferromagnetic metals has been controversial over many decades. Karplus-Luttinger initiated the discussion by focusing on the intrinsic thermodynamic Hall current produced by the band structure with a spin-orbit interaction. Later, it was argued that instead, scattering by impurity or disorder together with the spin-orbit interaction distorts the electron motion as the skew scattering or the side jump and these extrinsic contributions dominate over the Hall current. Here, we reexamine this issue by fully taking account of both the impurity scattering and the anomalous velocity in terms of the quantum transport theory. We demonstrate that apart from the conventional nonequilibrium transport current, an equilibrium Hall current flows even in the presence of dissipation in metals. This equilibrium Hall current contains the intrinsic one which has a topological non-perturbative nature associated with degeneracy of the band dispersions in the momentum space. We also show that there appears a crossover from the extrinsic regime to the intrinsic as the electron damping rate becomes comparable to or larger than the energy scale of the spin-orbit coupling. This resolves the long standing puzzle on the mechanism and reveals a new small energy scale governing the quantum transport in multi-band systems.

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