Quantum geometric Effect in Landau’s Fermi-Liquid theory

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Landau Fermi-liquid theory provides the paradigmatic low-energy description of interacting metals. In Wannier-obstructed systems, however, quasiparticles carry not only occupation numbers but also Bloch wave functions endowed with Berry phase and Hilbert-space geometry. We develop a Landau Fermi-liquid theory for spinless fermions that incorporates these quantum-geometric degrees of freedom. Using a Nozières--Luttinger construction, we derive a generalized Landau energy functional for quasiparticles carrying quantum geometry from low-energy theory which is systematically constructed by means of generalized Peierls substitution approach. The resulting theory reveals two geometric structures absent in conventional Fermi liquids: an anomalous coupling to the Berry connection and an interaction-driven quantum-geometric current, arising from the instantaneous deformation of Bloch states under external perturbations. We show that these geometric currents contribute to charge, thermal, and anomalous Hall transport, while leaving the Wiedemann--Franz law unchanged. In the Galilean-invariant limit, both the anomalous Hall conductivity and the Drude weight are protected from interaction renormalization even in the presence of quantum geometry. Our results establish quantum geometry, quasiparticle occupations, and Landau parameters as the fundamental ingredients of a Fermi-liquid theory in Wannier-obstructed systems.