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Quantum kinetic approach to chiral magnetic effect

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We derive a relativistic chiral kinetic equation with manifest Lorentz covariance from Wigner functions of spin-1/2 massless fermions in a constant background electromagnetic field. It contains vorticity terms and a 4-dimensional Euclidean Berry monopole which gives axial anomaly. By integrating out the zero-th component of the 4-momentum p, we reproduce the previous 3-dimensional results derived from the Hamiltonian approach, together with the newly derived vorticity terms. The phase space continuity equation has an anomalous source term proportional to the product of electric and magnetic fields ($F_{\sigma\rho}\tilde{F}^{\sigma\rho} \sim E_\sigma B^\sigma$). This provides a unified interpretation of the chiral magnetic and vortical effects, chiral anomaly, Berry curvature, and the Berry monopole in the framework of Wigner functions.

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