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Axial kinetic theory and spin transport for massive fermions

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In relativistic heavy ion collisions (HIC), not only a strong magnetic field but also strong vorticity could be generated. Recent observations of the polarization of Lambda hyperons have triggered intensive studies for vorticity-induced polarization and spin dynamics in relativistic fluids. However, more recent studies suggest that the spin polarization could be possibly led by non-equilibrium effects. It is thus desired to construct a quantum transport theory for investigating non-equilibrium dynamics of spin polarization for massive fermions. Based on the Wigner-function approach, we derive an axial kinetic theory (AKT) for massive fermions as modified Boltzmann equations involving quantum corrections associated with spin and chiral anomaly, which can be applied to track the phase-space evolution of both vector/axial charges and spin polarization in weakly coupled systems. Since spin of massive fermions is a dynamical degree of freedom, the AKT involves one scalar and one axial-vector kinetic equations with side-jump effects pertinent to the spin-orbit interaction. In the massless limit, the AKT also reproduces the chiral kinetic theory as a well-established quantum kinetic theory for Weyl fermions and manifests the spin enslavement in such a limit. The AKT could have various applications in different physical systems including the spin transport for strange quarks or for Lambda hyperons in HIC.

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