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Quantifying pre-thermal chiral magnetic effect with chiral kinetic theory

Summary

Chiral anomaly is a fundamental aspect of the quantum theory for chiral fermions. In a many-body system containing chiral fermions, such as the hot quark-gluon plasma created in heavy ion collisions at RHIC and the LHC, the chiral anomaly leads to macroscopic anomalous transport effects. A notable example is the chiral magnetic effect (CME), in which a vector current is generated along an external magnetic field given a nonzero imbalance between right-handed and left-handed fermions in the system. An observation of the CME is of great interest and significant efforts have been made. Current experimental data show encouraging evidences, but suffer from backgrounds. Realistic and quantitative modeling of CME signal is thus critically needed. The magnetic field in heavy ion collisions, however, is likely very short-lived, with its life time shorter than the onset time of hydrodynamics. It is thus a most pressing issue to simulate the CME in the pre-thermal stage in heavy ion collisions. The theoretical tool to do this, is the so-called chiral kinetic theory. We report the first attempt to utilize this tool for quantifying the pre-thermal CME. Exact solutions for collision-less case as well as the relaxation-time-approximation are obtained and used to compute two different CME-induced consequences: a pre-thermal charge separation across reaction plane, as well as a nonzero anomalous current along B field direction. We discuss the integration of these CME-induced initial conditions with subsequent hydrodynamic evolutions, and the implication of such results for the description of experimental data.

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