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Non-equilibrium Chiral Magnetic Effect from lattice QCD simulations

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First-principle lattice QCD studies of the Chiral Magnetic Effect (CME) have so far been mostly carried out in a thermal equilibrium state with background magnetic field and an artificial "chiral chemical potential". In this case, Bloch theorem prohibits any nonvanishing conserved currents in equilibrium, and the CME current vanishes identically.

In this talk, I introduce a novel formalism to measure the out-of-equilibrium Chiral Magnetic Effect in standard lattice QCD simulations of thermal equilibrium state with background magnetic field. The formalism captures time-like correlations between the axial charge density and the conserved electric current without any need for the "chiral chemical potential".

For free fermions, the axial-vector correlator only receives contributions from the lowest Landau level, and exhibits a linear dependence on both magnetic field and temperature with a universal coefficient. With an appropriate regularization, nonvanishing axial-vector correlator is compatible with the vanishing of the CME current in thermal equilibrium state with nonzero "chiral chemical potential".

The real-time axial-vector correlator is intimately related to the real-time form of the axial anomaly equation, which strongly limits possible corrections to out-of-equilibrium CME in full QCD. We present numerical results for the Euclidean-time axial-vector correlator in SU(2) lattice gauge theory with Nf=2 light quark flavors, demonstrating its closeness to the free fermion result on both sides of the chiral crossover. The proposed methodology can be used to interprete experimental data on CME in heavy-ion collisions (e.g. in the RHIC isobar run).

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