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Fermion helicity vs. chirality: transport, thermodynamic, and spin-polarization effects

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Helicity is a classically conserved quantity that can be used, in addition to and independently of the (vector) charge and chirality, to characterize thermodynamic ensembles of Dirac fermions. We demonstrate the existence of new nondissipative transport phenomena, helical vortical effects, that emerge in a helically-imbalanced rotating fermionic system. These phenomena lead to the appearance of a new gapless hydrodynamic excitation, the helical vortical wave. We also show that the presence of the helicity imbalance of quark matter increases the curvature of the QCD chiral pseudocritical line and shifts the critical endpoint towards lower temperatures and higher baryon chemical potentials. We demonstrate the existence of a thermodynamic duality between helical and vector (baryonic) chemical potentials. Finally, we argue that the enhancement in the spin polarization of anti-hyperons compared to the polarization of the hyperons in non-central relativistic heavy-ion collisions arises as a result of an interplay between the chiral and helical vortical effects: we are able to describe the ratio of the (anti)hyperon spin polarizations, obtained by the STAR group, without fitting parameters.

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