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Transport coefficients of two-flavor quark matter from the Kubo formalism

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We compute the transport coefficients of quark matter in the strong coupling regime within the two-flavor Nambu–Jona-Lasinio model. We apply the Kubo formalism to obtain the thermal (κ) and the electrical (σ) conductivities as well as the shear (η) and the bulk viscosities (ζ) at leading order in the $1/N_c$ power counting scheme. In this approximation the conductivities and the shear viscosity are given by single-loop skeleton diagrams, whereas the bulk viscosity includes an infinite geometrical series of multi-loop diagrams. The dispersive effects that lead to nonzero transport coefficients arise from quark-meson fluctuations above the Mott transition temperature T_M, where meson decay into two on-mass-shell quarks is kinematically allowed.

We find that the conductivities and the shear viscosity are decreasing functions of temperature and density above T_M. We also show, that the Wiedemann-Franz law for the ratio σ/κ does not hold. The ratio of the shear viscosity to the entropy density is larger than unity close to the Mott temperature and approaches the AdS/CFT bound $1/4\pi$ at higher temperatures. We conjecture on the basis of the uncertainty principle that the ratio $\kappa T/c_V$, where c_V is the heat capacity per unit volume, is bounded from below by 1/18.

The case of the bulk viscosity turns out to be special, because the multi-loop contributions dominate the single-loop contribution close to the Mott line in the case where the chiral symmetry is explicitly broken. The resulting bulk viscosity exceeds the shear viscosity close to the Mott line by factors 5-20. In the high-temperature domain the bulk viscosity is negligible compared to the shear viscosity. For practical applications we provide simple, but accurate fits to the transport coefficients which can facilitate the implementation of our results in hydrodynamics codes.

Type of contribution

Talk

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