

The shear viscosity of parton matter under two-body scatterings

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The shear viscosity η of a quark-gluon plasma in equilibrium can be calculated numerically using the Green-Kubo relation or analytically using several methods, including the Israel-Stewart, Navier-Stokes, relaxation time approximation, and Chapman-Enskog methods. In this study [1], we first examine these analytical methods for two-body isotropic and anisotropic scatterings and confirm that the Chapman-Enskog method is the most accurate as it agrees best with the Green-Kubo numerical results. We then apply the Chapman-Enskog method to study the shear viscosity of the parton matter in the center cell of Au+Au collisions at 200A GeV and Pb+Pb collisions at 2.76A TeV from a multi-phase transport (AMPT) model. At the parton scattering cross section of 3 mb that enables the transport model to reproduce bulk observables including the elliptic flow, the average η/s of the parton matter is found to be very small, between one to three times $1/(4\pi)$.

We further find that as a result of using a constant Debye mass or cross section for parton scatterings, the η/s ratio from the AMPT model increases with time (as the effective temperature decreases), contrary to the pQCD results that use temperature-dependent Debye masses [2]. This is one direction to improve the AMPT model. Here we also plan to show some results on extending the analytical calculation of shear viscosity to a parton matter that consists of multiple parton species under their corresponding temperature-dependent pQCD cross sections. They will lay the foundation for directly linking the parton cross sections in the model to the actual/extracted QCD shear viscosity.

[1] N. MacKay and Z.W. Lin. Eur. Phys. J. C 82, 918 (2022).

[2] P.B. Arnold, G.D. Moore, and L.G. Yaffe, JHEP 11, 001 (2000); JHEP 05, 051 (2003).

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