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Transport properties and jet transport coefficients of the strongly interacting quark-gluon plasma

An understanding of the energy loss of fast partons passing through the strongly interacting quark-gluon plasma (QGP) is important for the interpretation of experimental data on jet attenuation in the QGP created in heavy-ion collisions, as well as for the study of the modification of the QGP itself. However, gaining this knowledge is a challenging task, since it is related to the non-perturbative regime of QCD, for which only limited information from lattice QCD is currently available.

To work around this issue, we employ the dynamical quasi-particle model (DQPM). The DQPM describes the non-perturbative nature of the strongly-interacting QGP at finite temperature and baryon chemical potential based on a propagator representation of massive off-shell partons (quarks and gluons), whose properties are adjusted to reproduce the lattice QCD equation of state for the QGP in thermodynamic equilibrium. Using the DQPM propagators, we can explicitly derive the scattering amplitudes for the elastic ($2 \to 2$) and inelastic ($2 \to 3$) radiative interactions without approximations, allowing us to study both the transport properties of the QGP and jet energy loss in the medium.

We report the following findings:
1. We have obtained energy and temperature dependencies of the total elastic and radiative cross sections. We have found that, while elastic cross sections dominate at low energies and high temperatures, radiative cross sections increase at low temperatures and high energies, becoming comparable or even dominant.
2. We have found that the interaction rate and relaxation time in the QGP are primarily governed by elastic scattering, suggesting that inelastic processes are suppressed in the non-perturbative thermalized thermal medium.
3. We have obtained the jet transport coefficients, such as the transverse momentum transfer squared per unit length $\hat{q}$ and the energy loss per unit length dE/dx, and found their strong dependencies on the medium temperature, jet momentum and the choice of the strong coupling in thermal, jet parton and radiative vertices.
4. We have examined the ratio of $\hat{q}$ to shear viscosity η and shown that the scaling $\eta/s \approx 1.25T^3/\hat{q}$ is valid in the weak coupling regime at high temperatures, but is violated in the strong coupling regime at low temperatures.

References:

1. Grishmanovskii et al., Phys.Rev.C 110 (2024) 1, 014908
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Category

Theory

Collaboration (if applicable)

Authors: GRISHMANOVSKII, Ilia (ITP, Frankfurt); SONG, Taesoo; SOLOVEVA, Olga (Goethe University Frankfurt); GREINER, Carsten (University of Frankfurt); BRATKOVSKAYA, Elena

Presenter: GRISHMANOVSKII, Ilia (ITP, Frankfurt)

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