Effect of gluon Bremsstrahlung on the transport of heavy quark in Quark Gluon Plasma

Surasree Mazumder, Variable Energy Cyclotron Centre, Kolkata, India

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Charm Quark as probe of QGP: Why?

- Produced due to early hard collisions.
- Unlikely to be produced in QGP, mass is greater than temperature of QGP.
- Probability of creation and annihilation is very small: Therefore, the numbers of charm anti charm remain constant.
- Charm is out of equilibrium whereas the medium is in local thermal equilibrium.

Charm interaction with QGP

- Elastic binary scattering:
  \[ C + q \rightarrow C + q, \quad C + q \rightarrow C + q, \quad C + g \rightarrow C + g \]
- Gluon bremsstrahlung:
  \[ C + q / q / g \rightarrow C + q / q / g + g \]
- Coordinate system:
  \[ \vec{q} = (\vec{q}_1, q_z) = k_1 - k_3; k_5 = (E_k = k_1 \cdot \csc \theta, \vec{k}_1, k_1 = k_\perp \cot \theta) \]
- Approximations used:
  Soft + eikonal1 + eikonal2
- Heirarchy taken:
  \[ \sqrt{s} >> q_\perp >> E_s >> k_\perp >> m_0 >> \Lambda_{QCD} \]

Radiative transport coefficients

Charm quark follows Fokker Planck Equation

\[ \frac{\partial f}{\partial t} = \frac{\partial}{\partial k_{1i}} \left[ A_i(k_{1}) f + \frac{\partial}{\partial k_{1j}} \left\{ B_{ij}(k_{1}) f \right\} \right] \]

- drag
- diffusion

\[ X(\vec{k}_1, T) = \frac{1}{2E_1} \int \text{Phase space} \times \text{interaction} \times \text{transport} \]

\[ X_{\text{radiative}} = X_{\text{elastic}} \times \int \frac{d^3 k_5}{(2\pi)^3 2E_5} 12 g_s^2 \frac{1}{k_\perp^2} (1 + \frac{m^2}{s} e^{2\eta})^{-2} (1 + f(k_5)) \Theta(\tau - \tau_F) \Theta(E_1 - E_5) \]

\[ X_{\text{total}} = X_{\text{elastic}} + X_{\text{radiative}} \]

Equilibrium dist. of charm, \( \eta / s \) of QGP and gluon radiation

- Equilibrium dist. of charm is far from that of Boltzman, rather it follows Tsallis class of distribution.
- Radiation has no effect on the shape of the dist. func. Of charm

\[ \eta / s \text{ estimated by calculating transport parameter, } \hat{q} = 4B_\perp \]

\[ 4\pi \frac{\eta}{s} \approx 1.25 \pi \frac{T^3}{B_\perp} \]