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

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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:

$C+q\to C+q,\quad C+\bar{q}\to C+\bar{q},\quad C+g\to C+g$

❖ Gluon bremsstrahlung:

$$C+q/\bar{q}/g\to C+q/\bar{q}/g+g$$

❖ Coordinate system:

$$\vec{q}=(\vec{q}_\perp,q_z)=\vec{k}_1-\vec{k}_3;k_5=$$
$$(E_5=k_\perp\csc\theta_g,\vec{k}_\perp,k_z=k_\perp\cot\theta_g)$$

❖ Approximations used:

Soft + eikonal1 + eikonal2

$\frac{E_5}{\sqrt{s}}<<1\qquad\frac{q_\perp}{\sqrt{s}}<<1\qquad\frac{k_\perp}{\sqrt{s}}<<1$

❖ Heirarchy taken:

$$\sqrt{s}>>q_\perp>>E_5\geq k_\perp>>m_{th}>>\Lambda_{QCD}$$

Radiative transport coefficients

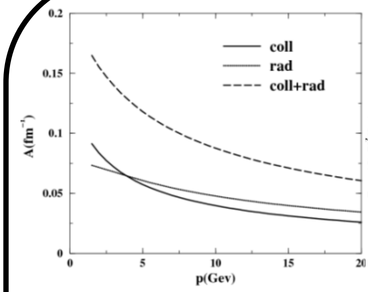
Charm quark follows Fokker Planck Equation

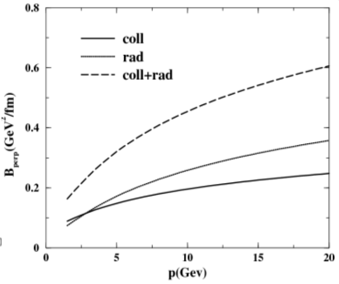
$$\frac{\partial f}{\partial t}=\frac{\partial}{\partial k_{1i}}\left[\underset{\substack{\downarrow\\\text{drag}}}{A_i(\vec{k}_1)f}+\frac{\partial}{\partial k_{1j}}\underset{\substack{\searrow\\\text{diffusion}}}{\{B_{ij}(\vec{k}_1)f\}}\right]$$

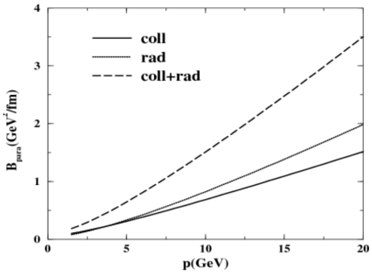
$$X(\vec{k}_1,T)=\frac{1}{2E_1}\int\text{Phase space}\times\text{ interaction }\times\text{transport}$$

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

$$X_{total}=X_{elastic}+X_{radiative}$$







Equilibrium dist. Of charm, η/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

➢ η/s estimated by calculating transport parameter, $\hat{q}=4B_\perp$

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