Effect of evolution on energy loss of heavy quarks in QGP

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Introduction

Suppression of high energy hadrons compared to pp collisions, called "jet quenching", is one of the important feature of the strongly interacting matter, Quark Gluon Plasma (QGP), produced in high energy heavy ion collisions. This phenomena occurs due to the energy loss of high energy partons, i.e. light and heavy quarks which are produced from initial hard collisions. Heavy flavour hadrons, containing charm or bottom flavour, are important probes of deconfined matter produced in ultra-relativistic nuclear collisions. Heavy quarks are produced only in the early stage of collision, and loose energy while traveling through QGP medium, which is reflected in the p_T distribution of corresponding hadrons (D or B mesons). The dynamic evolution of plasma will thus effect the fractional energy loss as well as nuclear modification factor R_{AA} of heavy mesons which will be studied here.

1. Heavy quark dissipation

The evolution of the heavy quark momentum distribution (f) while propagating through QGP can be studied by using the Fokker Plank (FP) equation [1],

$$\frac{\partial f}{\partial t} = \frac{\partial}{\partial p_i}\left[\gamma_i(p)f + \frac{\partial}{\partial p_i}[D_{ij}(p)f]\right] \qquad (1)$$

where γ_i and D_{ij} are drag and diffusion coefficients. The heavy quarks dissipate energy while propagating through QGP by two processes: (i) collisional and (ii) gluon radiation (bremsstrahlung). Hence, the drag and diffusion coefficients should include these two processes of energy dissipation, $\gamma_{eff} = \gamma_{coll} + \gamma_{rad}$ and $D_{eff} = D_{coll} + D_{rad}$. Following the procedure of earlier works [2, 3], and using the collisional energy loss given by Ref. [4] and radiative energy loss based on generalised dead cone approach [5], we evaluate the effective drag and diffusion coefficients.

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2. Space time evolution

The system formed in nuclear collision, evolves from initial to final state. To obtain the time evolution of the temperature, on which drag and diffusion co-efficients depends, we use a simple expanding fireball model with isentropic expansion [2]. We consider first order as well as QCD based EOS with hadronic resonances to estimate the temperature evolution. Initial time is considered $\tau_0 = 0.3$ fm and freeze-out temperature, $T_F = 160$ MeV and three collision scenario, (i) Au+Au collision, RHIC at $\sqrt{s_{NN}} = 200$ GeV, with $dN/d\eta = 625$ for $0-10\%$ centrality (ii) Pb+Pb collision, LHC at $\sqrt{s_{NN}} = 2.76$ TeV with $dN/d\eta = 1600$ and (iii) Pb+Pb collision, LHC at $\sqrt{s_{NN}} = 5.02$ TeV with $dN/d\eta = 1943$. The energy loss due to collisional and radiative process is given by,

$$\Delta E = E_0 - < E > \qquad (2)$$

where the average energy loss of heavy quarks in expanding medium is obtained by solving the time evolution of FP equation in a dynamical evolving plasma,

$$< E > = \int_0^\infty E D(p, L) dp. \qquad (3)$$

Here $D(p, L)$, is the probability distribution in momentum space, obtained by solving the FP equation [2, 3]. Fig. 1 shows the fractional energy loss of charm and bottom quarks with path length, due to elastic collision for heavy quark energy $E = 10$ GeV considering different evolution scenario.

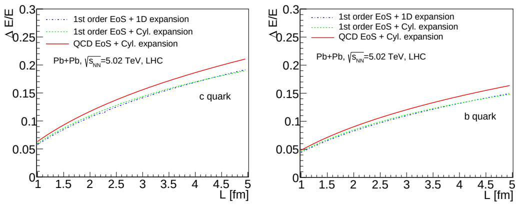

FIG. 1: Energy loss due to collision in QGP medium (left) for charm quarks (right) for bottom quarks, in PbPb collisions at 5.02 TeV for different evolution scenario.

Results

We report the fractional energy loss of charm and bottom quarks with path length L fm while traversing through the thermally evolving plasma for energy $E = 10$ GeV. Fig. 2 and Fig. 3 shows the results of fractional energy loss for charm and bottom quarks respectively. The length traversed by heavy quark inside the fireball depends on the geometry of the colliding system and the point where the heavy quark produced inside the plasma. We considered the heavy quark path length $L(r, \phi)$, where a parton created at a distance $\vec{r}$ with angle ϕ in the transverse direction. Estimation of the quenched spectrum of heavy quarks and the p_T dependence of nuclear modification factor R_{AA} of D and B mesons are in progress.

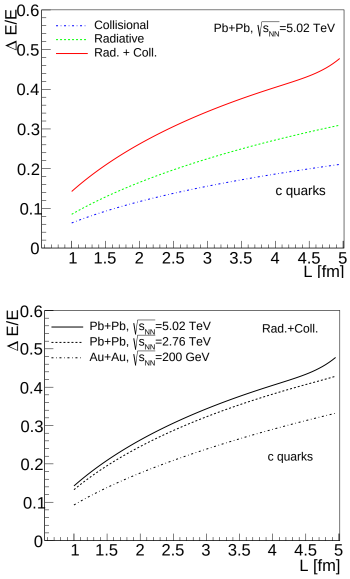

FIG. 2: Fractional energy loss for charm quark with path length (upper) for different energy loss scenario, (lower) for different collision scenario due to radiative plus collisional energy loss.

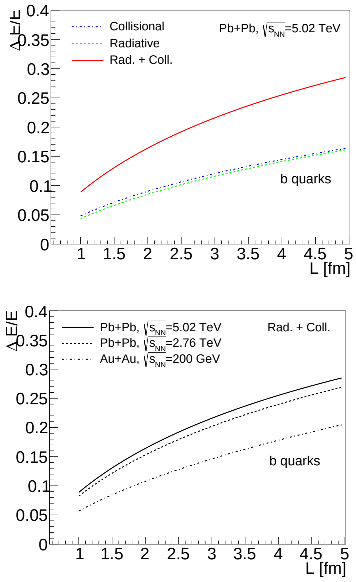

FIG. 3: Fractional energy loss for bottom quark with path length (upper) for different energy loss scenario, (lower) for different collision scenario due to radiative plus collisional energy loss.

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