Transport coefficients of B mesons in hot hadronic matter

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The suppression of the transverse momentum (p_T) distribution of hadrons produced in nucleus-nucleus collisions relative to (binary scaled) proton-proton interactions at the Relativistic Heavy Ion Collider (RHIC) has been used as a tool to understand the properties of matter formed in such collisions. The large value of the elliptic flow of hadrons measured at RHIC along with the suppression of the high p_T hadrons mentioned above indicate that the matter might have been formed in the partonic phase with liquid like properties characterized by low value of shear viscosity (η) to entropy density (s) ratio, η/s with a lower bound of $\eta/s \sim 1/4\pi$.

In addition to elliptic flow (v_2) and nuclear suppression (R_{AA}) of light hadrons these quantities have also been measured for the single electron spectra originating from the decays of the open charm and beauty mesons produced at RHIC collisions. The advantages with heavy mesons are two-fold. Firstly, they contain either a charm or a beauty quark which is produced very early and hence can witness the evolution of the partonic matter since its inception until it reverts to hadronic matter through phase transition/cross over and secondly, the heavy quarks do not decide the bulk properties of the matter. Therefore, charm and beauty quarks are considered to be efficient probes for the characterization of the partonic phase.

In most of the earlier works aimed at extracting the properties of quark gluon plasma (QGP) by analyzing the R_{AA} and v_2 of heavy flavours the role of the hadronic matter was ignored. However, for the characterization of QGP the interactions of heavy flavours with hadronic matter should be taken into consideration and the effects of hadrons must be subtracted out from the observables. A large amount of work has been done on the diffusion of heavy quarks in QGP, however, the diffusion of heavy mesons in hadronic matter has received much less attention so far.

In the present work the transport coefficients have been evaluated for the B meson propagating through a hot hadronic matter using matrix elements obtained from scattering lengths evaluated at NNLO using Heavy Meson Chiral Perturbation Theory ($HM\chi PT$) [1, 2]. We also revisit the transport coefficients of D meson [3] in a similar theoretical framework. We consider the interaction of the B meson with thermal pions, kaons and eta in the temperature (T) range $100 - 170$ MeV. In this range of T the thermal production of heavy mesons is Boltzmann suppressed because of their large mass. Therefore, the interactions of heavy mesons with thermal (light) hadrons will be essentially elastic. Moreover, it is expected that the relaxation time for heavy mesons are larger than the corresponding quantities for light hadrons. Therefore, the interaction of the non-equilibrated heavy mesons with the equilibrated hadrons may be treated within the framework of Fokker-Planck equation [4, 5].

The drag (γ) and diffusion (B_0) coefficients of the heavy mesons are evaluated using its elastic interaction with the thermal hadrons. For the (generic) process, $B(p) + h(q) \rightarrow B(p') + h(q')$ (h stands for pion, kaon and eta), the drag γ and diffusion (B_0) can be calculated by using the formalism discussed in Ref. [3].

The variation of the drag coefficient with temperature is displayed in Fig. 1 for B-mesons. γ is the thermal average of the square of the momentum exchanged between the heavy mesons and the bath particle weighted

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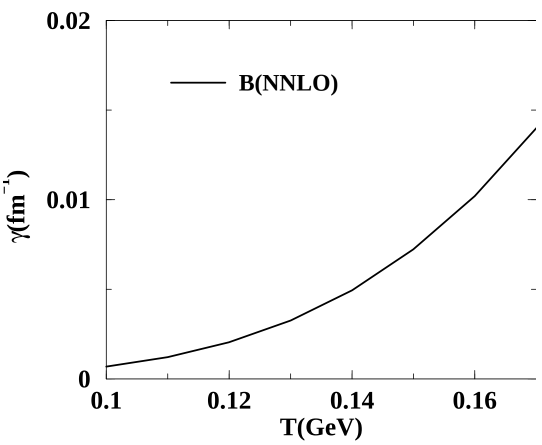

FIG. 1: The variation of drag coefficients with temperature due to the interaction of B mesons (of momentum 100 MeV) with thermal pions, kaons and eta.

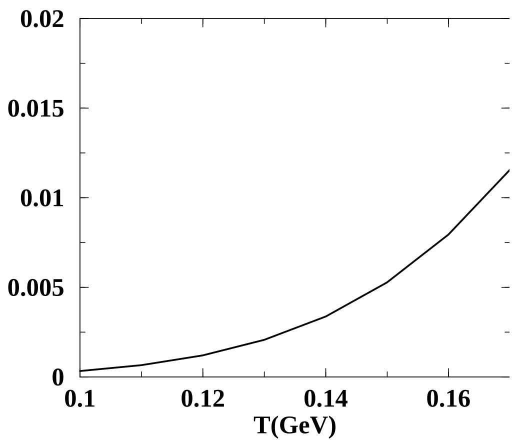

FIG. 2: The variation of diffusion coefficients with temperature due to the interaction of B mesons (of momentum 100 MeV) with thermal pions, kaons and eta.

by the interaction strength through the invariant amplitude of the process. Therefore, with the increase in temperature of the thermal bath the kinetic energy of the hadrons increases. Hence the hadrons gain the ability to transfer larger momentum during their interaction with the B mesons - resulting in the increase of the drag coefficient.

Since the diffusion coefficient involves the square of the momentum transfer it is also expected to increase with T. This is seen in Fig. 2.

In summary we have evaluated the drag and diffusion coefficients of open beauty mesons interacting with a hadronic background composed of pions, kaons and eta. It is found that the values of both the transport coefficients increase with temperature. The magnitude of the drag coefficient of the B meson indicates that while evaluating the suppression of the high p_T single electrons originating from the decays of B mesons the effects of hadrons should be taken into account. The D meson transport coefficients using same formalism as well as the role of the B and D meson transport coefficients on nuclear suppression (R_{AA}) will also be presented at the symposium.

References

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