Medium Effects on the Thermal and Diffusion Coefficients of a Hot Hadronic Two Component Mixture

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Introduction

Because of the immense opportunity it provides to explore strong interacting matter heavy ion collision have claimed deserving attention. Transport properties have been employed to understand the characteristics of he thermodynamic system created during such collision. Ever science

A large number of study has been made on viscous coefficients and but a negligible amount on the thermal conductivity or other coefficients like diffusion, this is mainly due to the fact the net barionic potential in mid rapidity region at RHIC and LHC is small. At FAIR the baryon Chemical potential is expected to be significant, moreover if the total number of particle is conserved then the system can sustain heat conduction. Based on the above scenario thermal conductivity (λ), Dufour ($D_T^{'}$) , thermal diffusion (D_T) and diffusion coefficients D have been calculated for a hadronic mixture constituting of pions and nucleons. To obtain these coefficients relaxation time approximation has been employed to solve the Boltzmann transport equation. Medium effects have been incorporated in the collision cross section of the constituent particles while calculating the relaxation time of collision. The effect of medium on the coefficients have been studied at different temperature for different nucleon chemical potential.

Relaxation Time Formalism

Under relaxation time approximation the Boltzmann transport equation takes the form.

$$p^\mu \partial_\mu f_\pi = -\frac{\delta f_\pi}{\tau_\pi} \tag{1}$$

$$p^\mu \partial_\mu f_N = -\frac{\delta f_N}{\tau_N} \tag{2}$$

where δf is the slight deviation from equilibrium of the distribution function f. The irreversible part of energy momentum tensor and particle flow is given by:

$$\Pi^{\mu\nu} = \int d\Gamma p^\mu p^\nu \delta f \tag{3}$$

$$V^\mu = \int d\Gamma p^\mu \delta f \tag{4}$$

Solving the above equations the we get

$$\lambda = -\frac{1}{3T}\sum_{k=1}^{2}\int d\Gamma_k (p_k \cdot U - h_k) \, p_k^\sigma \Delta_\sigma^\alpha B_\alpha^{(k)q} f_k^{(0)}[1 \pm f_k^{(0)}] \tag{5}$$

$$D_T^{'} = -\frac{1}{3nx_2x_1T}\sum_{k=1}^{2}\int d\Gamma_k (p_k \cdot U - h_k) \, p_k^\sigma \Delta_\sigma^\alpha B_\alpha^{(k1)} f_k^{(0)}[1 \pm f_k^{(0)}] \tag{6}$$

$$D = -\frac{1}{3nx_2}\Big(\frac{\partial \mu_1}{\partial x_1}\Big)_{PT}\sum_{k=1}^{2}\int d\Gamma_k (\delta_{k1} - x_k) \, p_k^\sigma \Delta_\sigma^\alpha B_\alpha^{(k1)} f_k^{(0)}[1 \pm f_k^{(0)}] \tag{7}$$

$$D_T = -\frac{1}{3nx_2x_1T}\sum_{k=1}^{2}\int d\Gamma_k (\delta_{k1} - x_k) \, p_k^\sigma \Delta_\sigma^\alpha B_\alpha^{(k)q} f_k^{(0)}[1 \pm f_k^{(0)}] \tag{8}$$

where n, x_2 and x_1 being the total number density af particle and the concentration

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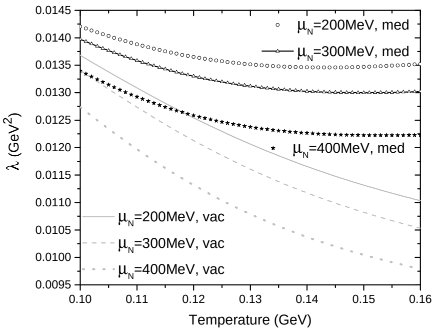

FIG. 1: Thermal conductivity for $80MeV$ pion chemical potential

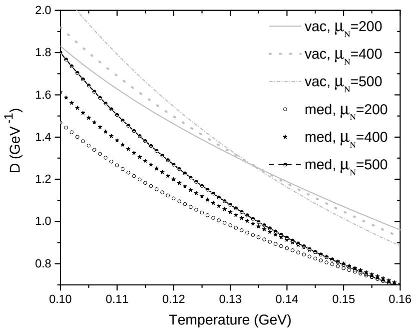

FIG. 2: Diffusion coefficient for $80MeV$ pion chemical potential

of first and second species respectively. The terms $B_{\alpha}^{(k)q}$, $B_{\alpha}^{(k1)}$ contains the relaxation time given by.

$$\tau_1^{-1} = \sum_2 \frac{g_2}{1+\delta_{12}} \tau_{12}^{-1}$$

Where τ_{12}^{-1} is the rate of reaction of particle (1) with particle (2). The dynamic part (i.e. cross section) is contained within the relaxation time.

Result

Fig. 1 Shows the variation of thermal conductivity with temperature for various nucleon chemical potential and $80MeV$ pion chemical potential. Cases with and without medium effect have been considered, and we see a significant change due to medium effect.

In Fig. 2 we see the variation of diffusion coefficient of nucleons into pions as a function of temperature. Here also we find a significant change due to the introduction of medium effect.

The Dufour coefficient as a function of temperature is shown in Fig. 3. Here the effect of medium on the coefficient is not so significant, the same can be said about Thermal diffusion coefficient also.

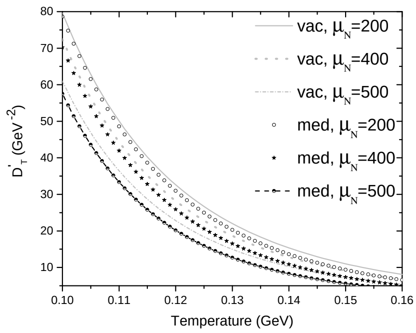

FIG. 3: Dufour coefficient for $80MeV$ pion chemical potential

References

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