Charge fluctuations of identified particles at RHIC energies

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Introduction

One of the major aim of heavy-ion experiments is to study the phase transition from hadronic matter to quark-gluon plasma (QGP). Event-by-event fluctuations of conserved quantities such as net-baryon number, net-electric charge, and net strangeness are proposed as possible signals of the QGP phase transition [1]. It can also help to understand the nature of such phase transition. It has been predicted to observe a large value of fluctuation strength around the QCD critical point. The location of the QCD critical point can be explored by systematically varying the tempreature(T) and baryonic potential (μ_B). The fluctuation strength is measured as

$$D = \frac{4}{\langle N_{\rm ch}\rangle}\langle \delta N_+^2 + \delta N_-^2 - 2\delta N_+ \delta N_-\rangle \approx \frac{4\langle \delta Q^2\rangle}{\langle N_{\rm ch}\rangle} \quad (1)$$

where $Q = N_+ - N_-$ being the difference between number of positive and negative particles(net charge) and $N_{\rm ch} = N_+ + N_-$ is the total number of charged particles measured in an event. The $\langle \delta Q^2\rangle$ is the variance of the net charge, which is proportional to the net charge fluctuation in the system. The value of D is found to be approximately four times smaller in the QGP phase as compared to the hadron gas phase. D-measure has been found to be dependent on detection efficiency. Hence to get rid of this effect, the net charge fluctuations are studied in terms of $\nu_{(\pm,{\rm dyn})}$. The $\nu_{(\pm,{\rm dyn})}$ is found to be robust against the single particle detection inefficiency and it is defined as

$$\nu_{(\pm,{\rm dyn})} = \frac{\langle N_+(N_+-1)\rangle}{\langle N_+\rangle^2} + \frac{\langle N_-(N_--1)\rangle}{\langle N_-\rangle^2} - 2\frac{\langle N_- N_+\rangle}{\langle N_-\rangle\langle N_+\rangle} \quad (2)$$

The value of $\nu_{(\pm,{\rm dyn})}$ gives the measure of the relative correlation strength of ("++", "−−" and "+−") charged particle pairs . The relation between D and $\nu_{(\pm,{\rm dyn})}$ is given as

$$\langle N_{\rm ch}\rangle \nu_{(\pm,{\rm dyn})} \approx D - 4 \quad (3)$$

Estimation of D-measure in different model

We have used HIJING(V.1.37) and UrQMD(V.1.30) to study the fluctuation variables(D or ν_{dyn}). The HIJING and UrQMD both are monte carlo event generators, which is used for nucleon-nucleon and nucleus-nucleus collisions in high energy physics simulations. These models provide the proper baseline to compare with the experimental data.

HIJING is based on pQCD model considering the mini-jet partons produced in collisions are transformed into string fragments and later it fragments into hadrons. It considers nucleus nucleus collisions as a superposition of *pp* collisons, it also considers the jet quenching and nuclear shadowing to study the nuclear effects [2].

The UrQMD model considers the microscopic transport of quarks and diquarks with mesonic and baryonic degrees of freedom. The formation of hadrons are explained by color string fragmentation, it also considers the resonance decays, multiple scattering between hadrons during the evolution. The conservation of baryon number, strangeness number and electric charge is incorporated in the

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model. It also include the baryon stopping phenomena, which is one of the feature of heavy-ion collisions specially at lower collision energies [3].

Results & Discussion

We have shown the estimated D for HIJING and UrQMD model as function of pseudorapidity window. It is observed that, the fluctuation strength decreases with increase in $\Delta\eta$ window. The higher value of D and $\nu_{(\pm,\mathrm{dyn})}$ at lower $\Delta\eta$ indicates the maximum correlation for smaller $\Delta\eta$ and the fluctuation strength gets diluted at higher $\Delta\eta$ intervals. We observe the net-charge and net-π shows similar behaviour since among all the charge particles the contribution from pion is largest. We observe similar behaviour in both the models.

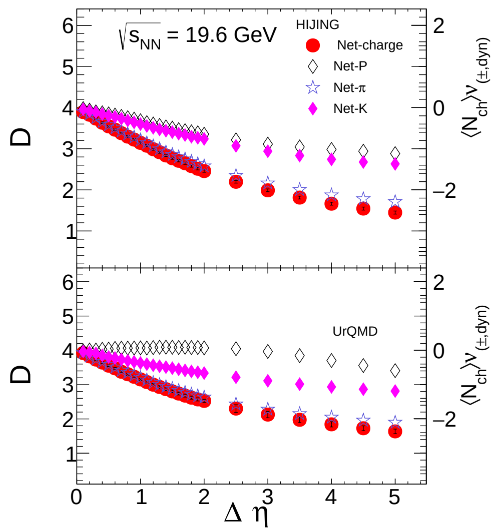

FIG. 1: D(left axis) and $\langle N_{\mathrm{ch}}\rangle\nu_{(\pm,\mathrm{dyn})}$(right axis) as a function of $\Delta\eta$ for net-charge, net-proton, net-pion and net-kaon fluctuations calculated for (0-5%) centrality in Au+Au collisions at $\sqrt{s_{NN}}$ = 19.6 GeV in HIJING and UrQMD model.

The simulated data (D vs $\Delta\eta$) are fitted with the error function $Erf(\Delta\eta/\sqrt{8}\sigma)$ which represents diffusion in rapidity space. The fit parameter σ is called diffusion coefficient characterizing the diffusion at the freeze-out.

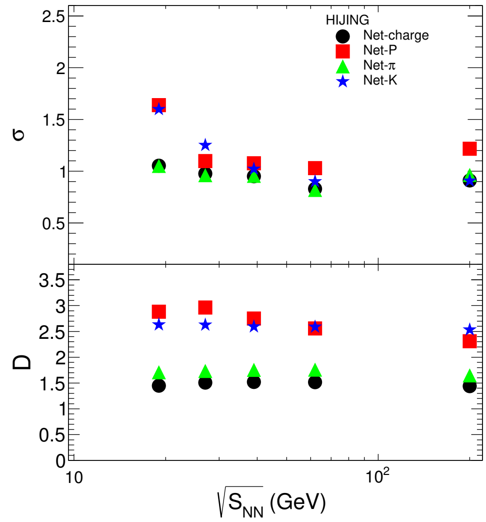

FIG. 2: The upper panel shows collision energy dependence of diffusion coefficient (σ) using HIJING model for (0-5%) centrality in Au+Au collisions. The lower panel shows the values of D calculated at $\Delta\eta$= 5.0 as function of collision energies.

The figure 2 displays the value of diffusion coefficient and fluctuation strength D at different collision energies. We observe the diffusion coefficients are consistent with unity. In the lower panel we observe the value of D remains almost independent of collision energies. A similar observation has been found in UrQMD model.

Summary

We have studied charge fluctuation strength using D and ν_{dyn} measures as function of $\Delta\eta$ and $\sqrt{s_{NN}}$ & extracted diffusion coefficients for identified particles at RHIC energies.

References

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