IMPORTANCE OF MULTIPLICITY FLUCTUATIONS IN ENTROPY SCALING

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US-DOE Nuclear Science Grant No. de-sc0019175
Initial Conditions and Small Systems

Shear viscosity is dependent on choice of initial condition. 

\[ \frac{\eta}{s} \text{ depends on IC: M. Luzum and P. Romatschke, [arXiv:0901.4588 [nucl-th]]} \]
Functional Form of Initial Entropy Density

Scaling Relation:

\[ f_p(cT_A, cT_B) = cf(T_A, T_B) \]

Model Agnostic Generalized Mean:

\[ f_p(T_A, T_B) = \left( \frac{T_A^p + T_B^p}{2} \right)^{\frac{1}{p}} \]

From Bayesian Analysis (\( p = 0 \)):

\[ \sqrt{T_A T_B} \]

TRENTO used ultra-central U+U collisions to exclude entropy scaling models from their analysis

Linear Functional Form

$$\sqrt{T_AT_B} \in f_p$$

Initial Energy Density in CGC:

$$T_AT_B \notin f_p$$

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Using another functional form needed Lognormal multiplicity fluctuations

Multiplicility Distributions

\[ T_{A,B}(x,y) = w_{A,B} \int dz \rho_{A,B}(x,y,z) \]

\[ P_k(w) = \frac{k^k}{\Gamma(k)} w^{k-1} e^{-kw} \]

\[ P_k(w) = \frac{2}{wk\sqrt{2\pi}} e^{-\frac{\log^2(w^2)}{2k^2}} \]

Updates to TRENTO: I added \(T_A T_B\) scaling and Lognormal Fluctuations
\[ \sqrt{T_A T_B} \] needs more fluctuations to reproduce data than \( T_A T_B \) which matches data with no fluctuations.

\[ N_{ch} \propto S_0 \]
Multiplicity: Lognormal fluctuations

$\sqrt{T_AT_B}$ plays well with $\Gamma$ but not Lognormal.

$\sqrt{T_AT_B}$ smooths out entropy more than $T_AT_B$ meaning it needs more fluctuations.
Eccentricities

Different $\epsilon_n$ affect the extraction of $\eta/s$ from $\nu_n$

4 Particle Cumulants

Plotting $\frac{\epsilon_n\{4\}}{\epsilon_n\{2\}}$ to see the event by event fluctuations

Using absolute value of $\epsilon_n\{4\}$ to portray negative values rather than leave them imaginary

Small systems have both linear and non-linear results so hydro simulations will give a more accurate description of $\frac{v_2\{4\}}{v_2\{2\}}$

AuAu
Effect is decreased in larger systems
Multiplicity: Lognormal Fluctuations

LogNorm Fluctuations $\sqrt{T_A T_B}$

AuAu @ 200GeV

Best Fit: $k=1$

Best Fit: $k=0.1$
Eccentricities

$T_A T_B$ gives a larger $\epsilon_3\{2\}$ than $\sqrt{T_A T_B}$, but they are the same in $\epsilon_2\{2\}$
If error bars of $\frac{\varepsilon_2\{4\}}{\varepsilon_2\{2\}}$ data can be decreased by factor of 2 then the two models can be distinguished from each other.
Conclusion

- Choice of functional form and multiplicity fluctuations can have an effect on extracted viscosity
- The effect on extracted viscosity is greater for small systems and less for large systems
- $\epsilon_2^2$ is good for distinguishing models

Future

- Both functional forms are symmetric, IP-JASMA used an asymmetric form with lognormal fluctuations
- Test sampling directly from the gluon spectrum
- Quantify the amount of an effect this would have on extracted viscosity