Longitudinal structure of the initial state from 3+1D Glasma simulations

Pragya Singh*, Sören Schlichting
Universität Bielefeld

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Solve 3+1D classical Yang-Mills equations and evolution equations for eikonal currents, before, during and after the collision.
Collision with (semi-) realistic charge distribution

Now in practice we employ a factorized ansatz for position and momentum dependence of the color charge distribution

\[
\langle \rho^a(x) \rho^b(y) \rangle = \delta^{ab} T(x + y) \Gamma(x - y)
\]

We determine the momentum dependence from TMDs in the dilute approximation (GBW model)

\[
\tilde{\Gamma}(k_\perp, k_z) = \frac{8\pi}{g^2} \frac{N_c}{N_c^2 - 1} \frac{k_\perp^4}{Q_s^2(x_2)} \exp \left( - \frac{k_\perp^2}{Q_s^2(x_2)} \right) \bigg|_{x_2 = -\sqrt{2}k_z/\sqrt{s_{NN}}}
\]

Superimpose 3D MC-Glauber profile of spatial distribution of color charges

\[
T(x, y, z) = \sum_{i=1}^{A} T_i(x, y, z).
\]
Effect of fluctuation at RHIC energies

Before the collision  
\[ t = -0.37 \text{ fm/c} \]

During the collision  
\[ t = 0 \text{ fm/c} \]

After the collision  
\[ t = 0.6 \text{ fm/c} \]

Au-Au collision at \( \sqrt{s} = 200 \text{ GeV} \)

Inhomogeneity emerge mostly due to the fact that different nucleons control energy deposition at different space-time positions.
Effect of fluctuation at RHIC energies

Fixed $\tau \simeq 0.75$ fm/c

Fluctuation relatively small $\leq 1\%$ and decreases with increasing $\sqrt{s}$
Decorrelation of $n$-th order anisotropic flow

Characterise overall decorrelation using forward-backward ratio

$$r_n(\eta_a, \eta_b) = \frac{\langle \text{Re}[\epsilon_n(-\eta_a) \cdot \epsilon^*_n(\eta_b)] \rangle}{\langle \text{Re}[\epsilon_n(\eta_a) \cdot \epsilon^*_n(\eta_b)] \rangle}$$

Using initial state $\epsilon_n$

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Simultaneous description of $r_2$ and $r_3$ for central collision

Strong decorrelation at lower energies
Conclusion & Outlook

Developed a framework to describe 3D profiles of initial energy deposition using CGC.

Successful results from numerical simulations; additional analytic insights highly desirable.

So far focused on longitudinal profiles of initial state energy deposition; also interesting to explore early time non-equilibrium dynamics.

Thank you...
Backup: 3+1D Glasma simulations

1. Sample 3D distribution of color charges $\rho(x^\pm, x_\perp)$ in each half boxes.

2. Solve for Weizsäcker-Williams fields (WW) of the incoming nuclei.

3. Evolve gauge fields and corresponding conjugate momenta according to the discretised 3+1D YM

$$[D_{\mu}, F^{\mu\nu}] = J^\nu$$

4. Evolve eikonal currents according to continuity equation.

$$[D_{\mu}, J^\mu] = 0$$

5. Solve 3. and 4. simultaneously to simulate early time dynamics of collision in 3+1D

Rigorous derivation of initial condition that successfully conserves Gauss Law.