

Validating the Pre-equilibrium Evolution of Heavy Ion Collisions in KØMPØST

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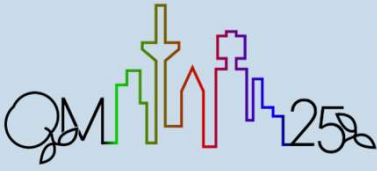
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Motivation

- KØMPØST [1] models **pre-equilibrium phase** of quark-gluon plasma (QGP) in **heavy ion collisions**
 - **Efficient approximation**
- Verifying the **applicability of KØMPØST**
 - Approximation of **dynamics of kinetic theory**
 - Comparison full kinetic theory in **relaxation time approximation (RTA)** [2] with KØMPØST in RTA

KØMPØST

- Propagation from **initial time** to **target time**:
 - Causality condition $|x - x'| < c(\tau - \tau_0)$
- Result equals **spatial average** + **perturbations**:

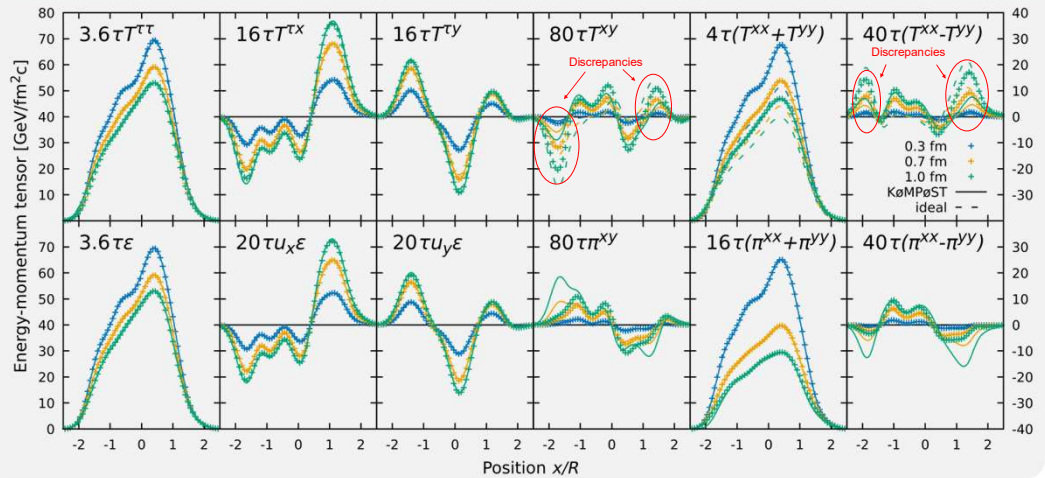
$$T_x^{\mu\nu}(\tau_0, x') = \bar{T}_x^{\mu\nu} + \delta T_x^{\mu\nu}(\tau_0, x')$$
- perturbations by linear response scheme using time-dependent **Green's functions** [4]:

$$\delta T_x^{\mu\nu}(\tau, x) = \int d^2 x' G_{\alpha\beta}^{\mu\nu}(x, x', \tau, \tau_0) \delta T_x^{\alpha\beta}(\tau_0, x') \frac{\bar{T}_x^{\tau\tau}(\tau)}{\bar{T}_x^{\tau\tau}(\tau_0)}$$

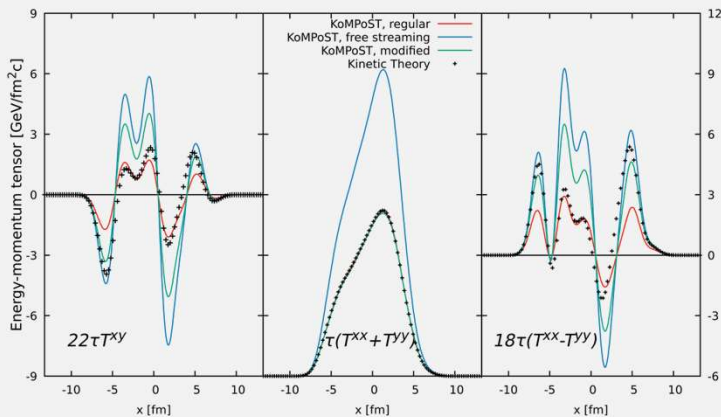
Results

- **Excellent agreement** between KØMPØST and kinetic theory in most components
- **Discrepancies** in components related to elliptic flow
 - Larger in peripheral regions
- Same result for average event
- Free-streaming KØMPØST shows near complete agreement
 - Substituting relevant Green's functions with free-streaming equivalent improves outer regions
 - Check rate of equilibration

$$\tilde{w} = \frac{T(\tau)\tau}{4\pi\eta/s}$$
 - Check weight function for average



Errors Analysis

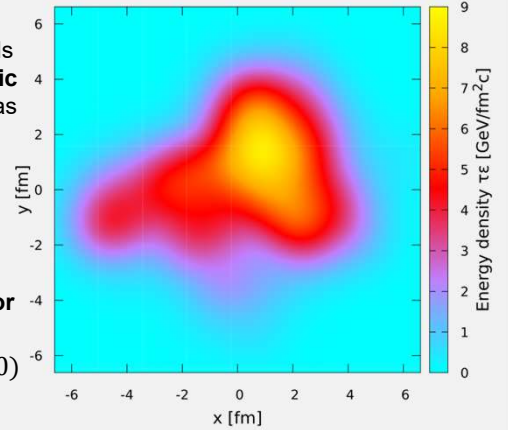


- Peripheral regions agreement with free-streaming, centre with regular KØMPØST
- Weight function: only small effect

Initial Conditions & Observables

- **Initial state** obtained by models of **(sub-) nucleonic interaction** such as T_RENTo [3]
- Pb-Pb collisions generated on grid
- **Initial energy-momentum tensor**

$$T_x^{\mu\nu}(\tau_0, x_\perp) = \text{diag}(\varepsilon, \varepsilon/2, \varepsilon/2, 0)$$



- Landau frame $T^{\mu\nu}u_\nu = T_{\text{eq}}^{\mu\nu}u_\nu = \varepsilon u^\mu$
- Energy-momentum tensor in equilibrium

$$T_{\text{eq}}^{\mu\nu}u_\nu = (\varepsilon + P)u^\mu u^\nu - P g^{\mu\nu}$$
 with $P = \varepsilon/3$
 - Non-equilibrium part $\pi^{\mu\nu} = T^{\mu\nu} - T_{\text{eq}}^{\mu\nu}$

Conclusion & Outlook

- KØMPØST simulates energy, energy flow and isotropic shear stress components correctly
- Elliptic flow is modelled incorrectly
 - Overestimation of equilibration in outer regions
- No difference for single or average event

- More detailed investigation of dynamics of elliptic flow in KØMPØST
- Modification of KØMPØST's background/fluctuation splitting

References

- [1] A. Kurkela, A. Mazeliauskas, J.-F. Paquet, S. Schlichting, and D. Teaney, Phys. Rev. Lett. 122 (2019), p. 122302
- [2] J.L. Anderson and H.R. Witting, Physica 74.3 (1974), pp. 466–488.
- [3] J.S. Moreland, J.E. Bernhard, and S.A. Bass, Phys. Rev. C 92.1 (2015), p. 011901.
- [4] S. Kamata, M. Martinez, P. Plaschke, S. Ochsensfeld, and S. Schlichting, Phys. Rev. D 102.5 (2020), p. 056003.