Anisotropic flow decorrelation in heavy-ion collisions at RHIC-BES energies with 3D event-by-event viscous hydrodynamics

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Motivation & Model

- Longitudinal structure of anisotropic flows brings additional constraints on the initial state and/or transport coefficients of the QGP.
- At RHIC-BES energies, flow decorrelation is just starting to be researched.
- There is a finite baryon and electric charge densities at all stages.
- GLISSANDO2 and TrENTo are extended to longitudinal direction following work of Bozek [Phys. Rev. C 85, 044910 (2012)].
- Total energy conservation is imposed in the initial state.
Anisotropic Flow

- Flow coefficients can be computed from
  \[ v_n = \frac{\int d\phi \cos(n(\phi - \Psi_n)) \frac{d^3N}{p_T dp_T dy d\phi}}{\int d\phi \frac{d^3N}{p_T dp_T dy d\phi}} \]

- To calculate flow coefficients we used 2-particle cumulant method [Phys. Rev. C 83, 044913 (2011)]

- Models with Glissando and UrQMD IC underestimate the \( p_T \)-integrated elliptic flow
• Longitudinal fluctuations can lead to decorrelations of anisotropic flows along the pseudorapidity direction

• The factorisation ratio is defined as

\[ r_n(\eta, \eta_{\text{ref}}) = \frac{\langle V_n(-\eta) V_n^*(\eta_{\text{ref}}) \rangle}{\langle V_n(+\eta) V_n^*(\eta_{\text{ref}}) \rangle} = \frac{\langle v_n(-\eta) v_n(\eta_{\text{ref}}) \cos n(\Psi_n(-\eta) - \Psi_n(\eta_{\text{ref}})) \rangle}{\langle v_n(+\eta) v_n(\eta_{\text{ref}}) \cos n(\Psi_n(+\eta) - \Psi_n(\eta_{\text{ref}})) \rangle} \]

• \( r_n(\eta) = 1 \Rightarrow \text{no decorrelation} \quad r_n(\eta) < 1 \Rightarrow \text{decorrelation} \)

UrQMD IS results in significantly stronger decorrelation
Analogously, we can define decorrelation of initial state spatial eccentricity:

\[
\rho_n^e(\eta_s) = \frac{\langle \epsilon_n(-\eta_s)\epsilon_n(\eta_s,\text{ref}) \cos[n(\Psi_n(-\eta_s) - \Psi_n(\eta_s,\text{ref}))]\rangle}{\langle \epsilon_n(\eta_s)\epsilon_n(\eta_s,\text{ref}) \cos[n(\Psi_n(\eta_s) - \Psi_n(\eta_s,\text{ref}))]\rangle}
\]
Summary

- We presented the elliptic flow and flow decorrelation in Au-Au collisions at $\sqrt{s_{NN}} = 27$, 62.4 and 200 GeV in 3-dimensional viscous hydrodynamic model with UrQMD, 3D GLISSANDO and 3D TRENTo initial states.
- Flow decorrelation at $\sqrt{s_{NN}} = 27$ GeV is a first calculation of a kind in a hydrodynamic model.
- At midrapidity, model with TrENTo IS ($p = 0$) best describes the elliptic flow.
- We observe that the flow decorrelation is mainly caused by flow angle decorrelation, which is in agreement with other studies [Phys. Rev. C 98, 024913 (2018), Phys. Rev. C 97, 034913 (2018)].
- The model with UrQMD IS overestimates the decorrelation, which is rooted in much stronger decorrelation of initial state eccentricity.
- References: [Phys. Rev. C 103, 034902 (2021)] and [Phys. Rev. C 104, 014904 (2021)].

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