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Initial momentum and conserved charges to final flow

The evolution of a relativistic heavy-ion collision is typically understood as a process that transmutes the initial geometry of the system into the final momentum distribution of observed hadrons, which can be described via a cumulant expansion of the initial distribution of energy density and is represented at leading order as the well-known eccentricity scaling of anisotropic flow. We extend this framework to include the contribution from initial momentum-space properties as encoded in other components of the energy-momentum tensor, as well initial conserved charge densities. We confirm the validity of the framework in state-of-the-art hydrodynamic simulations
of large and small systems.
With this new framework, it is possible to separate the effects of early-time dynamics from those of final-state evolution, even in the case when the distribution of energy does not fully determine subsequent evolution, as for example, in small systems. Specifically, we answer the question of when and how azimuthal correlations from the initial state survive to the final state.

In very small systems such as *p*-*p*, for example, initial momentum degrees of freedom dominate over energy. Thus, even if the system forms a quark-gluon plasma that is well described by hydrodynamics, the usual hydrodynamic picture of the transmutation of initial geometry to final momentum anisotropy is broken. Nevertheless, we show that the hydrodynamic response to the full energy-momentum tensor can be well understood in a similar manner as larger systems. Additionally, this framework elucidates the generic features of the system's evolution that are responsible for the impressive success of hydrodynamic simulations, but which may still hold even in cases where hydrodynamics is not applicable.

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Category

Theory

Collaboration (if applicable)

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