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Extract the speed of sound in the presence of quantum fluctuations

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The thermalization of quark-gluon plasma created in heavy-ion collisions is crucial for understanding its behavior as a relativistic fluid and the thermodynamic properties of the Quantum Chromodynamics (QCD). This study investigates the role of fluctuations in the relationship between transverse momentum and particle multiplicity, with a particular focus on their impact on extracting the QCD speed of sound. In a thermalized quark-gluon plasma, sources of
these fluctuations mostly originate from quantum fluctuations
at the level of the colliding nuclei, which as a consequence of independence of thermodynamic response follow a Gaussian distribution.}
In contrast, non-thermalized systems display non-Gaussian fluctuations, reflecting the breakdown of thermalization. By leveraging the Gaussianity condition of quantum-initiated fluctuations, the physical value of the speed of sound can be extracted statistically, even in the presence of significant event-by-event fluctuations. This framework provides a robust diagnostic tool for probing thermalization and extracting thermodynamic properties in both large and small collision systems.

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