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Particle multiplicity fluctuations of quantum origin and high-multiplicity pp collision events

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The multiplicity dependence of the two-particle Bose-Einstein momentum correlation radii in pp collisions at the LHC has been measured at a fixed energy of collisions. One notable feature of these measurements is that the effective system's volume, when extracted from the correlation radius parameters, appears to scale nearly linearly with charged-particle multiplicity [1-3], except for low multiplicities where initial state effects dominate and, quite unexpectedly, except for very high multiplicities where, at variance with the expected behavior for emission from hydrodynamically expanding systems, one sees systematic deviations from such a scaling behavior. That is, the striking feature of the data is that the correlation radius parameters become approximately independent of the particle multiplicity in the limit of very high multiplicities [1,2]. The question naturally arises: How can this controversy with hydrodynamics be resolved?
In Ref. [4], we argue that quantum-origin multiplicity fluctuations dominate the fluctuations in particle multiplicity in high-multiplicity pp collision events at a fixed LHC energy. The quantum-to-classical transition of multiplicity fluctuations happens when the interference term between the corresponding states becomes negligible. Until this happens, superposition cannot be interpreted as a classical ensemble of its component states. To connect quantum fluctuations of particle multiplicity to event-by-event multiplicity fluctuations, we introduce the statistical ensemble of the multiplicity fluctuations of particles after the system's freeze-out. We utilize the maximum entropy prescription to determine a quantum state at kinetic freeze-out and derive expressions for multiplicity-selected particle momentum spectra and correlation functions by applying a fixed particle-number constraint to this state. Then, we study how multiplicity fluctuations at high multiplicities impact the multiplicity-selected particle momentum spectra and correlation functions. In particular, we find that the effective system's volume should become approximately independent of the particle multiplicity in the limit of very high multiplicities in multiplicity-selected collision events.

References

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