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Probing conserved charge dynamics via HBT interferometry in relativistic heavy-ion collisions

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The quark-gluon plasma (QGP), a transient state of deconfined quarks and gluons governed by quantum chromodynamics (QCD), existed microseconds after the Big Bang and can be recreated in ultra-relativistic heavy-ion collision experiments. Probing its properties requires a detailed understanding of the spatio-temporal structure of the particle-emitting sources at the time of freeze-out. In this study, we utilize Hanbury Brown–Twiss (HBT) interferometry to calculate the HBT correlation functions and extract the three-dimensional HBT radii for various identical particle pairs, providing insights into the source geometry and emission duration. For our analysis, we employed a hybrid framework combining viscous hydrodynamics with hadronic transport, along with a Monte Carlo Glauber-based initial condition generator, to simulate the collision dynamics and evolution of the QGP medium, incorporating different QCD conserved charges, particularly baryon number. Our analysis lays the foundation for exploring the particle emission surfaces via meson–baryon–antibaryon splitting in the HBT radii, which may provide unique access to the underlying freeze-out dynamics and, ultimately, to the initial conditions of the system.

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