The Influence of Radial Flow on p-p Correlations

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For an ideal, adiabatic expansion process, a simultaneous measurement of the freeze-out temperature and the degree of initial thermalization of the available center-of-mass energy is sufficient to determine the freeze-out density [1]. In general, however, the sharing of the available energy between collective radial motion and random (thermal) energy will also reflect the degree of dissipation during the expansion. Further constraints on the space-time density of the system at freeze-out might be provided by particle interferometry. Thus a combination of interferometric and thermodynamic informations might allow a closer look at the expansion dynamics.

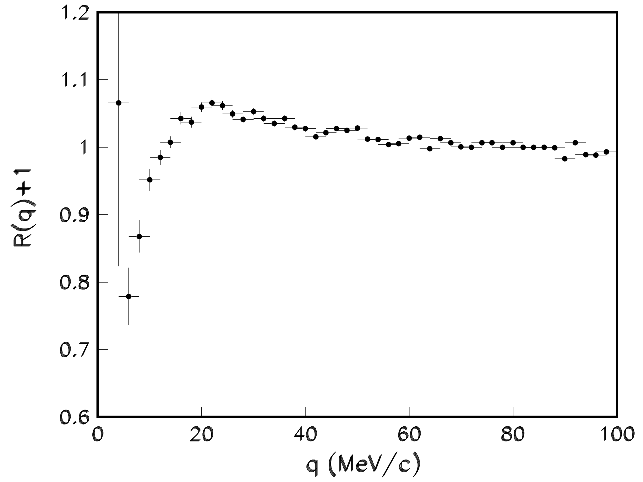

Figure 1: Proton - proton correlation for central ^{197}Au+^{197}Au collisions at E/A = 150 MeV.

Figure 1 shows a p-p correlation function R(q)+1 for central ^{197}Au+^{197}Au collisions measured at an incident beam energy of 150 MeV per nucleon. Assuming, as a point of reference, a spherical Gaussian-shaped source of density $\rho(r) \propto e^{-r^2/r_0^2}$ and negligible lifetime [2], the observed strength is consistent with a source radius $r_0 \approx 6$ fm. This value corresponds to a sharp sphere radius of $R_s = \sqrt{5/2}r_0 \approx 10$ fm.

While this theoretical estimate neglects correlations between momentum and ordinary space, a radial flow will introduce such correlations. Indeed, the analysis of the kinetic energy spectra of fragments in central Au+Au reactions has revealed a considerable collective outward motion superimposed on the random motion. At the breakup stage approximately one-half of the energy available in the center-of-mass frame is stored in an explosive radial flow [3, 4]. For such large radial flow velocities, particle pairs at small relative momenta will probe only a limited spatial region of the source [5, 6, 7], giving rise to smaller apparent source sizes.

In order to quantify the sensitivity of the proton-proton correlation to a collective expansion, schematic calculations based on the Pratt formalism [8] were performed. Nucleons were assumed to be emitted from a homogeneously filled sphere of radius R_s. In addition to the thermal velocity distribution characterized by a temperature parameter T, a self-similar flow profile was superimposed. Parameter pairs of the flow energy per nucleon at the surface, $(E/A)_f$, and the associated temperature parameter T were constrained to give (nearly) identical kinetic

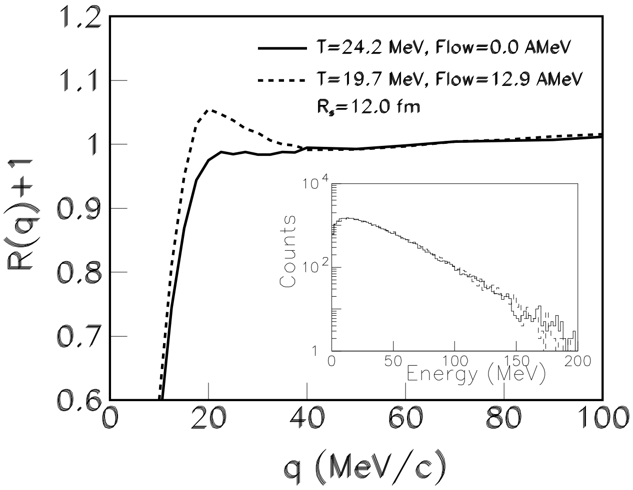

Figure 2: Calculated proton - proton correlation for two different combinations of random (thermal) and collective (flow) motion. The corresponding center-of-mass kinetic energy spectra are compared in the insert.

energy spectra which mimic the experimentally observed single proton spectra (see insert in Fig. 2). Despite identical spatial source dimensions and rather similar single particle distributions, we obtain significantly enhanced *two*-particle correlation functions in the presence of flow (Fig. 2).

The apparent source radius is monotonously decreasing with increasing flow energy per nucleon, while for a given flow energy per nucleon the relative reduction is rather insensitive to the actual source radius. For flow values comparable to the experimental findings in central Au+Au collisions at E/A=150 MeV [3], we expect an apparent reduction of the source radius by approximately 15%. This leads to an overestimation of the density by about 40% if the effect of flow on the correlation function is neglected.

Clearly these considerations are still preliminary and schematic. Several other effects (e.g. finite lifetime, sequential decay, medium corrections to the p - p interaction, and multi-body Coulomb interactions) have to be considered in addition before definite conclusions can be reached. Nonetheless the present calculations illustrate that two particle correlations at small relative momenta show sensitivities to the expansion dynamics which are different from that of single-particle distributions.

References

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