Hadron -hadron interferometry in nucleus-nucleus collisions at 1.9A GeV

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Abstract

Correlations of proton-proton and pion-pion pairs emitted in Al+Al and Ni+Ni collisions at a beam energy of 1.9A GeV were investigated with the FOPI spectrometer at GSI Darmstadt. The structure of the correlation function for an expanding system addresses the dimensions of the region of homogeneity, the size and shape of the phase space cloud of the outgoing particles whose velocities have a specific magnitude and direction. Comparison of the experimentally obtained correlation function to the theoretical predictions provides information on the sizes of the particle emission sources in heavy-ion collisions.

The attractive single S-wave interaction between the two coincident protons gives rise to a maximum in the correlation function at a relative momentum of $q \approx 20$ MeV/c. Experimental data are compared to the Koonin-like model, which allows for the extraction of the effective Gaussian radius of the emitting source for the protons. These results are in good agreement with the previous FOPI measurements.

A positive correlation is observed for small relative momenta of a pair of pions in the region of momentum difference $q < 50$ MeV/c. One-dimensional correlation functions are obtained in term of the relative momentum of the pion pairs. Three-dimensional two identical pion relative momentum distributions are obtained in the longitudinally co-moving system (LCMS). Spatio-temporal information on the pion source is obtained by fitting the experimental pion-pion correlation function by a Gaussian function.

Dependence of the source size on the system size, total kinetic energy, and average transverse momentum of two coincident particles is studied. The source radius is found to increase with increasing size of the colliding system. This dependence is due to a larger number of participants in the collision zone. With increasing total kinetic energy and total transverse momentum of the two coinciding particles the source radius becomes smaller. This dependence is consistent with the idea that nucleus-nucleus collisions are characterized by the collective expansion of nuclear matter after the compression phase. The extracted size of the pion source is significantly larger than that of the protons.