Strange Particle Production and Equilibration at SIS energies within a Semiclassical Off-shell Transport Approach

W. Cassing, S. Juchem
University of Giessen

Recently we have formulated a novel transport approach that incorporates the propagation of particles off the mass-shell [1]. It goes beyond the conventional transport description within the on-shell quasiparticle limit to propagate particles with a finite lifetime by means of a dynamical spectral function. This spectral function is directly determined by the spacetime and momentum-dependent imaginary part of the particle self-energy. By this procedure it is guaranteed, that the actual spectral function is consistently adjusted to the scatterings and decays of the particle in the nuclear medium as well as in vacuum.

Within this off-shell transport approach we have studied strange meson production in the SIS energy regime. When treating baryons as well as antikaons off-shell we obtain an increase by a factor of about two for the production of K^- mesons in comparison to the on-shell calculation for $Ni + Ni$ at 1.8 A GeV (Fig. 1). This enhancement arises since antikaons couple strongly to nucleons such that they achieve a considerable collision width in the nuclear medium which leads to an effective lowering of their production threshold. So the antikaons might be produced at subtreshold energies and enhance the final K^--yield when becoming asymptotically on-shell. The inclusion of the off-shell propagation therefore gives a (partial) explanation for the high K^- abundancy that has been measured by the FRS, KaoS and FOPI Collaborations [2,3]. The data are still underestimated by the off-shell calculations that have been performed without any potentials for the strange mesons. Thus antikaon potenials will still be necessary to get a full description of the experimental results. We have also investigated the production of K^+ mesons in

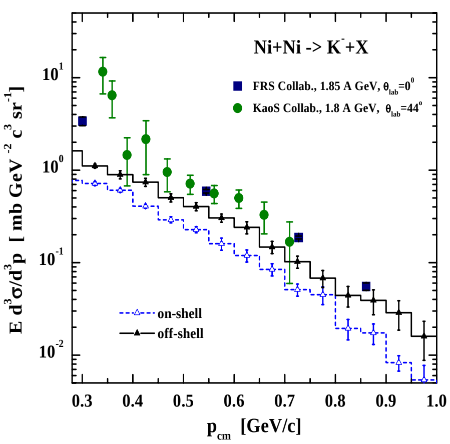

Figure 1: The inclusive spectra of K^- for $Ni + Ni$ at 1.8 A GeV within the off-shell transport approach (solid histogram, full triangles) and in the on-shell limit (dashed histogram, open triangles). The data are from [2] for $\theta_{lab} = 0^o$ (squares) and from [3] for $\theta_{lab} = 44^o$ (circles).

the same reaction, however, find only a small enhancement within the off-shell treatment relative to the on-shell limit which should be attributed to the weak coupling of kaons to nucleons [1b].

Furthermore, we have studied equilibration phenomena in the off-shell transport approach. For this aim we have confined the system to a box in coordinate space with periodic boundary conditions (using a density of $\rho = \rho_0$). We find that the off-shell generalization has practically no influence on the equilibration time of the nuclear system for various bombarding energies up to 1 A GeV [1c].

In order to study the equilibrium properties we compare the results of our transport (box) calculations with a simple statistical model for an ideal hadron gas . All hadron species that are propagated in the transport calculation (N,Δ,π) are also taken into account in the statistical model within the grand canonical ensemble. In Fig. 2 we

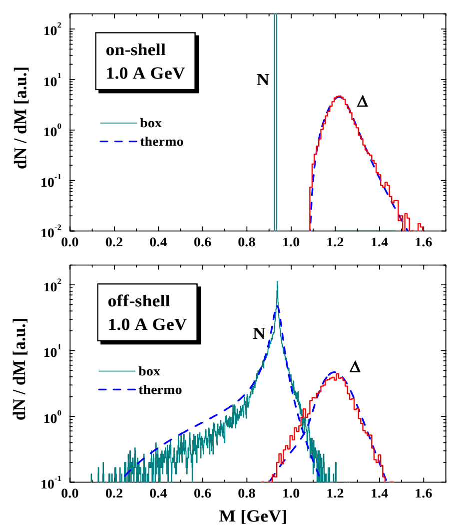

Figure 2: Differential distribution in mass for nucleons and Δ resonances for a bombarding energy 1 A GeV at $\rho = \rho_0$.

show the differential distributions in mass for nucleons and Δ resonances in the long time limit of the transport (box) calculations in comparison to the statistical model (dashed lines) for a bombarding energy of 1 A GeV. We find that the transport theoretical treatment yields nearly the same distributions in mass as the thermodynamical model, when for the latter the same spectral functions as in the transport calculation are employed. A temperature of 97 MeV (deduced from a transverse mass analysis of the particle spectra) has been used here. This result indicates that the actual realization of the off-shell dynamics guarantees the correct stationary solution in the long time limit.

References

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