Dilepton production in heavy ion collisions at intermediate energies

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During the last decade, the problem of the description of hadrons in dense and hot nuclear matter received great attention. The purpose of the current investigations is to determine experimentally mass shifts and the broadening of hadronic resonances at finite density and temperature. The dilepton spectra from heavy-ion collisions are a suitable tool for this purpose. The dilepton spectra measured by the CERES and HELIOS-3 Collaborations at CERN SPS found a significant enhancement of the low-energy dilepton yield below the ρ and ω peaks [1]. In contrast to the spectra taken at the SPS the spectra obtained by the DLS Collaboration at the BEVALAC [2] for the incident energies around 1 A.GeV cannot be reproduced by present transport calculations [3], even if full spectral functions and/or a dropping mass scenario for the vector mesons is taken into account. This fact is known as the DLS *puzzle*.

Therefore a precise and rather complete knowledge of the relative weights for existing decay channels is indispensable in order to draw reliable conclusions from dilepton spectra and to try to solve the DLS puzzle. In [4] we performed a systematic study of meson decay channels including channels which have been neglected up to now such as e.g. $\rho^0 \to \pi^0\pi^0 e^+e^-$. Recently in [5], we derived phenomenological kinematically complete relativistic expressions for decays rates of nucleon resonances with arbitrary spin and parity into the dilepton pairs in terms of the magnetic, electric, and Coulomb transition form factors. For the description of the transition form factors of the nucleon resonances the VMD model was extended to include higher radially excited ρ-mesons $\rho(1450)$ and $\rho(1700)$ in the transition form factors $RN\gamma$ to ensure the correct asymptotic behavior of the amplitudes in line with the quark counting rules. The free parameters of the model are fixed by fitting the experimental data on the photo- and electroproduction amplitudes and by fitting the results of the multichannel πN-scattering partial-wave analysis and the quark model predictions for these amplitudes. Thus one obtains an *unified* description of radiative $R \to N\gamma$ and the mesonic $R \to NV$ decay data. The transition form factors determined this way are used for the calculation of the dilepton branching ratios and dilepton spectra from decays of the nucleon resonances $R \to Ne^+e^-$ with masses below $\mathbf{2}$ GeV.

With this input we performed QMD transport calculations for $C+C$ reactions at 1 AGeV. In Fig. 1 we compare the results to the DLS data. Although we included significantly more decay channels and apply an improved description of the baryonic resonance decays our results are close to those obtained in [3]. As in [3] we underestimate the DLS data below the ρ peak by the same order of magnitude. To describe the resonance decays we introduced radially excited ρ-mesons in the transition form factors to ensure the correct asymptotic behavior of the amplitudes in line with the quark counting rules. Thereby we required the destructive interference of the ground-state and the excited ρ-mesons. In heavy-ion collisions, the interference between the virtual ρ, ρ', and ρ''-resonances produced in the nucleon resonance decays can be destroyed at least partially by interactions with the hot and dense nuclear medium. In the case of total decoherence, the ρ, ρ', and ρ'' contributions to the subthreshold part of the cross section $pp \to e^+e^-X$ must be summed up decoherently which leads to an enhancement of the resonance contributions due to the presence of the nuclear medium.

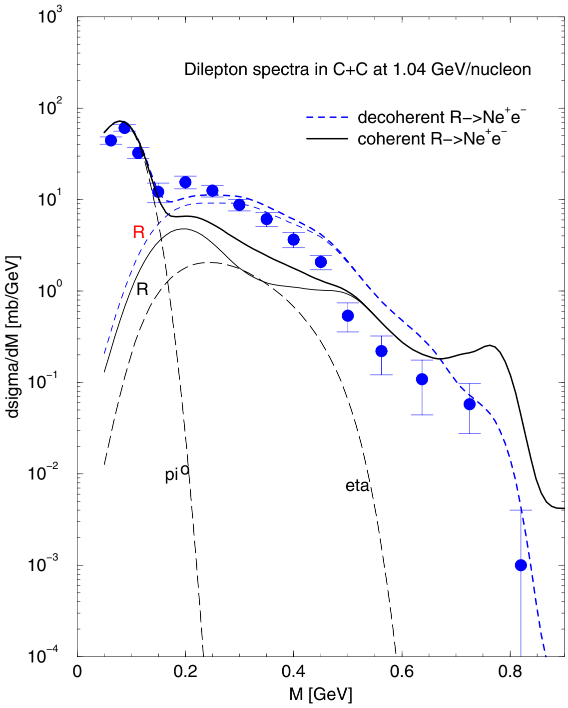

Figure 1: Dilepton spectra in $C+C$ reactions at 1.04 AGeV. Results using vacuum formfactors (solid, coherent) for $R \to Ne^+e^-$ decays of baryonic resonances are compared to the DLS data [2]. The contributions from π, η and resonances (R) are shown seperately. The dotted line (decoherent) shows the result where total decoherence of the virtual vector mesons in the resonance decays to dileptons is assumed.

We estimated this decoherence effect assuming total decoherence between the various intermediate ρ states in the decay of the baryonic resonances. The resulting curve is also shown in Fig. 1. It is seen that this leads to a significant enhancement of the dilepton yield in the kinematical region where the DLS data are underpredicted. We conclude that this fact provides a strong indication for such a destruction of quantum interference due to the presence of the nuclear medium which can explain the DLS puzzle.

References

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