ON THE NEW HERMES DATA FOR THE ELECTROPRODUCTION ON NUCLEI*

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We analyze recent data on the electroproduction of hadrons on nuclei using the Lund model for electroproduction on nucleons and a simple geometrical model for the absorption effects. We show that the model seems to overestimate the A-dependence of the absorption effects, although it described the earlier data of the same HERMES experiment reasonably well. We trace the origin of this discrepancy to the surprising difference between the data for nitrogen and neon.

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1. Introduction

In a recent paper [1] we presented a comparison of the data from the HERMES Collaboration on the electroproduction on N, Kr and Xe nuclei both for the single spectra [2] and for the two hadron systems [3] with a simple model based on the `PYTHIA` [4] code for the electroproduction on nucleons and the geometrical scheme for calculating the absorption effects. We investigated the ratios of spectra for which many systematic uncertainties cancel.

We discussed a very simple picture, in which only the obvious part of the Lund space-time development is used, and we supplemented it with (equally obvious) pure absorptive effects. We restricted ourselves to the use of hadronic (and not partonic) degrees of freedom, since we discussed the low energy data for which the typical Q^2 values are small.

Surprisingly, we found a reasonably good description of data for the ratios of single spectra of charged hadrons. With only one free parameter, a "hadronization proper time" $\tau_{\rm h}$, the dependence on the relative energy

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$z = E_{\rm h}/\nu$ is well described both for nitrogen ($A = 14$) and krypton ($A = 84$) for the range of z in which the non-absorptive effects may be neglected ($z > 0.1$ and $z > 0.3$, respectively). These data are dominated by pions, but for identified kaons the krypton data were also compatible with model predictions using smaller value of $\tau_{\rm h}$ (as expected for heavier particles). Even the data for "second fastest" hadron are qualitatively compatible with the model for Kr and Xe nuclei in similar range of z. We did not try to compare the model with the data as functions of Q^2 or ν, since it is rather difficult to estimate the limits of applicability of a purely absorptive model for these variables.

Recently the HERMES Collaboration presented a new version of data [5] with the identification of pions, kaons and (anti)protons in the full range of $z > 0.1$ for He, Ne, Kr and Xe nuclei. In the next section we present a comparison of these data with the predictions of our model (with no new parameters). The conclusions are included in the last section.

2. The model and the data

As before, we are using the Monte Carlo generator `PYTHIA 6.203` and generate more than a quarter million of events per each nucleus, applying all the kinematical cuts from HERMES data, either by setting the proper values of `PYTHIA` parameters, or explicitly in the program for the event analysis.

We supplement the ordinary information provided by `PYTHIA` for each event by extracting the values of one extra parameter from the generating algorithm: the GAM(3) parameter, set for *each* string break in the PYSTRF procedure and denoting the proper time τ_0 (time measured in the string rest frame) between the string formation and its break. This time, corrected for the Lorentz dilatation, is used to calculate the distance between the string formation and string breaking point in the nucleus rest frame

$$s^0_{\rm form} = \tau_0 v_{\rm str} \gamma_{\rm str} \,.$$

To account for the time needed to rearrange partons from the break into hadrons, we introduce the only free parameter of our model, a "hadronization proper time" $\tau_{\rm h}$ (found to be 0.7–0.8 fm for pions and 0.3–0.4 fm for kaons), which is subsequently dilatated by a *string* Lorentz factor $\gamma_{\rm h}$

$$s_{\rm form} = (\tau_0 + \tau_{\rm h}) v_{\rm str} \gamma_{\rm str} \,.$$

The generation of the string creation point inside nucleus and the calculation of the absorption factor is performed as described in our previous paper [1].

In Figs. 1 and 2 we show the ratios of the properly normalized single spectra

$$R^{\mathrm{h}}\left(z,\nu,p_{\mathrm{t}}^2,Q^2\right)=\left(\frac{N_{\mathrm{h}}\left(z,\nu,p_{\mathrm{t}}^2,Q^2\right)}{N_e(\nu,Q^2)}\right)_A\Bigg/\left(\frac{N_{\mathrm{h}}\left(z,\nu,p_{\mathrm{t}}^2,Q^2\right)}{N_e(\nu,Q^2)}\right)_d$$

for pions and kaons produced on Ne, Kr and Xe. The He data, which are compatible within errors with no significant absorption effects both in the data and in the model, are omitted for transparency. We do not show the data for protons, as our purely absorptive model is obviously unable to reproduce them.

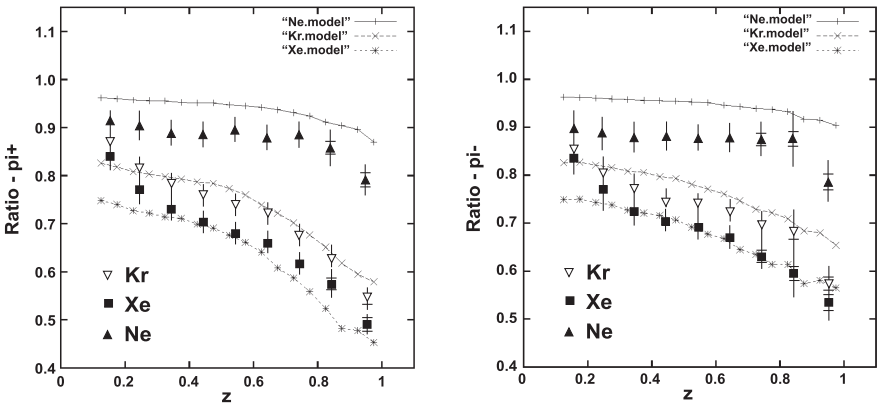

Fig. 1. The experimental ratio of the π^+ (on the left) and π^- (on the right) z-spectra from neon, krypton and xenon to that from the deuterium [5] compared with the model calculations for $\tau_{\mathrm{h}}=0.8$ fm/c.

We see that the agreement of the model with data for the Ne nucleus is poor: the data are significantly below the predictions. In addition, the data for pions (which dominate the spectra) show much weaker dependence on the atomic mass A than expected from the model. The data for xenon are above the predictions. The change of the value of the only free parameter of the model, τ_{h}, cannot improve the situation: *e.g.* for $\tau_{\mathrm{h}}=0.6$ fm the model agrees with neon data but overestimates the absorption effects for both heavier nuclei (the curve is far below the data). For kaons the agreement is even worse and a similar pattern is seen. In both cases the model is not applicable for Kr and Xe when $z\leq 0.3$ since no secondary production is included.

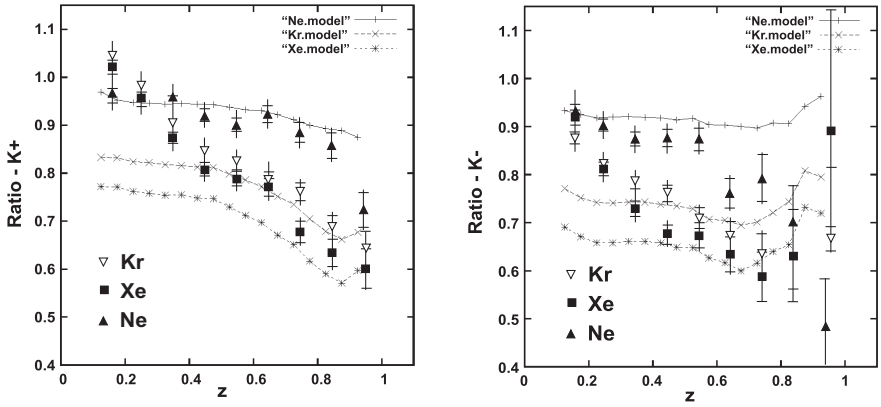

Fig. 2. The experimental ratio of the K^+ (on the left) and K^- (on the right) z-spectra from neon, krypton and xenon to that from the deuterium [5] compared with the model calculations for $\tau_{\rm h} = 0.4$ fm/c.

This disagreement is surprising in view of the successes of the model for the previous data. Thus we decided to compare the data and model predictions for two light nuclei: nitrogen [2] and neon [3]. For nitrogen all charged hadrons are counted; for neon positive pion spectra are shown. This is motivated by the facts that the identified particle spectra for nitrogen cover only a small range in z, pions dominate "all charged" data and the negative pion spectra are practically indistinguishable from the positive ones. The comparison is shown in Fig. 3.

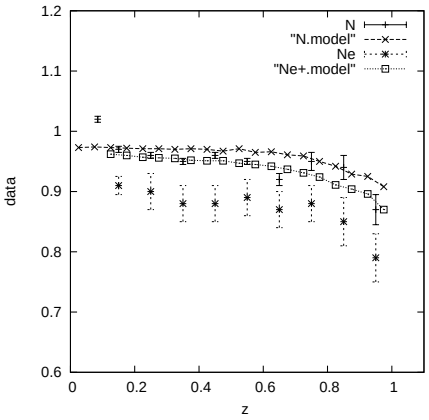

Fig. 3. The experimental ratio of the charged hadrons z-spectra for nitrogen to deuterium [2] and the positive pions for neon to deuterium [5] compared with the model calculations.

We see clearly that the model predicts very little difference for these two nuclei. This is understandable as the difference in the atomic number (14 *vs* 20) corresponds to less than 15% in the value of nuclear radius. Thus the absorption effects measured by the deviation of the ratio of spectra from *one* should not differ very much for the two nuclei.

However, the data show a significant difference. The lack of fluctuations in the neon data indicates that the errors are dominated by systematic effects. Still, these data suggest the absorption effects twice as big as for the nitrogen. This discrepancy is the main reason for the disagreement of our model with new HERMES data.

3. Conclusions

We have investigated the electroproduction of hadrons inside the nuclei using the `PYTHIA` event generator. The results from the recent HERMES experiment [5] are compared with the simple absorption model used earlier to describe the older data from the same experiment [2, 3]. We have found a surprising discrepancy. Its origin can be traced back to the unexpectedly large difference between the data for the nitrogen and neon nuclei. This difference seems to contradict any simple geometrical absorption picture. Thus any definite statements about the (dis)agreement of models with these data should be postponed until this difference is cleared out.

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