

NONPARTONIC EFFECTS IN PION ELECTROPRODUCTION IN THE HERMES KINEMATICAL REGION*

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The presentation is concerned with higher twist corrections of nonpartonic origin to semi-inclusive observables in the kinematical region relevant for the HERMES experiment. We demonstrate a strong impact of the VDM-like interaction and the exclusive production of ρ^0 meson on the extraction of the $\bar{d}-\bar{u}$ asymmetry from charged pion DIS multiplicities. We also show that it is the exclusive- ρ^0 channel which accounts for the experimentally observed effect of the excess of charged over neutral pions produced at large z .

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1. Introduction

Recently the interest in semi-inclusive processes has increased significantly. They appear to be a very useful tool for separating the flavour- and spin-dependent quark distributions in the nucleon. The interpretation of such experiments is based on the quark-parton model, often in its simplest form. Therefore, from a practical point of view, some of very important topics are: the presence of mechanisms beyond the QPM in the studied reactions, contributions of such mechanisms to measured cross sections and their influence on the analysed quantities.

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The HERMES Collaboration has precisely measured multiplicities of charged and neutral pions produced in unpolarised DIS off the proton [1]. Previously, charged pion production off proton and deuteron targets was used for the extraction of the $\bar{d}-\bar{u}$ asymmetry [2]. Since the HERMES experiment corresponds to the kinematical region of relatively small momentum transfer where the applicability of the quark-parton model is not obvious a possible influence of mechanisms beyond QPM on the HERMES observables should be of particular interest.

2. Effects in the extraction of the $\bar{d}-\bar{u}$ asymmetry

An extraction of the light quark asymmetry of the nucleon sea from charged pion multiplicities performed by HERMES [2] is based on the pure QPM description of the pion electroproduction. The pion production process is assumed to take place in two steps: first, a hard interaction of the incoming virtual photon with a quark in the nucleon, and second, a hadronisation of the struck quark into final pion(s). Then, one can combine yields of positive and negative pions produced off proton and neutron, and using isospin invariance, isolate a quantity sensitive to the $\bar{d}-\bar{u}$ asymmetry [2]:

$$\frac{\bar{d}(x) - \bar{u}(x)}{u(x) - d(x)} = \frac{J(z)[1 - r(x, z)] - [1 + r(x, z)]}{J(z)[1 - r(x, z)] + [1 + r(x, z)]}, \quad (1)$$

where $J(z) = \frac{3}{5} \cdot \frac{1+D_-(z)/D_+(z)}{1-D_-(z)/D_+(z)}$ depends on the favoured $D_+(z)$ and unfavoured $D_-(z)$ [light quark]-pion fragmentation functions, and $r(x, z) = \frac{N_p^{\pi^-}(x, z) - N_n^{\pi^-}(x, z)}{N_p^{\pi^+}(x, z) - N_n^{\pi^+}(x, z)}$ is a ratio of differences of charged pion yields off proton and neutron.

In such an approach pions produced via other than partonic mechanisms are ignored. At the same time, *experimental* multiplicities $N_{p,n}^{\pi^+, \pi^-}$, which one inputs into the right-hand side of Eq. (1) in order to obtain experimental $\bar{d}-\bar{u}$ asymmetry, *do* contain such nonpartonically produced pions. Thus, Eq. (1) is not an exact equation. In the $Q^2 \rightarrow \infty$ limit the nonpartonic contributions vanish, but in the HERMES kinematical region where $\langle Q^2 \rangle \approx 2.5 \text{ GeV}^2$ they cannot be neglected. Two mechanisms appear to be especially important: so-called VDM-like production and exclusive- ρ^0 channel [3]. In the VDM-like production the incoming virtual photon interacts with the nucleon strongly, via its intermediate vector meson state into which it fluctuates just before the interaction. The exclusive- ρ^0 channel corresponds to the reaction $\gamma^* + N \rightarrow \rho^0 + N$ with a subsequent decay $\rho^0 \rightarrow \pi^- \pi^+$.

Based on the world data for pion production in πN collisions and for ρ^0 electroproduction we have estimated contributions of these mechanisms¹ and found them noteworthy.

The influence of the VMD and exclusive- ρ^0 channels on the measured quantity $\frac{\bar{d}-\bar{u}}{u-d}$ can be seen in Fig. 1. The shown HERMES points were ob-

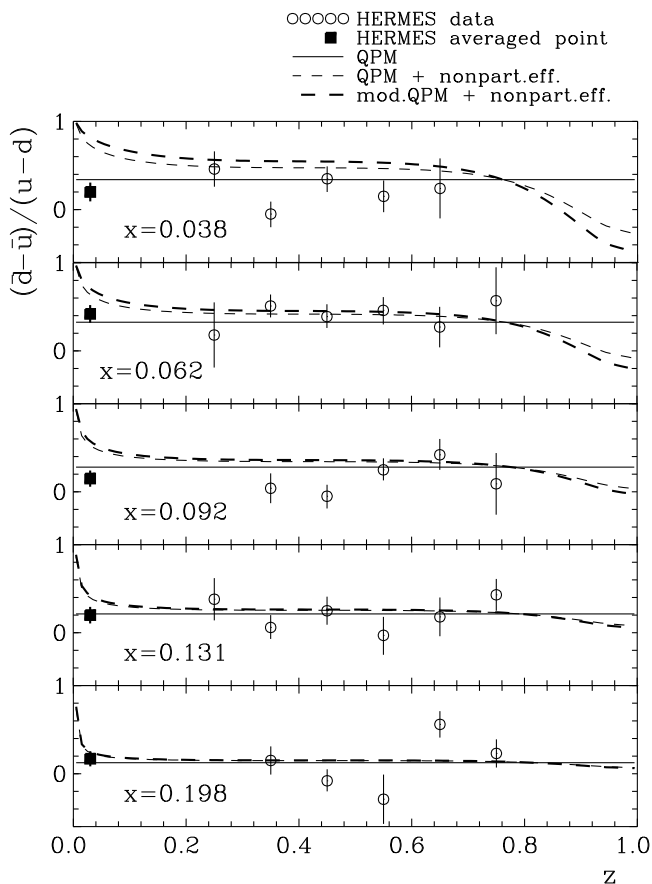


Fig. 1. $\frac{\bar{d}-\bar{u}}{u-d}$ obtained from the r.h.s. of Eq. (1) in different bins of Bjorken- x .

tained with experimentally measured multiplicities $N_{p,n}^{\pi^+,\pi^-}$. The solid curve independent of z represents the pure QPM result calculable from both sides of Eq. (1). The two dashed curves correspond to calculations in which contributions of the nonpartonic mechanisms are included in two ways: either by simple adding them to the main partonic term, or with additional modification of the QPM term by a damping Q^2 -dependent factor which is required

¹ For a detailed analysis see Ref. [3].

for QPM to work properly at such a low Q^2 [4]. A discrepancy between the solid and dashed lines gives us a theoretical error on the working formula (1). As one can see, it is comparable to or even larger than the given *total* (containing both statistical and systematic components) uncertainty of the final z -averaged HERMES experimental points (solid squares). The effect is stronger for the case of modified QPM term, *i.e.* for the more correct one. The averaging in z also looks doubtful because of the clearly visible z -dependence.

3. Excess of charged over neutral pions at large z

A very interesting phenomenon has been recently observed by the HERMES Collaboration: different yields of charged and neutral pions produced off proton at large z : $\frac{1}{2}(N_p^{\pi^+} + N_p^{\pi^-}) > N_p^{\pi^0}$ for $z \gtrsim 0.7$ [1]. In the QPM picture with quark fragmentation there is no room for such an effect; there the neutral pion yield is exactly equal, due to isospin symmetry, to the charged pion yield. As a possible source for the difference, alongside the instrumental resolution, exclusive pion production channels (*e.g.* $\gamma^* + p \rightarrow \pi^+ + \Delta^0$) were suggested [1]. In our opinion however, exclusive *pion*-production channels cannot be responsible for an effect in a broad region of z since pions produced in this way carry almost the whole energy of the virtual photon and therefore contribute to measured multiplicities only in a narrow region near $z \sim 1$. In contrast, the discussed in the previous section the exclusive production of the ρ^0 meson, which decays into two pions, gives a contribution to the charged pions multiplicity in a broad z -range. It is especially important at larger z where the partonic rate is smaller. The contributions to the neutral pion multiplicity, caused *e.g.* by the exclusive- $\rho^\pm$ channels, are much smaller due to smaller cross sections of these processes (ρ^0 production, known as the dominant exclusive γ^*N channel, is dominated by the Pomeron exchange which is absent in the case of charged- ρ channels).

In the top panel of Fig. 2 we show the pion multiplicities for $z > 0.4$. The experimental points are from [1]. The short-dashed curve represents the QPM prediction which is the same for both types of multiplicities. The solid curve includes also the contribution of the exclusive- ρ^0 channel to the charged pion yield (this contribution is also shown separately). As one can see, the exclusive- ρ^0 channel nicely explains the observed effect. This is especially well visible in the bottom panel where the ratio of charged-to-neutral pion multiplicities is shown.

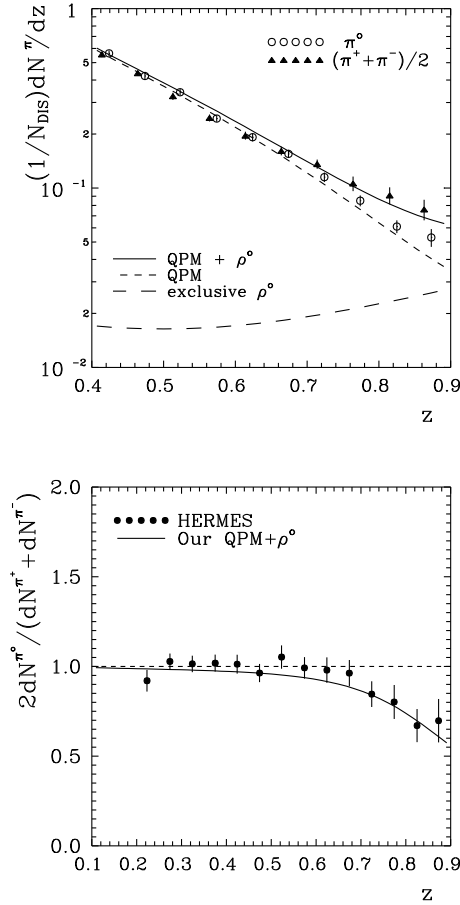


Fig. 2. Neutral and charged pion multiplicities (top panel) and their ratio (bottom panel) as a function of z .

4. Conclusions

We have discussed the role of some mechanisms beyond the quark-parton model in semi-inclusive production of pions in the kinematical region relevant for the HERMES experiment.

We have shown that production of pions via VDM-like interaction and via exclusive- ρ^0 channel have a strong impact on the extraction of the $\bar{d}-\bar{u}$ asymmetry from the charged pion DIS multiplicities which was done by the HERMES Collaboration. The extracted asymmetry turns out to be very sensitive to the influence of the mentioned mechanisms and neglecting them leads to a significantly distorted result.

We have also shown that the exclusive production of ρ^0 mesons accounts for the experimentally observed excess of charged over neutral pions produced at large z .

To conclude, nonpartonic mechanisms are essential for a good theoretical description of the pion electroproduction in the HERMES kinematical region and cannot be omitted in a proper analysis. In addition, we would like to stress that similar nonpartonic correction should be expected in polarised processes, as well.

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