Charge Distribution in a Two-Chain Dual Model

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Abstract. Charge distributions in the multiple production processes are analysed using the dual chain model. A parametrisation of charge distributions for single dual chains based on the $v\nu$ and $\bar{v}p$ data is proposed. The rapidity charge distributions are then calculated for $pp$ and $p\bar{p}$ collisions and compared with the previous calculations based on the recursive cascade model of single chains. The results differ at the SPS collider energies and in the energy dependence of the net forward charge supplying the useful tests of the dual chain model.

1. Introduction

The two-chain dual model [1] can successfully describe the shape and energy dependence of single particle distributions in hadronic collisions [2]. In particular it has been recently shown [3] that charge distributions in hadron–hadron collisions obtained in this model agree rather well with high energy data on $pp$ and $\pi p$ collisions.

In this paper we present a continuation and modifications of the study from [3] to which the reader is referred for details of kinematics and formalism. The main difference between [3] and our approach is the description of the charge distribution in single chains. In [3] these distributions were calculated using a recursive cascade model for quark and diquark jets [4] where one assumes the independent fragmentation of both chain ends. Then the rapidity charge distribution has a discontinuity in the centre of the chain and the net charge in each hemisphere is independent of the chain energy. These two features are not observed in the neutrino interactions which are believed to proceed through single chain formation. Therefore we propose instead a parametrisation of charge distributions in single chains compatible with the neutrino data.

In Sect. 2 we present our parametrisation of single chain distributions and compare them with the neutrino data and with the parametrisation based on the recursive cascade model. In Sect. 3 we show the results of our calculations for $pp$ and $p\bar{p}$ collisions. We find that the results are similar to those in [3] and agree rather well with the data at 200 GeV/c. However the predictions at the SPS collider energy and the energy dependence of the forward net charge in $p\bar{p}$ collisions are clearly different in the two approaches. Our results can be used to test the model by comparison with the future data.

2. Charge Densities in Neutrino Reactions

To describe the charge density in quark and diquark fragmentation we use neutrino data of ABCMO [5, 7] and Argonne–Carnegie–Purdue [8] collaborations which present the rapidity charge densities in $v\nu$ and $\bar{v}p$ interactions for several intervals of energy of the produced hadrons. The data show the following main features. Firstly, the shape of the rapidity distributions depends on energy suggesting the separation of quark and diquark fragmentation at high energies. Secondly, the integrated net charge in each hemisphere varies with energy and seems to approach rather slowly the asymptotic values expected from the quark model [7].

To describe these features we use the following parametrisations for charge distribution in quark and
Diquark fragmentation in the hadronic cms

\[ \frac{dQ_q}{dy} = c_1 (y_{\text{max}}^2 - y^2)^2 e^{-\alpha y} \]  

(1)

and

\[ \frac{dQ_{\text{d}}}{dy} = c_2 (y_{\text{max}}^2 - y^2)^2 e^{-\alpha_{\text{d}} y}. \]  

(2)

Here \( y_{\text{max}} \) is the maximum value of rapidity of produced hadrons

\[ y_{\text{max}} = \arcsinh \frac{p_A}{m_r} \]  

(3)

where \( p_A \) is the quark or diquark momentum calculated as in [3] assuming the quark mass of 0.33 GeV and the diquark mass of 0.66 GeV. We used the value of average transverse hadronic mass \( m_r \) of 0.33 GeV for the quark fragmentation and of 0.5 GeV for the diquark fragmentation. The latter value averages between the values for pions and nucleons. Further, the choice of the second power of the bracket in (1), (2) and of the values of \( \alpha_q = 1.0 \) and \( \alpha_{\text{d}} = 0.75 \) was made to describe the shape of the data. Finally the constants \( c_1 \) and \( c_2 \) are calculated to normalize the distributions to the values \( Q_u = \frac{8}{9} \), \( Q_d = -\frac{4}{9} \), \( Q_{uu} = \frac{13}{9} \) and \( Q_{uu} = \frac{8}{9} \) [3].

![Figure 1](image1.png)

**Fig. 1a and b.** Rapidity charge distributions in \( \bar{p}p \) compared with the parametrisation proposed in eqs (1) and (2) (continuous line) and the predictions of the recursive cascade model from [3] (broken line) calculated at \( W = 3 \) GeV, \( \bar{p}p \) data from [6] (solid histogram) and from [7] (broken histogram) for \( 2 < W < 4 \) GeV compared with the predictions at \( W = 3 \) GeV, b) data from [6] (solid histogram) at \( 8 < W < 16 \) GeV and from ref. [7] (broken histogram) at \( W > 10 \) GeV compared with the predictions at \( W = 10 \) GeV.

Using (1) and (2) one can calculate the charge densities of hadrons produced in \( \bar{p}p \) collisions \( (u-u) \) chain) and in \( \bar{p}p \) collisions \( (d-ud) \) chain)

\[ \frac{dQ}{dy}_{\bar{p}p} = \frac{dQ_u}{dy} + \frac{dQ_{uu}}{dy} \]  

(4)

and