ОБЪЕДИНЕННЫЙ
ИНСТИТУТ
ЯДЕРНЫХ
ИССЛЕДОВАНИЙ

ДУБНА

E2 - 7257

S.Berceanu, T.Besliu, A.Gheorghe, A.L.M.Mihul

ASYMPTOTIC PROPERTIES OF CHARGE DISTRIBUTIONS

1973

ЛАБОРАТОРИЯ ВЫЧИСЛИТЕЛЬНОЙ
ТЕХНИКИ И АВТОМАТИЗАЦИИ

E2 - 7257

S.Berceanu,[1] T.Besliu,[2] A.Gheorghe,[1] A.L.M.Mihul[2]

ASYMPTOTIC PROPERTIES OF CHARGE DISTRIBUTIONS

Submitted to Letters al Nuovo Cimento

[1] On leave of absence from the Institute of Atomic Physics, Bucharest.

[2] On leave of absence from the University of Bucharest.

In the last few years several distributions of quantum numbers of secondaries in high-energy hadronic collisions have been introduced and performed. The purpose of this note is to present some asymptotic properties of the charge distributions suggested in ref. /1/. Using the constraints imposed by the laws of energy and charge conservation and certain model-independent assumptions, we shall establish that the invariant charge distributions approach a zero limiting value in the central region and satisfy several Pomeranchuk properties in the fragmentation domains. We shall also show that these properties imply the vanishing of any charge-exchange cross-section (normalized to the corresponding total one) and a separate charge conservation in both the c.m. hemispheres when the incident energies go to infinity.

Let us introduce the m-particle normalized distributions

$$P^{ab}_{c_1}(s,\vec{\xi}_1)=(\sigma^{ab}_{tot}(s))^{-1}\frac{d\sigma^{ab}_{c_1}}{d^3\vec{\xi}_1}, \tag{1a}$$

$$P^{ab}_{c_1\ldots c_m}(s,\vec{\xi}_1,\ldots,\vec{\xi}_m)=\left(\frac{d\sigma^{ab}_{c_1\ldots c_{m-1}}}{d^3\vec{\xi}_1\ldots d^3\vec{\xi}_{m-1}}\right)^{-1}\frac{d\sigma^{ab}_{c_1\ldots c_m}}{d^3\vec{\xi}_1\ldots d^3\vec{\xi}_m},$$

$$m>1, \tag{1b}$$

where a,b,c_1,... , and c_m are specific stable hadrons, $\sigma^{ab}_{tot}(s)$ is the total cross-section of the ab collision, s is the square of its total energy, $d\sigma^{ab}_{c_1...c_m}/d^3\vec{\xi}_1...d^3\vec{\xi}_m$ is the differential cross-section of the inclusive reaction $a+b \to c_1+...+c_m+$ anything, $\vec{\xi}_i=(x_i, \vec{p}_{i\perp})$ for i=1,..., m , $x_i = 2s^{-1/2}p_{i\parallel}$, $p_{i\parallel}$ and $\vec{p}_{i\perp}$ are the longitudinal and transverse momenta of particle c_i, and all variables are given in the c.m. system.

Let us consider the charge distributions [1]

$$Q^{ab}_{c_1...c_{m-1}}(s,\vec{\xi}_1,...,\vec{\xi}_m)=\sum_{c_m} Q_{c_m} P^{ab}_{c_1...c_m}(s,\vec{\xi}_1,...,\vec{\xi}_m), \quad (2)$$

and the invariant charge distributions

$$S^{ab}_{c_1...c_{m-1}}(s,\vec{\xi}_1,...,\vec{\xi}_m)=\sum_{c_m} Q_{c_m} \xi^o_{c_m} P^{ab}_{c_1...c_m}(s,\vec{\xi}_1,...,\vec{\xi}_m), \quad (3)$$

where $\xi^o_{c_m}=[x^2_m+4s^{-1}(\vec{p}^{\,2}_{m\perp}+M^2_{c_m})]^{1/2}$, Q_{c_m} and M_{c_m} are the charge and mass of particle c_m, and the summation over c_m is over all species of stable hadrons. Here the charge means any additively conserved quantum number. In the case m=1, the charge distribution given by eq. (2) apparently is the expectation value of the charge $\vec{\xi}_1$-density operator in the state T|in>, where T is the usual transition matrix and |in> denotes the initial state [2].

The charge and energy sum rules [3] can be written

$$\int d^3\vec{\xi}_m Q^{ab}_{c_1...c_{m-1}}(s,\vec{\xi}_1,...,\vec{\xi}_m)=Q_a+Q_b-\sum_{i=1}^{m-1}Q_{c_i}, \quad (4)$$

$$\sum_{c_m}\int d^3\vec{\xi}_m K^{ab}_{c_1...c_m}(s,\vec{\xi}_1,...,\vec{\xi}_m)=1-\frac{1}{2}\sum_{i=1}^{m-1}\xi^0_{c_i}, \quad (5)$$

where the sums from the r.h.s. of eqs. (4) and (5) are dropped for m=1 and

$$K^{ab}_{c_1...c_m}(s,\vec{\xi}_1,...,\vec{\xi}_m)=\frac{1}{2}\xi^o_{c_m} P^{ab}_{c_1...c_m}(s,\vec{\xi}_1,...,\vec{\xi}_m). \quad (6)$$

Consider now the average charge of the additional particles produced in the ab collision and found in the region $|x_m| \leq \epsilon$, where $0 < \epsilon \leq 1$, knowing that the particles c_i $(i<m)$ are emitted at the momenta given by $\vec{\xi}_i$:

$$\tilde{Q}^{ab}_{c_1 \ldots c_{m-1}}(s, \vec{\xi}_1, \ldots, \vec{\xi}_{m-1}, \epsilon) = \tag{7}$$
$$= \int d^3\vec{\xi}_m \theta(\epsilon - |x_m|) Q^{ab}_{c_1 \ldots c_{m-1}}(s, \vec{\xi}_1, \ldots, \vec{\xi}_m).$$

Here θ denotes the usual unit step function: $\theta(x) = 1$ for $x > 0$ and $\theta(x) = 0$ for $x < 0$.

Fixing ϵ, we remark that the above average charge admits energy-independent upper and lower bounds. Indeed, eqs. (2) and (4)-(7) imply

$$|\tilde{Q}^{ab}_{c_1 \ldots c_{m-1}}(s, \vec{\xi}_1, \ldots, \vec{\xi}_{m-1}, \epsilon)| < (m+1 + 2\epsilon^{-1}) \max_c Q_c \, . \tag{8}$$

Let us introduce the difference of the $\vec{\xi}_m$ -densities of inelasticity for the particle c_m and its antiparticle, $\bar{c}_m$, when the particles c_i $(i < m)$ are found at the momenta given by $\vec{\xi}_i$:

$$D^{ab}_{c_1 \ldots c_m}(s, \vec{\xi}_1, \ldots, \vec{\xi}_m) = K^{ab}_{c_1 \ldots c_m}(s, \vec{\xi}_1, \ldots, \vec{\xi}_m) - \tag{9}$$
$$- K^{ab}_{c_1 \ldots c_{m-1} \bar{c}_m}(s, \vec{\xi}_1, \ldots, \vec{\xi}_m).$$

We now suppose that there exist two functions, $\epsilon_0(s)$ and $A(\vec{\xi}_1, \ldots, \vec{\xi}_{m-1})$, and a strictly positive number η such that

$$0 < \epsilon_0(s) \leq 1, \quad \lim_{s \to \infty} \epsilon_0(s) = 0, \quad \lim_{s \to \infty} \epsilon_0(s) \ln(s \mu_0^{-2}) = \infty \, , \tag{10}$$

$$|D^{ab}_{c_1 \ldots c_m}(s, \vec{\xi}_1, \ldots, \vec{\xi}_m)| \leq A(\vec{\xi}_1, \ldots, \vec{\xi}_{m-1}) M^{-2}_{c_m \perp} \times \tag{11}$$
$$\times [\ln(M_{c_m \perp} \mu_0^{-1})]^{-1-\eta} ,$$

where $|x_m| \leq \epsilon_0(s)$ and each $\vec{\xi}_i (i<m)$ is fixed with $x_i \neq 0$ [4]*.

Here $M_{c_{m\perp}} = (\vec{p}^{\,2}_{m\perp} + M^2_{c_m})^{1/2}$ is the transverse mass of c_m and μ_0 is a strictly positive mass smaller than any hadronic one.

We next show that if eq. (11) is satisfied and each $\vec{\xi}_i$ $(i<m)$ is fixed with $x_i \neq 0$, then the <u>invariant charge distribution</u>

$$S^{ab\,\prime}_{c_1 \ldots c_{m-1}}(s, \vec{\xi}_1, \ldots, \vec{\xi}_{m-1}, x_m) = \int d^2\vec{p}_{m\perp} S^{ab}_{c_1 \ldots c_m}(s, \vec{\xi}_1, \ldots, \vec{\xi}_m) \quad (12)$$

approaches a <u>zero</u> limiting value in the central region at asymptotic energies (i.e. in the limits $s \to \infty$ and $x_m \to 0$).

It is convenient to write eq. (12) in the form

$$\tilde{Q}^{ab}_{c_1 \ldots c_{m-1}}(s, \vec{\xi}_1, \ldots, \vec{\xi}_{m-1}, \epsilon) = I(s) + \sum_{c_m} Q_{c_m} \theta(Q_{c_m}) I_{c_m}(s), \quad (13)$$

where

$$I(s) = \int_{-\epsilon}^{\epsilon} dx_m (x_m^2 + 4s^{-1}\mu_0^2)^{-1/2} S^{ab}_{c_1 \ldots c_{m-1}}(s, \vec{\xi}_1, \ldots, \vec{\xi}_{m-1}, x_m) =$$

$$= S^{ab\,\prime}_{c_1 \ldots c_{m-1}}(s, \vec{\xi}_1, \ldots, \vec{\xi}_{m-1}, x'_m) \int_{-\epsilon}^{\epsilon} dx_m (x_m^2 + 4s^{-1}\mu_0^2)^{-1/2}, \quad |x'_m| \leq \epsilon, \quad (14)$$

$$I_{c_m}(s) = 2 \int d^3\vec{\xi}_m \theta(\epsilon - |x_m|)[(\xi^{\circ}_{c_m})^{-1} - (x_m^2 + 4s^{-1}\mu_0^2)^{-1/2}] \times$$
$$\times D^{ab}_{c_1 \ldots c_m}(s, \vec{\xi}_1, \ldots, \vec{\xi}_m). \quad (15)$$

---

*The r.h.s. of eq. (11) is energy-independent, but no scaling property is required. At least for $m=1$, equation (11) is satisfied by a wide class of models including recent ones which predict large cross-sections at high transverse momenta [4]. In the case $m>1$, we assume no violation of eq. (11) from the long-range correlations between the particle c_m and the particle c_i $(i<m)$ when $s \to \infty$.

Notice that x_m' is dependent of s and x_m. Choosing $\epsilon=\epsilon_0(s)$, it follows from eqs. (10), (11), and (15) that

$$\lim_{s\to\infty}(\ln(s\mu_0^{-2}))^{-1} I_{c_m}(s)=0. \tag{16}$$

Combining eqs. (8), (13), (14), and (16), we obtain

$$\lim_{s\to\infty} S^{ab\prime}_{c_1\ldots c_{m-1}}(s,\vec{\xi}_1,\ldots,\vec{\xi}_{m-1},x_m')=0, \tag{17a}$$

where x_m' goes to zero as $s\to\infty$. If $S^{ab\prime}_{c_1\ldots c_{m-1}}(s,\vec{\xi}_1,\ldots,\vec{\xi}_{m-1},x_m)$ scales, then eq. (17a) can be improved:

$$\lim_{x_m\to 0}\lim_{s\to\infty} S^{ab\prime}_{c_1\ldots c_{m-1}}(s,\vec{\xi}_1,\ldots,\vec{\xi}_{m-1},x_m)=0. \tag{17b}$$

It is easy to see that eq. (17a) is an immediate consequence of the charge sum rule provided the scaling hypothesis holds and the limit $s\to\infty$ commutes with the integral from the l.h.s. of eq. (4) [5].

In order to illustrate the foregoing remarks for πp and pp collisions at present accelerator and ISR energies, we show in Figs. 1 and 2 some electric and baryonic charge distributions of the type [6,7]*

$$S^{ab\prime\prime}(s,x,p_\perp^2)=(\sigma^{ab}_{tot}(s))^{-1}\sum_c Q_c\xi_c^{c}\frac{\partial^2\sigma_c^{ab}}{\partial x\partial p_\perp^2},\quad x=x_1,p_\perp=|\vec{p}_{1\perp}|, \tag{18a}$$

$$S^{ab\prime}(s,x)=\int dp_\perp^2 S^{ab\prime\prime}(s,x,p_\perp^2), \tag{18b}$$

$$Q^{ab\prime\prime}(s,x,p_\perp^2)=(\sigma^{ab}_{tot}(s))^{-1}\sum_c Q_c\frac{\partial^2\sigma_c^{ab}}{\partial x\partial p_\perp^2}, \tag{19a}$$

---

*No error bars are shown in Figs. 1 and 2, because here the statistical errors are less important than the systematical ones due to: 1) the reading of the single-particle distributions from plots; 2) the construction of the neutron spectra in Fig. 2b) (see ref. [6] and [7])); 3) the normalization of the distributions from different experiments [7].

$$Q^{ab\prime}(s,x)=(\sigma^{ab}_{inel}(s))^{-1}\sum_c Q_c \frac{d\sigma^{ab}_{c\ inel}}{dx}, \quad x=p_{1\parallel}/p_{1\parallel\,max}, \tag{19b}$$

where $d\sigma^{ab}_c/dx$ and $\partial^2\sigma^{ab}_c/\partial x\partial p_\perp^2$ are the differential cross-sections for the inclusive process $a+b\to c+$anything, $\sigma^{ab}_{inel}(s)$ is the inelastic cross-section for the ab collision, and $d\sigma^{ab}_{c\ inel}/dx$ is the inelastic part of $d\sigma^{ab}/dx$.

Figure 1 shows that the invariant electric charge distributions decrease at $x=0$ about 1.8 times in π^+p collisions between 6 and 22 GeV/c, and about 5 times in pp collisions between 24 and 1500 GeV/c. In general, in the central region at asymptotic energies one expects the approach to a common limiting value for the inelasticity distributions of positive and negative particles with respect to each of the electric and baryonic charges and hypercharge (see eq. (17a)).

It must be noticed that there are unexpected peaks near $x=0$ for the electric charge distributions in π^+p and pp collisions (see ref. /6/ and Fig. 2a)), and also for the baryonic charge distribution in pp collisions at 1500 GeV/c (see Fig. 2b)). We remember that one expects the disappearance of the central peaks at very high energies /6/. We write this hypothesis in the form

$$\lim_{\epsilon\to 0}\lim_{s\to\infty}\tilde{Q}^{ab}_{c_1\ldots c_{m-1}}(s,\vec{\xi}_1,\ldots,\vec{\xi}_{m-1},\epsilon)=0, \tag{20}$$

where any $\vec{\xi}_i$ is fixed with $x_i\neq 0$. Equation (20) holds if there exist $\epsilon>0$, $\eta>0$, and $A(\vec{\xi}_1,\ldots,\vec{\xi}_{m-1})$ such that

$$D^{ab}_{c_1\ldots c_m}(s,\vec{\xi}_1,\ldots,\vec{\xi}_m)\leq A(\vec{\xi}_1,\ldots,\vec{\xi}_{m-1})\times$$
$$\times[(\ln|x_m|^{-1})^{-1-\eta}+(\ln s\,\mu_0^{-2})^{-1-\eta}]M^{-2}_{c_m\perp}[\ln(M_{c_m\perp}\mu_0^{-1})]^{-1-\eta}, \tag{21}$$

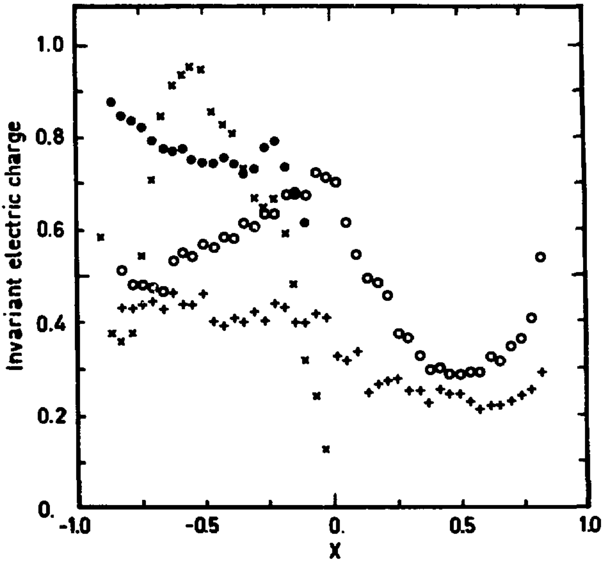

Fig. 1. Invariant electric charge distributions versus the reduced c.m. longitudinal momentum x. The data are from ref./6/: o π^+p 6 GeV/c; + π^+p 22 GeV/c; • pp 24 GeV/c; × pp 1500 GeV/c. For pp collisions see eq. (18a) with $p_\perp$ = 0.4 GeV/c. For π^+p collisions see eq. (18b)/7/.

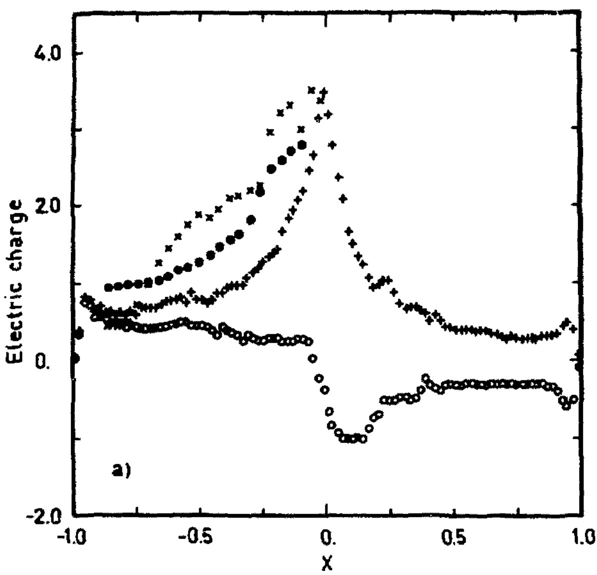

Fig. 2. Charge distributions versus the reduced c.m. longitudinal momentum x : a) Electric charge distributions. b) Baryonic charge distributions. The data are from ref. /6/: + π^+p 16 GeV/c; o π^-p 16 GeV/c; • pp 24 GeV/c; × pp1500 GeV/c. For pp collisions see eq. (19a) with $p_\perp = 0.4$ GeV/c. For $\pi^\pm p$ collisions see eq. (19b)/7/.

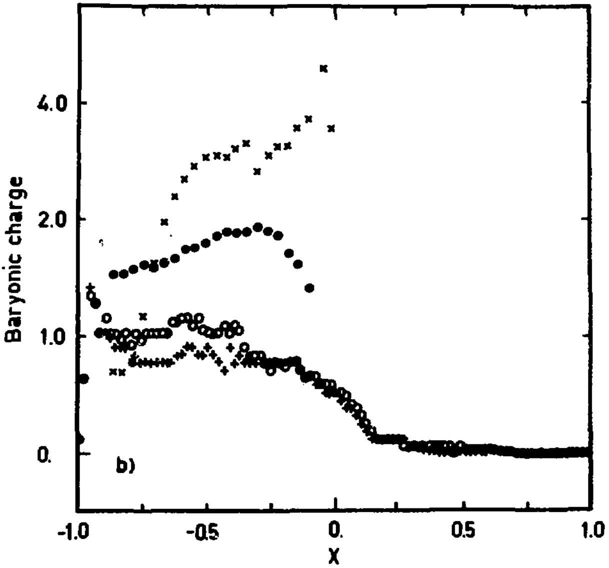

Fig. 2b

where $|x_m| \le \epsilon$ and each $\vec{\xi}_i$ $(i<m)$ is fixed with $x_i \neq 0$. Equation (21) is satisfied, for example, in certain multiperipheral and Mueller models [5,8].

We now present some Pomeranchuk properties of the considered charge distributions in the fragmentation regions at asymptotic energies (i.e. $x_i \neq 0$ for $i=1,...,m$ in the limit $s \to \infty$).

Let us suppose that the following consequence of the Pomeranchuk hypothesis for inclusive reactions holds [9]:

$$\lim_{s\to\infty} D^{ab}_{c_1 \dots c_m}(s, \vec{\xi}_1, \dots, \vec{\xi}_m) = \lim_{s\to\infty} D^{\bar{a}b}_{c'_1 \dots c'_m}(s, \vec{\xi}_1, \dots, \vec{\xi}_m), \tag{22}$$

$$c'_i = \begin{cases} c_i & \text{if } x_i < 0 \\ \bar{c}_i & \text{if } x_i > 0 \end{cases}, \quad i = 1, \dots, m, \tag{23}$$

where the limits exist and are finite, all $\vec{\xi}_i$ are fixed with $x_i \neq 0$ and the longitudinal momentum of a, is taken to be positive.

By eqs. (1)-(3), (6), (9), (22), and (23), we get the following correlations between the limiting charge distributions for particle-target and for antiparticle-target collisions:

$$\lim_{s\to\infty} Q^{ab}_{c_1 \dots c_{m-1}}(s, \vec{\xi}_1, \dots, \vec{\xi}_m) = -(\operatorname{sgn} x_m) \lim_{s\to\infty} Q^{\bar{a}b}_{c'_1 \dots c'_{m-1}}(s, \vec{\xi}_1, \dots, \vec{\xi}_m), \tag{24a}$$

$$\lim_{s\to\infty} S^{ab}_{c_1 \dots c_{m-1}}(s, \vec{\xi}_1, \dots, \vec{\xi}_m) = -(\operatorname{sgn} x_m) \lim_{s\to\infty} S^{\bar{a}b}_{c'_1 \dots c'_{m-1}}(s, \vec{\xi}_1, \dots, \vec{\xi}_m), \tag{24b}$$

where all $\vec{\xi}_i$ are fixed such that $x_i \neq 0$ and eq. (23)

is satisfied for $i<m$. Here $\operatorname{sgn} x=1$ for $x>0$ and $\operatorname{sgn} x=-1$ for $x<0$.

Let us suppose that the following weak condition of small transverse momentum holds:

$$\lim_{s\to\infty} \int d^2\vec{p}_{1\perp} \dots d^2\vec{p}_{m\perp} Q^{ab}_{c_1\dots c_{m-1}} (s,\vec{\xi}_1,\dots,\vec{\xi}_m) = \int d^2\vec{p}_{1\perp} \dots d^2\vec{p}_{m\perp} \lim_{s\to\infty} Q^{ab}_{c_1\dots c_{m-1}} (s,\vec{\xi}_1,\dots,\vec{\xi}_m), \tag{25}$$

where $x_i \neq 0$ for $i=1,\dots,m$.

Fixing ϵ at a strictly positive value, considering eq. (4) for both the ab and $\bar{a}b$ collisions, and using eqs. (22)-(25), we obtain the following limiting charge sum rule:

$$\int d^3\vec{\xi}_m\, \theta(-\epsilon \pm x_m) \lim_{s\to\infty} Q^{ab}_{c_1\dots c_{m-1}}(s,\vec{\xi}_1,\dots,\vec{\xi}_m) = \frac{1}{2}(Q_a+Q_b) \pm \frac{1}{2}(Q_a-Q_b) - \sum_{j=1}^{m-1} Q_{c_j}\, \theta(\pm x_j) - \Gamma^{ab\mp}_{c_1\dots c_{m-1}}(\vec{\xi}_1,\dots,\vec{\xi}_{m-1},\epsilon) \tag{26}$$

with

$$\Gamma^{ab\mp}_{c_1\dots c_{m-1}}(\vec{\xi}_1,\dots,\vec{\xi}_{m-1},\epsilon) = \frac{1}{2} \lim_{s\to\infty} \int d^3\vec{\xi}_m\, \theta(\epsilon-|x_m|) \times (Q^{ab}_{c_1\dots c_{m-1}}(s,\vec{\xi}_1,\dots,\vec{\xi}_m) \mp Q^{\bar{a}b}_{c'_1\dots c'_{m-1}}(s,\vec{\xi}_1,\dots,\vec{\xi}_m)), \tag{27}$$

where each $\vec{\xi}_i$ with $i<m$ is fixed such that $x_i \neq 0$; c_i and c'_i satisfy eq. (23) for $i<m$, and the sum in the r.h.s. of eq. (26) is omitted for $m=1$.

Now we return to Fig. 2a). The electric charge distributions for $\pi^{\pm}p$ reactions at 16 GeV/c have the same (resp. opposite) signs in the left (resp. right) hemisphere excepting a small interval of negative values of x. According to eqs. (24a) and (25), one expects that these distributions at asymptotic energies should be equal in the left hemisphere and symmetric with respect to the x-axis in the right one. Moreover, if the functions given by eq. (27) with $m=1$ vanish as $\epsilon \to 0$, then eq. (26) implies a limiting separate charge conservation in either hemisphere:

$$\int_{-1}^{1} dx\, \theta(\pm x) \lim_{s\to\infty} Q^{ab'}(s,x) = \frac{1}{2}(Q_a + Q_b) \pm \frac{1}{2}(Q_a - Q_b). \quad (28)$$

In the case $m=1$, eq. (28) can be obtained from eqs. (20), (26), and (27), and is satisfied, for example, in certain multiperipheral, fragmentation, and Mueller models [5,8,10]. The data at present accelerator energies do not give a spectacular approximation for eq. (28). Thus Fig. 2a) shows that the average total charges in the left and right hemispheres for $\pi^- p$ collisions at 16 GeV/c are appreciably smaller (by 2 to 3 times) than the initial charges.

Notice that if eq. (20) holds, then all functions defined by eq. (27) go to zero as $\epsilon \to 0$. Moreover, using eqs. (20) and (25)-(27), and the method of generating functionals *, we find

$$\lim_{s\to\infty} (\sigma_{tot}^{ab}(s))^{-1} \int d\sigma_{c_1 \ldots c_n}^{ab\,ex} \times$$
$$\times \{ \exp[\frac{z}{2}(Q_a + Q_b) \pm \frac{z}{2}(Q_a - Q_b)] - \exp[z \sum_{j=1}^{n} Q_{c_j} \theta(\pm x_j)] \} = 0, \quad (29)$$

where z is an arbitrary number and $d\sigma_{c_1 \ldots c_n}^{ab\,ex}$ is the differential of the cross-section for the exclusive reaction $a + b \to c_1 + \ldots + c_n$. Equation (29) shows that the only events without exchange of charges from one hemisphere to the other can give a nonzero contribution to $(\sigma_{tot}^{ab}(s))^{-1} d\sigma_{c_1 \ldots c_n}^{ab\,ex}$ as $s \to \infty$. Therefore any charge-exchange cross-section "normalized to the total cross-section tends to zero in the

* See, for example, the third reference [3].

limit of infinite energy provided eqs. (20), (22), (23), and (25) hold. Moreover, it follows from these hypotheses and isospin invariance that the ratios $\sigma^{\pi^+ p}_{tot}(s)/\sigma^{\pi^- p}_{tot}(s)$ and $\sigma^{K^+ p}_{tot}(s)/\sigma^{K^- p}_{tot}(s)$ go to unity as $s \to \infty$ /11/.

Acknowledgments

It is a pleasure to thank I.Berceanu for help in preparing this paper and useful suggestions. The authors wish to express their deep gratitude to V.Cautis, V.Karnaukhov, Dr.E.Mihul, and Dr. V.I.Moroz for several valuable discussions.

References

1. L. Van Hove. Phys. Rep., 1C, 347 (1971).
2. K.J.Biebl and J.Wolf. Phys.Lett., 37B, 197 (1971). H.Araki and R.Haag. Comm.Math.Phys., 4, 77 (1967).
3. T.T.Chou and C.N.Yang. Phys.Rev.Lett., 25, 1072 (1970). C.E. De Tar, D.Z.Freedman and G.Veneziano. Phys. Rev., D4, 906 (1971). L.S.Brown. Phys.Rev., D5, 748 (1972).
4. D.Amati, L.Caneschi and M.Testa. Phys.Lett., 43B, 186 (1973). M.Greco and Y.N.Srivastava. Preprint CERN TH-1616 (1973).
5. L.Caneschi. Phvs.Lett., 37B, 288 (1971).
6. D.R.O.Morrison. Proceedings of the Fourth International Conference on High Energy Collisions (Oxford, 1972).
7. A.L.M.Mihul and T.Besliu. Preprint JINR E1-6745, Dubna, 1972. E.Flaminio, J.D.Hansen, D.R.O.Morrison, N.Tovey. Preprint CERN-HERA 70-2, 70-5, 70-7 (1970). V.Barger and R.J.Phillips. Nucl.Phys., 32B, 93 (1971).
8. W.R.Frazer et al. Rev.Mod.Phys., 44, 284 (1972).
9. M.Cornille and A.Martin. Phys.Lett., 39B, 223 (1972).
10. T.T.Chou and C.N.Yang. Phys.Rev., D7, 1425 (1973). G.H.Thomas and C.Quigg. Preprint ANL/HEP 7253 (1972).
11. S.M.Roy. Phys.Rep., 5C, 125 (1972).

Received by Publishing Department
on June 18, 1973.