Pramāṇa, Vol. 17, No. 5, November 1981, pp 395-404. © Printed in India.

Isospin violations in large P_T pion inclusive processes in perturbative quantum chromodynamics

H S MANI, M NOMAN*, M RAFAT and R RAMACHANDRAN
Department of Physics, Indian Institute of Technology, Kanpur 208 016, India
*Present Address: Department of Physics, B N College, Patna University, Patna 800 004, India

MS received 28 April 1981; revised 22 September 1981

Abstract. We investigate the asymmetries arising due to electromagnetic interactions in large P_T pion inclusive processes. The hard QCD processes that contribute to such asymmetries are $q + g \to q + \gamma$, $q + \bar{q} \to g + \gamma$ etc. which are suspected to be substantial, as indicated by the QCD predictions for a significant and increasing γ/π^0 ratio at large P_T. We calculate the expected isospin related asymmetries and propose tests that might detect them. Our estimates indicate that the effects are much smaller than may be naively expected. We also observe a remarkable scaling of asymmetries in the variable $P_T/(s)^{1/2}$.

Keywords. Large P_T; isospin asymmetry; perturbative quantum chromodynamics; structure functions; scaling.

1. Introduction

Quantum chromodynamics (QCD) is being increasingly realised as the theory of strong interactions. (see *e.g.* Ellis 1979). Perturbative calculations in QCD have been shown to be reliable, whenever interactions at short distances (or large space-like or time-like momentum transfers) are expected to dominate. Large P_T inclusive processes come under this category. The basic subprocesses which contribute (in the lowest order) to such strong processes are parton parton hard scatterings of the type:

$$a + b \to c + d,$$

where a, b, c, d are quarks, antiquarks or gluons. However there are subprocesses which would possibly include photon as a final product namely

$$a + b \to c + \gamma,$$

e.g. $\quad q + \bar{q} \to g + \gamma \quad \text{or} \quad q + g \to q + \gamma.$

Such electromagnetic subprocesses which contribute to the large P_T inclusive processes, would induce isospin violations. The amount of violation is calculable in perturbative QCD. In this paper, we investigate these isospin violations, induced by the underlying electromagnetic effects, with a view to provide further observable tests for quantum chromodynamics.

The basic ingredients in the large P_T inclusive phenomena are contained in the following master equation for the cross-section (Glück and Reya 1977; Glück *et al* 1978). In a collision of two hadrons A and B, the inclusive differential cross-section for hadron C is given by:

$$E_C \frac{d\sigma}{dP_C^3} = \frac{1}{\pi} \sum_{a,b,c,d} \int_{x_{a_{\min.}}}^{1} dx_a \int_{x_{b_{\min.}}}^{1} dx_b \, P_{a/A}(x_a, Q^2)\, P_{b/B}(x_b, Q^2) \times \frac{d\sigma^{a+b\to c+d}}{d\hat{t}} \frac{1}{Z} D^{C/c}(Z, Q^2), \quad (1)$$

where the symbols have their usual meanings.

$P_{a/A}(X_a, Q^2)$ is the structure function for the parton a in the hadron A, carrying a fraction x_a of its longitudinal momentum. Similarly, $D^{C/c}(Z, Q^2)$ refers to the fragmentation function of the parton c, radiating hadron C with a longitudinal momentum fraction Z of the original parton. The Q^2 dependences of the structure functions and the fragmentation functions are dictated by the renormalization group requirements. $d\sigma^{a+b\to c+d}/d\hat{t}$ is the differential cross-section for the hard subprocesses $a+b\to c+d$ and $\hat{s}$, $\hat{t}$ and $\hat{u}$ are the Mandelstam variables associated with this subprocess. To order α_s^2, the large P_T reactions are determined by the following ten hard processes: (i) $q+q\to q+q$, (ii) $q+\bar{q}\to q+\bar{q}$, (iii) $\bar{q}+q\to q+\bar{q}$, (iv) $q+g\to q+g$, (v) $g+q\to q+g$, (vi) $\bar{q}+g\to \bar{q}+g$, (vii) $g+\bar{q}\to \bar{q}+g$, (viii) $g+g\to q+\bar{q}$, (ix) $g+g\to g+g$ and (x) $q+\bar{q}\to g+g$.

While all the above processes will lead to isospin symmetric cross-section, we may expect an isospin asymmetry, if we include as hard processes (a) $q+g\to q+\gamma$, (b) $\bar{q}+g\to\bar{q}+\gamma$, (c) $g+q\to q+\gamma$, (d) $g+\bar{q}\to\bar{q}+\gamma$, (e) $q+\bar{q}\to g+\gamma$ and (f) $\bar{q}+q\to g+\gamma$. Compared with the corresponding isospin preserving subprocesses such as $q+g\to q+g$, the electromagnetic process differs by a factor $\alpha_e/\alpha_s(Q^2)$. Since the running coupling constant decreases logarithmically as Q^2, this factor becomes favourable (*i.e.* the electromagnetic subprocesses become non-negligible compared to strong ones) as the transverse momentum P_T in the inclusive process becomes large. (If we include higher order radiative corrections, there will be a further enhancement arising from an effective $\alpha_e(Q^2)$.) Indeed, it has been noticed that the ratio of inclusive cross-section for direct photon and pion increases as P_T increases; in $p+p$ collisions at the c.m. energy of 53 GeV, the yield of γ and π° becomes equal at $P_T \cong 14$ GeV/c (Brodsky *et al* 1978; Fritzsch and Minkowski 1977). This suggests substantial contribution from the same subprocesses which are expected to contribute to large observable isospin asymmetry as well.

2. Proposed tests

2.1 *Test* 1

Consider the inclusive cross-section for $\pi^\pm$ in the collision of either π^+ or π^- on an isoscalar nucleon target. Isospin symmetry (rather charge reflection symmetry) implies that:

$$N_{++} \equiv \sigma^{\pi^+ N \to \pi^+ X} (s, P_T, \theta_{cm}) = \sigma^{\pi^- N \to \pi^- X} (s, P_T, \theta_{cm}) \equiv N_{--}, \quad (2a)$$

where N_{++} and N_{--} may be regarded as the relevant counting rates for equal fluxes of π^+ and π^- beams. $\theta_{c.m.}$ is the scattering angle in the centre of mass frame and N is the isoscalar nucleon target.

Similarly

$$N_{+-} \equiv \sigma^{\pi^+ N \to \pi^- X} (s, P_T, \theta_{cm}) = \sigma^{\pi^- N \to \pi^+ X} (s, P_T, \theta_{cm}) \equiv N_{-+}. \quad (2b)$$

On including the electromagnetic subprocesses, the above equalities will not be satisfied. Denoting the strong subprocesses to order α_s^2 by S_1 and S_2 and the electromagnetic processes to order $\alpha_e\ \alpha_s$ by $E_{1,2}$ and $\bar{E}_{1,2}$, we have:

$$N_{++} = S_1 + E_1, \quad (3a)$$

$$N_{+-} = S_2 + E_2, \quad (3b)$$

$$N_{--} = S_1 + \bar{E}_1, \quad (3c)$$

$$N_{-+} = S_2 + \bar{E}_2. \quad (3d)$$

To eliminate the flux uncertainties, it is convenient to work with the ratios,

$$A \equiv \frac{N_{+-}}{N_{++}} = \frac{S_2}{S_1}\left[1 + \frac{E_2}{S_2} - \frac{E_1}{S_1}\right], \quad (4a)$$

$$B \equiv \frac{N_{-+}}{N_{--}} = \frac{S_2}{S_1}\left[1 + \frac{\bar{E}_2}{S_2} - \frac{\bar{E}_1}{S_1}\right]. \quad (4b)$$

The asymmetry

$$R_1 \equiv \frac{A - B}{A + B} = 2\left[\frac{(E_2 - \bar{E}_2)}{S_2} - \frac{(E_1 - \bar{E}_1)}{S_1}\right], \quad (5)$$

is a measure of isospin violation.

We note here that amongst the six electromagnetic subprocesses listed in §1 only the following four contribute to isospin asymmetry (a) $g + q \to q + \gamma$, (b) $g + \bar{q} \to \bar{q} + \gamma$, (c) $\bar{q} + q \to g + \gamma$ and (d) $q + \bar{q} \to g + \gamma$. To see this , consider the expression in the integrand of (1) (identifying A with π^+, a with q, B with N and b with g),

$$P_{q/\pi^+}\, P_{g/N} \frac{d\sigma^{q+g \to q+\gamma}}{d\hat{t}} \frac{D^{\pi^+/q}(Z, Q^2)}{Z}.$$

By isospin symmetry, this expression is identically equal to

$$P_{\bar{q}/\pi^-} P_{g/N} \frac{d\sigma^{\bar{q}+g\to\bar{q}+\gamma}}{d\hat{t}} \frac{D^{\pi^-/\bar{q}}(Z, Q^2)}{Z},$$

since the hard subprocesses $q + g \to q + \gamma$ and $\bar{q} + g \to \bar{q} + \gamma$ have the same cross-section. Thus, $g + q \to q + \gamma$ contributing to E_1 (*i.e.* N_{++}), and $\bar{q} + g \to \bar{q} + \gamma$ contributing to $\overline{E_1}$ (*i.e.* N_{--}) being equal, cancel each other in the expression (5) for R_1. A similar analysis shows that the respective contributions of $q + g \to q + \gamma$ and $\bar{q} + g \to \bar{q} + \gamma$ to E_2 and $\overline{E_2}$ also cancel each other. Thus R_1 derives no net contribution from the subprocesses $q + g \to q + \gamma$ and $\bar{q} + g \to \bar{q} + \gamma$. Now we will examine the manner in which the subprocesses $q + \bar{q} \to g + \gamma$ and $\bar{q} + q \to g + \gamma$ contribute to R_1; we note that the nucleon contains no valence antiquarks, antiquarks are found in sea only. Writing the quark content in either pion or nucleon as a sum of valence and sea part

$$q = q_v + q_s.$$

The integrand in (1) now takes the form

$$P_{q/\pi^+} P_{\bar{q}/N} \frac{d\sigma^{q+\bar{q}\to g+\gamma}}{d\hat{t}} D_g^{\pi^+}(Z, Q^2)/Z$$

$$= P_{(q_v+q_s)/\pi^+} P_{\bar{q}_s/N} \frac{d\sigma^{q+\bar{q}\to g+\gamma}}{d\hat{t}} D_g^{\pi^+}(Z, Q^2)/Z.$$

This is the contribution to E_1 (*i.e.* N_{++}) from the subprocesses $q + \bar{q} \to g + \gamma$. The contribution from $\bar{q} + q \to g + \gamma$ to E_1 is

$$P_{(\bar{q}_v+\bar{q}_s)/\pi^+} P_{(q_v+q_s)/N} \frac{d\sigma^{\bar{q}+q\to g+\gamma}}{d\hat{t}} D_g^{\pi^+}(Z, Q^2)/Z.$$

We can similarly see that the contributions to $\overline{E_1}$ (*i.e.* N_{--}) from the subprocesses $\bar{q} + q \to g + \gamma$ and $q + \bar{q} \to g + \gamma$ are

$$P_{(\bar{q}_v+\bar{q}_s)/\pi^-} P_{(q_v+q_s)/N} \frac{d\sigma^{\bar{q}+q\to g+\gamma}}{d\hat{t}} D_g^{\pi^-}(Z, Q^2)/Z$$

$$+ P_{(q_v+q_s)/\pi^-} P_{\bar{q}_s/N} \frac{d\sigma^{q+\bar{q}\to g+\gamma}}{d\hat{t}} D_g^{\pi^-}(Z, Q^2)/Z.$$

Therefore the net contribution to $E_1 - \overline{E_1}$ from the subprocesses $q + \bar{q} \to g + \gamma$ and $\bar{q} + q \to g + \gamma$ is seen to be

$$(P_{\bar{q}/\pi^+} - P_{\bar{q}/\pi^-}) P_{q_v/N} \frac{d\sigma^{\bar{q}+q\to g+\gamma}}{d\hat{t}} D_g^{\pi^+}, \tag{6}$$

making use of the relations

(i) $P_{q/\pi^+} = P_{\bar{q}/\pi^-}$,

(ii) sea has equal quark and antiquark content,

(iii) $\dfrac{d\sigma^{q+\bar{q}\to g+\gamma}}{d\hat{t}} = \dfrac{d\sigma^{\bar{q}+q\to g+\gamma}}{d\hat{t}}$ and

(iv) $D_g^{\pi^+} = D_g^{\pi^-}$.

The contribution to $E_2 - \bar{E}_2$ has an exactly identical expression. It is clear from the above expression that the contribution of $\bar{q} + q \to g + \gamma$ and $q + \bar{q} \to g + \gamma$ is small; firstly because in (6) $P_{\bar{q}/\pi^+}$ and $P_{\bar{q}/\pi^-}$ have opposite signs and secondly because $D_g^{\pi^\pm}$ is smaller as compared to quark fragmentation functions $D_q^{\pi^\pm}$.

It will be convenient to break up the electromagnetic contributions $E_{1,2}$ and $\bar{E}_{1,2}$ derived from the subprocesses $g + q \to q + \gamma$, $g + \bar{q} \to \bar{q} + \gamma$, $q + \bar{q} \to g + \gamma$ and $\bar{q} + q \to g + \gamma$ into even and odd parts and introduce

$$E^e = \frac{E_1 + E_2}{2}, \quad E^o = \frac{E_2 - E_1}{2}, \tag{7a}$$

$$\bar{E}^e = \frac{\bar{E}_1 + \bar{E}_2}{2}, \quad \bar{E}^o = \frac{\bar{E}_2 - \bar{E}_1}{2}. \tag{7b}$$

The asymmetry R_1 has the form

$$R_1 = \frac{2}{S_1 S_2} [(S_1 + S_2)(E^o - \bar{E}^o) + (S_1 - S_2)(E^e - \bar{E}^e)]. \tag{8}$$

The first part containing the odd part of electromagnetic contribution generates the dominant effect. The second part derives contribution from the processes $q + \bar{q} \to g + \gamma$ and $\bar{q} + q \to g + \gamma$ and as already noted is small being proportional to $(S_1 - S_2)$. From the identical expression (6) of contributions to $E_1 - \bar{E}_1$ and $E_2 - \bar{E}_2$ from the subprocesses $q + \bar{q} \to g + \gamma$ and $\bar{q} + q \to g + \gamma$, one can infer that the net contribution would be proportional to $(S_1 - S_2)$ by virtue of (5).

While the experimental determination of the asymmetry should now be straightforward, the theoretical estimates are besieged of several uncertainties, such as imprecise knowledge of the structure functions of pion. In particular, there is no way to estimate theoretically the gluon content of pion.

2.2 *Test* 2

Since the structure functions are more accurately determined by deep inelastic lepton-nucleon scattering, we propose a second test involving nucleons. Consider proton-neutron scattering for inclusive pion production $p+n\to\pi^{\pm}X$. In the absence of isospin violation, we should find

$$E_{\pi^-}\frac{d\sigma}{dp^3_{\pi^-}}(s,t,u)=E_{\pi^+}\frac{d\sigma}{dp^3_{\pi^+}}(s,u,t), \tag{9a}$$

or equivalently

$$E_{\pi^-}\frac{d\sigma}{dp^3_{\pi^-}}(s,P_T,\theta_{\rm cm})=E_{\pi^+}\frac{d\sigma}{dp^3_{\pi^+}}(s,P_T,\pi-\theta_{\rm cm}). \tag{9b}$$

The strong subprocesses which contribute to the inclusive cross-section are the ten subprocesses listed in § 1. The electromagnetic subprocesses *viz.* $q+g\to q+\gamma$, $\bar{q}+g\to\bar{q}+\gamma$, $g+q\to q+\gamma$, $g+\bar{q}\to\bar{q}+\gamma$, $q+\bar{q}\to g+\gamma$, and $\bar{q}+q\to g+\gamma$ would disturb the relations given in (9) and would lead to the isospin violations. However, we expect significant contribution to the cross-section from only two sub-processes $q+g\to q+\gamma$ and $g+q\to q+\gamma$. The other four subprocesses are proportional to the antiquark content in the nucleon and since the antiquarks are found in nucleon sea only, the contribution from these subprocesses is small.

We write the isospin asymmetry as

$$R_2=\frac{E_{\pi^+}\frac{d\sigma}{dp^3_{\pi^+}}(s,P_T,\theta_{\rm cm})-E_{\pi^-}\frac{d\sigma}{dp^3_{\pi^-}}(s,P_T,\pi-\theta_{\rm cm})}{E_{\pi^+}\frac{d\sigma}{dp^3_{\pi^+}}(s,P_T,\theta_{\rm cm})+E_{\pi^-}\frac{d\sigma}{dp^3}(s,P_T,\pi-\theta_{\rm cm})} \tag{10}$$

Experimentally, one measures the π^- yield at one angle with the π^+ yield at the supplementary angle in the c.m. system. However, since one cannot perform a p - n collision experiment in the centre of mass, precise knowledge of the beam momentum is necessary to identify the lab angle which corresponds to the complimentary position in the c.m. These uncertainties are somewhat offset by the better knowledge of the structure functions.

3. Calculation and results

In computing the asymmetries given by (5) and (10), we make use of the parametrisation for the nucleon and pion structure functions as given by Owens, Reya and Glück. (Glück *et al* 1978) The salient features as well as the defects of this parametrisation are summarized here; for details the reader may refer to the original references: (i) At $Q_0^2=1\cdot8$ (GeV)^2, gluons carry 50% of the nucleon momentum and as per the threshold counting rules (Farrar 1974; Gunion 1974) are given by

$$G(x,Q_0^2)=\frac{3(1-x)^5}{x}. \tag{11}$$

(ii) The valence and the sea quark distributions are obtained by Buras and Gaemers (1978) from their fits to deep inelastic $e(\mu)p$ data and conform to Q^2 dependence as dictated by QCD in the region $1 \leqslant Q^2 \leqslant 10^2$ (GeV)^2. (iii) The sea is assumed to be SU(3) symmetric and the charm content is neglected. (iv) The fragmentation functions, related by isospin and charge conjugation invariance, are expressed in terms of two functions for pion and three for kaon. These are further related by plausible quark content considerations and their Z dependence divided into a *valence* and a *sea* part. (v) Gluon fragmentation function is assumed to be steeper than for favoured *valence* component of quark fragmentation function. (vi) The Q^2 evolution: for the running coupling constant, we take the form consistent with 4 flavours—

$$\alpha_s (Q^2) = \frac{12\pi}{25 \ln Q^2/\Lambda^2}, \tag{12}$$

with $\Lambda = 500$ MeV and choose

$$Q^2 = \frac{\hat{s}\,\hat{t}\,\hat{u}}{\hat{s}^2 + \hat{t}^2 + \hat{u}^2}. \tag{13}$$

An enhancement of α_e is also expected with Q^2; but it is negligible. We therefore take α_e to be a constant throughout the calculation.

The computations are straightforward; contributions to S_1 and S_2 in (8) and the quantities in (9a) and (9b) arise from the hard subprocesses $qq \to qq$, $q\bar{q} \to q\bar{q}$, $\bar{q}q \to q\bar{q}$ and $q\bar{q} \to gg$ on the one hand and from $qg \to qg$, $gq \to qg$, $\bar{q}g \to \bar{q}g$, $g\bar{q} \to \bar{q}g$, $gg \to q\bar{q}$ and $gg \to gg$ on the other. The electromagnetic subprocesses are $gq \to q\gamma$, $g\bar{q} \to \bar{q}\gamma$ and $q\bar{q}$, $\bar{q}q \to g\gamma$ in the case of R_1 and $gq \to q\gamma$, $g\bar{q} \to \bar{q}\gamma$, $qg \to q\gamma$, $\bar{q}g \to \bar{q}\gamma$, $q\bar{q} \to g\gamma$ and $\bar{q}q \to g\gamma$ in the case of R_2.

3.1 *Case I*

In the case of $\pi N \to \pi X$, the main contribution to S_1 and S_2 comes from the valence-valence scattering (see figure 1). This is consistent with the earlier calculations in the concerned region. We have already noted that all the electromagnetic subprocesses do not contribute to the asymmetry. The non-vanishing contribution to asymmetry arises only from $g/\pi + q$, $\bar{q}/N \to q, \bar{q} + \gamma$ and $q, \bar{q}/\pi + \bar{q}, q/N \to g + \gamma$ with the result that the contribution is directly proportional to the gluon content of the pion. (As already noted in (8), $\bar{q} + q \to g + \gamma$ and $q + \bar{q} \to g + \gamma$ give a contribution proportional to $(S_1 - S_2)$ which is small.) In contrast, the direct photon inclusive cross-section derives contributions from all other electromagnetic subprocesses as well *i.e.* $q + g \to q + \gamma$, $\bar{q} + g \to \bar{q} + \gamma$.

We can make an order of magnitude estimate of the asymmetry by considering the following factors: (i) $\alpha_e/\alpha_s \cong 1/30$. The strong subprocesses are of order α_s^2 while the electromagnetic ones are of order $\alpha_e\,\alpha_s$. As (5) indicates R_1 is essentially the ratio of the cross-sections of the electromagnetic to strong subprocesses. (ii) Colour factor of $\frac{gq \to q\gamma}{gq \to qg} = \frac{3}{4}$; as already noted above the dominant contribution to asymmetry comes

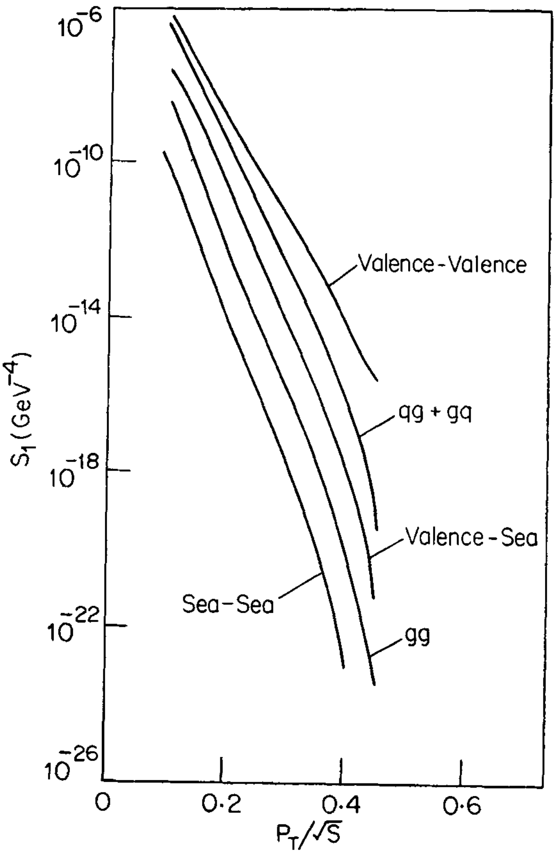

Figure 1. Various contributions (valence-valence, valence-sea, sea-sea, qg and gg) to $\pi^+N \to \pi^+X$ cross-section at $s = 2800\ \mathrm{GeV}^2$.

from the subprocesses involving gluon from pion. (iii) $e_u^2 - e_d^2 = \frac{1}{3}$. This factor arises because the quark coupling to photon is proportional to quark charge. The expression $e_u^2 - e_d^2$ arises because u and d content is same in the iso-scalar nucleon and $D_u^{\pi+} = D_d^{\pi-}$. The expression $E^0 - \bar{E}^0$ of (8) therefore becomes proportional to $e_u^2 - e_d^2$. (iv) The asymmetry derives contribution from four among the six processes that might contribute to hadronic contribution; among these four only $gq \to q\gamma$ gives a significant contribution. $g\bar{q} \to \bar{q}\gamma$ is proportional to sea quark content in the nucleon and is therefore negligible. $\bar{q}q \to g\gamma$, and $q\bar{q} + g\gamma$ contribution is proportional to $(S_1 - S_2)$ (see (6)) and also to D_g^π and is therefore negligible. We thus get an effective factor $\sim \frac{1}{5}$. (v) While $gq \to g\gamma$ has s and u channel poles, the process $gq \to gq$ has in addition a t channel pole by virtue of gluon coupling. As noted, the dominant contribution from asymmetry comes from the processes involving gluon from pion. This gives a factor of about $\frac{1}{6}$. Thus the expected asymmetry is $\cong 3 \times 10^{-4}$. The calculated asymmetry is of the order of 10^{-5} (figure 2) *i.e.* one order of magnitude smaller than the above estimate. This suppression is due to kinematic effects and also due to the fact that gluon processes give cross-sections lower than the quark processes (see figure 1) and the photon production is proportional to the gluon content.

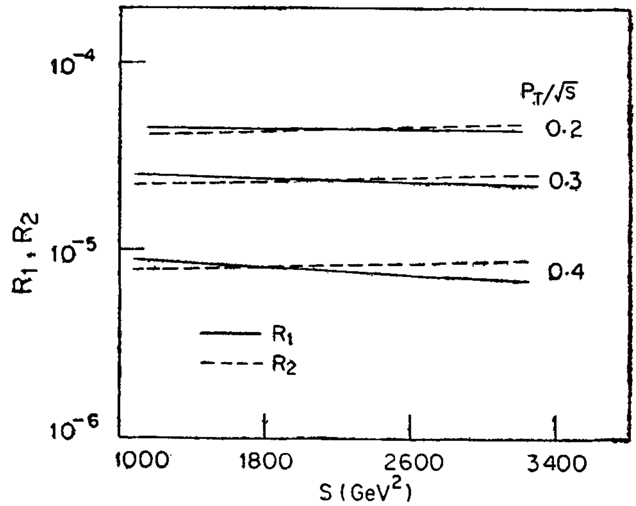

Figure 2. Scaling of the asymmetry parameters R_1 and R_2 in the variable $P_T/(s)^{1/2}$.

The s dependence (energy dependence) of S_1, S_2 and the electromagnetic contribution is essentially given by the non-scaling behaviour of the valence functions and the fragmentation functions. This dependence in each of the terms is of similar nature (Glück *et al* 1978) and is almost factored out in the calculation of the asymmetry. As a result the asymmetry exhibits scaling; it depends only on $P_T/(s)^{1/2}$ and not on P_T and s separately. (figure 2).

3.2 *Case II*

The calculation of $pn \to \pi X$ gives results very similar to $\pi N \to \pi X$. We again find the dominant contribution to cross-section from qq scattering. An order of magnitude estimate for the asymmetry R_2 proceeds on the lines similar to $\pi N \to \pi X$ case. The asymmetry is $\cong 10^{-5}$ (figure 2) showing a similar suppression by one order of magnitude. The remarkable scaling of asymmetry in the variable $P_T/(s)^{1/2}$ persists here also.

Aurenche and Lindfors (1980) have estimated the cross-section of the basic process $qq \to qq\gamma$. According to their estimate this cross-section is about 10% of the other lower order QCD processes which produce a photon ($qg \to q\gamma$, and $q\bar{q} \to g\gamma$, which have been considered by us). Thus the inclusion of this higher order process would not significantly affect the asymmetry.

4. Conclusions

The calculated asymmetry, while being an order of magnitude smaller than that expected on general grounds, appears to persist over a wide range of large P_T values; thus making it easier to look for the general features of isospin violation.

Our analysis is easily generalized to include in the single particle inclusive cross-sections kaons and protons in addition to pions and look for general single particle charge asymmetry. In view of the fact that most fragmentation functions have very similar characteristics the expected asymmetry will not be very different from that for pion inclusive cross-section. Finally the effect is significantly enhanced if the $\pi^{\pm}$ asymmetry is sought, while tagging a prompt 'γ' ray at fixed P_T. The model dependance and other features of the tagged isospin asymmetry is currently under study.

Acknowledgement

One of us (R R) would like to thank Professor F Lobkowicz for discussion on the experimental feasibility.

References

Aurenche P and Lindfors J 1980 *Nucl. Phy.* **B168** 296
Brodsky S, Gunion J F and Ruckl R 1978 UCLA Preprint.
Buras A J and Gaemers K J F 1978 *Nucl. Phys.* **B132** 249
Ellis J 1979 *Lepton and photon interactions at high energy*, Proc. Int. Symp., Fermi Lab., (ed.) T B W Kirk and Abarbanel H D I 412
Farrar G 1974 *Nucl. Phys.* **B77** 429
Fritzsch H and Minkowski P 1977 CERN Report Th. 2320
Gluck M, Owens J F and Reya E 1978 *Phys. Rev.* **D18** 1501
Gluck M and Reya E 1977 *Nucl. Phys.* **B130** 76
Gunion J F 1974 *Phys. Rev.* **D10** 242