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OBSERVATION OF TRANSVERSAL HANDEDNESS IN THE DIFFRACTIVE PRODUCTION OF PION TRIPLES

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A rather large, transversal to the production plane, handedness was observed in coherent production of $(\pi^-\pi^+\pi^-)$ triples by 40 GeV π^--beam on nuclei.

Наблюдение поперечной спиральности пионных троек при дифракционном рождении

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Для когерентно рожденных на ядре пионных троек $(\pi^-\pi^+\pi^-)$ 40 ГэВ π^--пучком наблюдена значительная, поперечная к плоскости рождения, спиральность этих троек.

Some years ago the concept of jet handedness was introduced as a measure of polarization of parent partons (or hadrons) [1]. For strong interaction process, parity invariance requires that at least three particles (spinless or spin averaged) in final state or the pair of particles and jet direction were measured in order to have a correlation in the fragmentation (or decay) distribution with initial helicity. Namely, from three particle momenta one can construct a pseudovector $n_\mu \propto \varepsilon_{\mu\nu\sigma\rho} k_1^\nu k_2^\sigma k^\rho$ $(k = k_1 + k_2 + k_3)$ which gives, when contracted with the initial polarization pseudovector, a scalar component in the strong process. Thus measuring the asymmetry (handedness) in some component of **n** in the rest frame of the triple and averaging over the other component can give information on the initial polarization in this direction

$$H_i = \frac{N(n_i > 0) - N(n_i < 0)}{N(n_i > 0) + N(n_i < 0)} = A_i P_i, \qquad (1)$$

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providing the analysing power A is large enough. The direction i could be chosen as longitudinal (L) with respect to the triple momentum $\mathbf{k}$ as transversal ones ($T1$ or $T2$) perpendicular to the triple production plane or in the plane[1]. It was argued [1] that for jet fragmentation process the longitudinal and transversal analysing power could be of different value while for a three-particle decay they are equal.

The longitudinal handedness was first probed in $e^+e^- \to Z \to q\bar{q} \to$ 2-jet process [5], where quarks are longitudinally polarized due to interference of the vector and axial coupling. The best result of measurement was $H^{e^+e^-} = (1.2 \pm 0.5)\%$ seen for leading $(++-)$ and $(--+)$ pion triples in the ρ-resonance region of invariant mass of $(+-)$-pairs. The SLD result [6] obtained with a polarized electron beam is $H < 2\%$. Also the correlation of longitudinal handedness in two-jet events was investigated [7] giving a puzzling sign contradicting to the CP-conjugation of the two jets and to factorization of q and $\bar{q}$ fragmentation functions.

In this paper we present the first probe for measuring the *transversal* handedness in the diffractive hadron process [8]

$$\pi^- + A \to (\pi^-\pi^+\pi^-) + A, \tag{2}$$

where A is for Be, Si and Pb nuclei.

The direction of normal to the production plane of the pion triple was defined as

$$\mathbf{N} = (\mathbf{v}_{3\pi} \times \mathbf{v}_b), \tag{3}$$

where $\mathbf{v} = \mathbf{k}/\varepsilon$ are the velocities of initial π^--beam and final 3π-system in the Lab r.f. The direction of normal to the «decay plane» of the 3π-system was defined as

$$\mathbf{n} = (\mathbf{v}_f^- - \mathbf{v}^+) \times (\mathbf{v}_s^- - \mathbf{v}^+), \tag{4}$$

where $\mathbf{v}_{f(s)}^-$ or $\mathbf{v}^+$ are the velocities of fast (slow) π^- or π^+.

The handedness (1) for longitudinal component of $\mathbf{n}$

$$n_L = \mathbf{n} \cdot \mathbf{v}_{3\pi} \tag{5}$$

and two transversal components

$$n_{T1} = \mathbf{n} \cdot \mathbf{N} \text{ and } n_{T2} = \mathbf{n} \cdot (\mathbf{v}_{3\pi} \times \mathbf{N}) \tag{6}$$

were measured using about 10000 events for each of the targets. With no cut applied the result was as follows

$$\begin{aligned} &H_{T1}^{\text{Be}} = 10.0 \pm 1.0\% \quad H_{T1}^{\text{Si}} = 7.1 \pm 1.0\% \quad H_{T1}^{\text{Pb}} = 6.5 \pm 1.0\% \\ &H_{T2}^{\text{Be}} = -0.6 \pm 1.0\% \\ &H_{L}^{\text{Be}} = 0.0 \pm 1.0\%. \end{aligned} \tag{7}$$

So, one can see that the only component allowed by parity conservation H_{T1} is different from zero and large enough.

[1] In fact an idea similar to the handedness was earlier proposed in works [2]. Its application to a certain heavy quark decays was studied in Ref.3. Similar technique was also studied in the work [4].

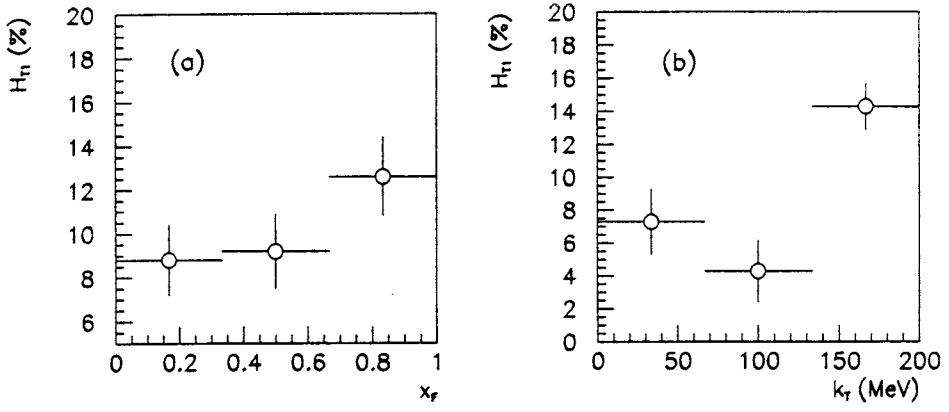

Fig. The handedness dependence on x_F (a) and k_T (b) for Be

The statistics permits one also to break the events into three bins in transversal momenta k_T of the triples or in fraction of longitudinal momentum $x_F = k_{Lf}/k_b$ of the fast π^-. The result of the binding for berillium target is presented in the Figure. It seems that some increase of the handedness value H_{T1} with increasing k_T or x_F is seen. This reminds a similar behaviour of Λ polarization or single spin pion asymmetry produced on a polarized target [9].

Trying to understand the reason of the phenomena, a cut was applied selecting events with the invariant mass of the triples in the region of a_1-resonance and invaruiant mass of each of the neutral pair in the region of ρ-meson. No noticeable change of the effect was observed after the cuts ($H_{T1} = 10.6 \pm 1.8\%$), just as for the cut of the neutral pairs invariant mass alone.

For convinction that the observed effect is not a consequence of some kinematics the Monte-Carlo events of reaction (2) were generated with a constant mass spectrum of the 3π-system in the interval 0.6—2.5 GeV/c^2 and with the experimental decrease with $t' = t - t_{\min}$ of cross section with the slope 40 (Gev/c)$^{-2}$. The same selection of events with leading π^- shows no transversal handedness H_{T1} within the accuracy of 0.2%. Also no noticeable angular dependence of the normal **n** Expr. (4) was found both in earlier hydrogen bubble chamber data of reaction (2) at 4.5 GeV for the proton target and in the Regge pole exchange model which provides a reasonable description of that experiment [10].

In conclusion, rather large handedness transversal to the production plane was observed in the diffractive production of ($\pi^-\pi^+\pi^-$) triples in the π^--beam fragmentation region. The physical reason for this phenomenon is far from clear. We are going to study the effect in more detail using more rich statistics.

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