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The Quark Mechanism of High Energy Spin Effects in Hadronic Binary Reactions

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We present the results on spin effects in the inelastic hadronic binary reactions $(0,\ 1/2) \rightarrow (0,\ 1/2)$ in the framework of the quark model for the U-matrix. This model is based on the use of the QFT three-dimensional dynamic equations for the amplitudes. These equations take into account the unitarity of the S-matrix. The expressions for the helicity non-flip $F_o(s,t)$ and helicity flip $F_f(s,t)$ amplitudes of a binary process $ab \rightarrow cd$ are as follows:

$$
\begin{aligned}
F_o(s,t) &= \frac{s}{\pi^2}\int_0^\infty b\,db\,J_o(b\sqrt{-t})\,U_o(s,b)\left[1-iU(s,b)\right]^{-1} \\
F_f(s,t) &= \frac{s}{\pi^2}\int_0^\infty b\,db\,J_1(b\sqrt{-t})\,U_f(s,b)\left[1-iU(s,b)\right]^{-2},
\end{aligned}
\tag{1}
$$

where $U(s,b)$ is the generalized reaction matrix for the elastic scattering process of initial hadrons, and U_o, U_f are related to dynamics of inelastic hadron interactions. It is assumed in the model that the interaction of hadronic structures results in arising of some effective potential field. The elastic hadron scattering corresponds to the case when the valence quarks are elastically and quasi-independently scattered by this field. Accordingly, the expression for U is represented in the form of the product of the quark amplitudes

$$
U(s,b) = \prod_{q=1}^{N} f_q(s_q,b), \qquad f_q(s,b) = g_q\sqrt{s}\,\exp(-m_q b),
\tag{2}
$$

where N is a total number of valence quarks. The functions U_o and U_f in eqs. (1) are expressed as a product of the (N-N') quark scattering amplitudes, and the functions $\varkappa_o$ and $\varkappa_f$, which describe valence quark "transitions", namely, $q\bar{q}$-annihilation and creation of the quark pair of different flavour, quark exchanges, etc.

Two possible mechanisms to flip the quark helicity: at elastic scattering $q(\uparrow) \rightarrow q(\downarrow)$ or at quark transition $q(\uparrow) \rightarrow q'(\downarrow)$ are met with:

$$
\begin{aligned}
U_o(s,b) &= \varkappa_o(\{s_q\},\ b)\prod_{q=1}^{N-N'} f_q(s_q,\ b) \\
U_f(s,b) &= \varkappa_o(\{s_q\},\ b)\,f_{q_1 f}(s_{q_1},\ b)\prod_{q=1}^{N-N'-1} f_q(s_q,b)
\end{aligned}
\tag{3}
$$

or

$$
U_f(s,b) = \varkappa_f(\{s_q\},b)\prod_{q=1}^{N-N'} f_q(s_q,b)
\tag{4}
$$

It is natural to consider the ratios $\varkappa_o/\varkappa_f \sim 1$ and $f_q/f_{qf} \sim \sqrt{s}$ [2].

Calculating[1] the amplitudes F_o and F_f, we find that the major over s contribution to the polarization in binary processes at fixed t-values is due to the quark transition mechanism $q(\uparrow) \rightarrow q'(\downarrow)$. For another case of the helicity flip: $q(\uparrow) \rightarrow q(\downarrow)$, eq.(3), the relation $F_o \sim s^{\frac{1}{2}+\delta} F_f$, $\delta > 0$ is valid. The measurements[3] of polarization in the charge exchange reactions $\pi^- p \rightarrow (\pi^o,\ \eta,\ \eta')n$ at $p_L = 40$ GeV/c reveal considerable spin effects.

Therefore, one may conclude that in such processes the polarization rise is related to dominance of inelastic quark transitions $q(\uparrow) \rightarrow q'(\downarrow)$. Due to this mechanism we expect considerable spin effects at high energies. The contribution to the polarization from the transitions $q(\uparrow) \rightarrow q(\downarrow)$ is suppressed over s at fixed t.

The expression for the polarization parameter is:

$$
\mathbf{P}(s,t) = -\sin\Delta(s)\,2M\sqrt{-t}\,\cos\left[2R(s)\sqrt{-t}\right]\left\{M^2-t-(M^2+t)\sin\left[2R(s)\sqrt{-t}\right]\right\}^{-1}
\tag{5}
$$

Here $R(s)$ is the effective radius of elastic scattering process $ab \rightarrow ab$ and $\Delta(s)$ is the phase difference of the functions $\varkappa_o$ and $\varkappa_f$, $M = Nm_q$.

Note the universality of the t-dependence of polarization for the processes $ab \to cd$ in respect to final hadrons. The different values of $\sin \Delta(s)$ for various inelastic reactions are determined by the relative phases of the functions, describing the quark processes $u\bar{u} \to \bar{u}u$, $d\bar{d}$, $s\bar{s}$. This leads to different values of $\mathbf{P}(s,t)$, e.g. in the reactions $\pi^- p \to (\pi^0, \eta) n$:

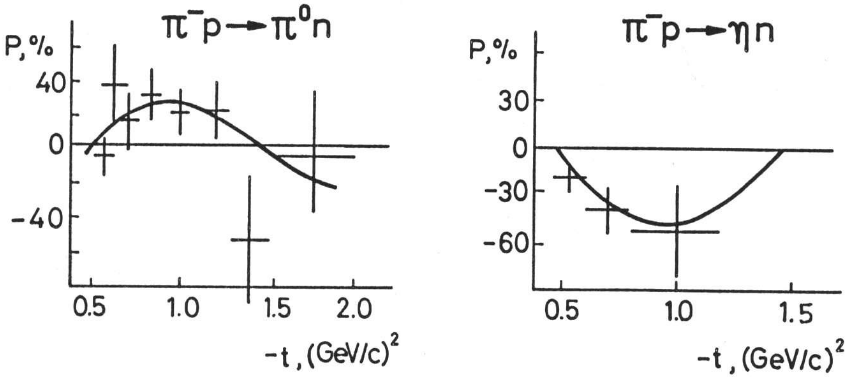

Fig. 1 Comparison of eq. (5) with the IHEP data at p_L = 40 GeV/c[3].

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