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POLARIZATION PHENOMENA IN REACTIONS OF DEUTERON STRIPPING TYPE

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The investigation of the polarization characteristics in the stripping-type processes of the fast deuteron is very interesting because it can give the information about the deuteron structure at small internucleon distances.

The process of the tensor polarized deuteron fragmentation is considered in the present paper. Special attention is focussed on the analysis of the deuteron tensor polarization component T_{20}; its measurements have been done recently /1,2/.

As is shown in Ref. /3/, one can't restrict oneself with the analysis of the spectator graph of Fig. 1a. Considerable contributions to the proton spectrum are given by the graphs of Figs 1b /4/ and 1c /3/ in some kinematic region, and small contributions are given by those in Figs 1d /3/ and 1e /5/. Therefore for the simplicity we calculated the inclusive proton spectrum and T_{20} taking into account only the graphs of Figs 1a-c. The expression for T_{20} can be written in our case in the following general form /6/:

$$T_{20}=\frac{Sp(\rho_0 F_d^{+} \Omega_{20} F_d)}{Sp(\rho_0 F_d^{+} F_d)}, \tag{1}$$

where the following notation is introduced $\rho_0=\frac{1}{6}P_T$; $P_T=\frac{3+\sigma_p\sigma_n}{4}$ is the projection operator of the triplet basic deuteron state, F_d is the amplitude of the reaction $dN\to pX$; $\Omega_{20}=\frac{1}{\sqrt{2}}\left\{\frac{3}{2}(1+\sigma_{pz}\sigma_{nz})-2\right\}$ is the spin-tensor operator corresponding to the polarization component T_{20}; σ_p,σ_n are the Pauli matrices proper to the proton and neutron; σ_{pz}, σ_{nz} are their Z-components.

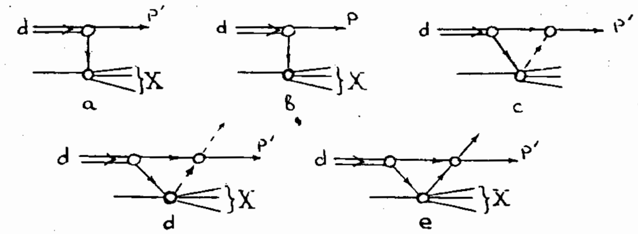
As is known, in a general relativistic case it is impossible to introduce the concept of the deuteron wave function. But it is better to consider such processes in the infinite momentum frame (IMF) using light cone variables. In that frame time ordered graphs of the old perturbation theory (OPTh) may be used instead of relativistic invariant Feynman graphs, many OPTh graphs are negligible /7/. There are only those graphs when the concept of the wave function of the light cone dynamics may be introduced /8-10/. The amplitude proper to the graphs of Figs 1a-c in the IMF can be written in the following form:

$$F_d = C\{ f_{NN}^{(1)}\, \Psi_d(x',p_t') + f_{NN}^{(2)}\, \Psi_d(x,p_t) + \mathcal{F}_d^{(3)} \}, \qquad (2)$$

where $C=(2(2\pi)^3)^{\frac{1}{2}}$ is the normalized coefficient /5/, $\Psi_d(x,p_t)$ is the relativistic deuteron wave function (WFD) related to the nonrelativistic WFD $\Psi_{n.r.}$ but depending on the invariant variable /9,10/ $K=\left(\frac{m^2+p_t^2}{4x(1-x)}-m^2\right)^{\frac{1}{2}}$, x', x and p_t', p_t are the light cone variables and the transverse momenta of the spectator and nonspectator protons, respectively; $f_{NN}^{(1)}$, $f_{NN}^{(2)}$ are the amplitudes of the N-N interaction corresponding to the graphs of Figs 1a,b; $\mathcal{F}_d^{(3)}$ is the amplitude corresponding to all graphs of Fig 1c type, it is calculated in the OPTh, as in Ref. /3/, but the relativisation of WFD was taken into account. The Raid's function with the soft core /11/ was used as the deuteron wave function. The spin structure of $NN \to NX$ and $NN \to \pi X$ reactions was neglected by the calculation of T_{20} using (1) and the inclusive proton spectrum, this is sufficiently correct at high energies. On this assumption there is not interference between the graphs of Figs 1a,b and 1c. The interference between the graphs of Fig. 1a and 1b was calculated supposing that in lower vertices of Figs 1a,b there are elastic N-N scatterings, as in Ref. /3/.

The calculation results of the proton spectrum of the reaction $dP \to PX$ and the value of $A=\sqrt{2}\,T_{20}$ and experimental data /12,1/ are represented as a function of the momentum of the proton emitted backward in the deuteron rest system. Curves 1 in these figures are the calculation results in the spectator mechanism, i.e. the contribution of only one graph of Fig. 1a; curves 2 are the results obtained with the inclusion of the Fig. 1a-c graphs. Fig. 2b shows the discrepancy of calculated curves 1 and 2 with the experimental data on T_{20} at $q \gtrsim 0.4$ (GeV/c) or $K \gtrsim 0.55$ (GeV/c). For this reason in some papers /2,10/ some addition to the deuteron wave function caused by the probable existence of the six quark state is introduced. But it was necessary for the successful description of the experimental data on T_{20} in the spectator mechanism frame that it was complex at the phase $\varphi = 55^\circ$ /2/. If the graphs of Figs 1a-c are taken into account then as the calculations have shown, the complex 6q-component will be necessary to describe the T_{20} experimental data at $q \gtrsim 0.4$ (GeV/c). Here the 6q-state was taken into account according to ref. /13/. This complexity contradicts the quantum-mechanical principles, because it is well known that a bound state particularly that of the deuteron, is described by a real function.

Fig.1



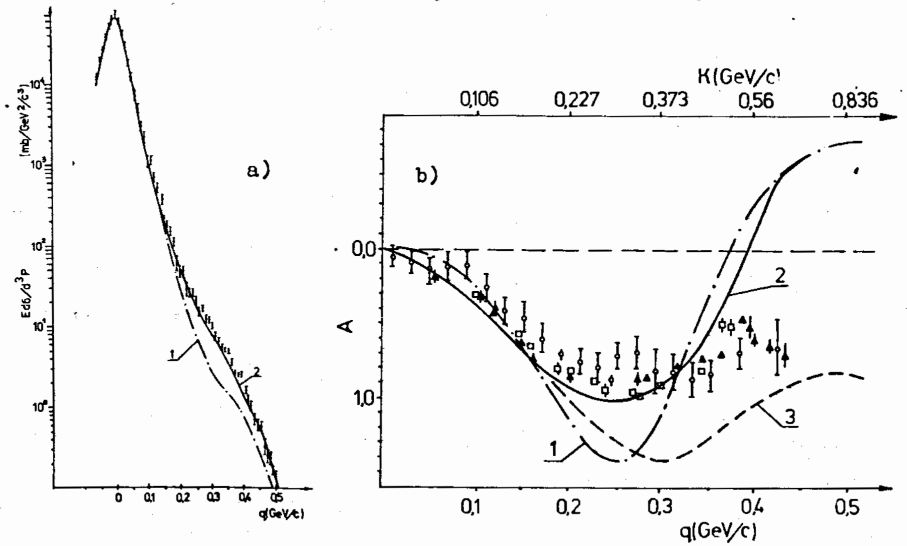


Fig.2

We think, therefore, that the discrepancy of calculated curve 2 with the T_{20} experimental data at $q \gtrsim 0.4$ (GeV/c) can't be a direct indication of the 6q-state existence in the deuteron.

The calculation results presented in Fig. 2a,b allow the following conclusions. It is just incorrect to use only the spectator mechanism, i.e. the Fig. 1a graph, for the analysis of the deuteron stripping type reaction. As is very clearly shown in Fig.2a, it is necessary to take into account the nonspectator type graphs of Fig. 1b,c at $0.15 \lesssim q \lesssim 0.5$ (GeV/c). Therefore the measurement of the proton inclusive spectrum in the discussed reactions is not the direct measurement of the square of the WFD. The contribution of the Fig. 1b,c graphs can't be considered as a small correction to the Fig. 1a graph at $q \gtrsim 0.15$ (GeV/c). The inclusion of the Fig. 1b,c graphs allows a much better description of the T_{20} experimental data at $q \lesssim 0.4$ (GeV/c). The great discrepancy between calculated curve 2 in Fig. 2b and the experimental data at large proton momenta,

$q > 0.4$ (GeV/c) can be due different causes, for example, because of the chosen method of the deuteron wave function relativization. So in Ref. /14/ another method is proposed for inclusion of the relativistic effects of the deuteron structure. In Fig. 2b the calculation result of T_{20} from Ref. /15/ is presented (see curve 3) in the frame of the spectator mechanism. It is shown that T_{20} values remain negative at large q or K. The comparison of curves 2 and 3 in Fig. 2b allows the following conclusion. The reaction mechanism must be taken into account more complectly at small q, $q \leqslant 0.4$ (GeV/c), i.e. the Fig. 1a-c graphs, but the relativisation effects of the deuteron vertex decay into two nucleons are very important at larger q or $K > 0.55$ (GeV/c). Different relativisation methods give different T_{20} behaviour at $q > 0.4$ (GeV/c).

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