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DISPERSION SUM RULES FOR DEUTERON DISINTEGRATION PROCESSES IN POLE APPROXIMATION

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Considering deuteron processes we look for such cases where super-convergent dispersion sum rules can be considered in a simple pole approximation. A nucleon pole appears in the $d\bar{N}$ -reactions, for instance in $d\bar{N} \to \pi N$ and $d\bar{N} \to \gamma N$ described by the t-channel of Fig. 1.

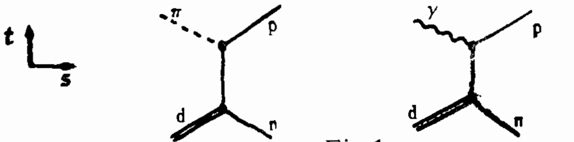

Fig.1.

while in the s-channel we have the corresponding deuteron disintegration processes. The N^*_{33} – resonance is forbidden because of I-spin invariance so that the nucleon pole alone should give a certain saturation. A first correction would be the inclusion of anomalous contributions coming from the deuteron-nucleon vertex. In the following we treat the photon reaction in more detail. The pion-reaction cannot give further results because of the simple structure of the $NN\pi$ – vertex.

Following Sakita and Goebel[1] and Le Bellac et al.[2] we write the total amplitude for the photodisintegration:

$$\langle p, p' | R | k, d \rangle = (2\pi)^4 \delta^{(4)}(p + p' - k - d) \left(\frac{m^2}{(2\pi)^6 \, 2E_\gamma E_d 2E_p E_{p'}} \right)^{1/2}$$

$$\times \bar{u}(p) M^{\mu\nu}(p, p'_i, k, d) \, i r_2 C \bar{u}^T(p') e_\mu u_\nu \qquad (1)$$

Fig.2.

Instead of the three independent momenta p, p' and k we use

$$q = \frac{1}{2}(p - p'), \quad Q = \frac{1}{2}(p + p'), \quad k. \qquad (2)$$

The decomposition into the independent kinematical invariants is

$$M^{\mu\nu} e_\mu U_\nu = \sum_{i=1}^{12} I_i(Q,q,k,e,U) H_i(s,t,u) \tag{3}$$

The twelve invariants I_i and their crossing symmetry sign $\epsilon(i)$ for $t \to u$ are listed in the table. This table also contains their asymptotic behaviour in the t-channel and the nucleon pole residua where A and B are the two form factors of the d-np vertex on mass shell, while μ_s and μ_v are the isoscalar and isovector magnetic moments respectively. The crossing relation is given by

$$H_i^{(I)}(s,t,u) = (-1)^I \epsilon(i) H_i^{(I)}(s,u,t) \tag{4}$$

($I = 0$ isoscalar part, $I = 1$ isovector part.) The dispersion sum rule[3,4] with fixed s

$$\int_{-\infty}^{\infty} \operatorname{Im} H_i^{(I)}(t,s)\, dt = 0 \tag{5}$$

gives non-trivial results for $(-1)^I \epsilon(i) = -1$. (6)

We assume that sum rules exist if the invariants behave asymptotically as t^2. $i=3,4$ we do not consider since in these cases kinematical singularities are present. Taking the pole approximation in (5) the resulting equations are

$$\begin{array}{llll} i=6 & \frac{1}{2} m B \mu_v = 0, & i=9 & \frac{1}{4} m B = 0, \\ i=7 & 0=0, & i=10 & \frac{1}{2}(A - m B)_{\mu_s} = 0. \\ i=10 & & & \end{array} \tag{7}$$

The solutions are $1.\ \mu_s = 0$, $2.\ B = 0$, $A \neq 0$.

The first relation is experimentally well satisfied and was already found by many authors[5] in other reactions.

Concerning the second result we remark that B is proportional to the d-state probability α for the deuteron ground state. In agreement with experiments one has found $\alpha = 0.07$[6]. Our result $\alpha = 0$ would be consistent with a pure $(^3S_1)$- deuteron ground state which seems to be not wrong in connection with our rough approximation. Further we have found that the sum rules for the pion reaction indicated in Fig.1. are in agreement with $B=0$.

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Table

i	I_i	$\epsilon_{(i)}$	α	nucleon pole residua
1	$(2m)^{-1}\{(eq)(uk)-(eu)(qk)\}$	+	1	$\frac{1}{2}mB$
2	$(2m)^{-1}\{(eu)(Qk)-(eQ)(uk)\}$	-	0	$-mB(\frac{1}{2}+\mu_k)$
3	$m^{-4}\{(eq)(Qk)-(eQ)(qk)\}(uq)$	-	2	$-\frac{1}{2}mB\,m^2/(Qk)$
4	$m^{-3}\{(eQ)(qk)-(eq)(Qk)\}i(\gamma u)$	-	2	$\frac{1}{2}Am^2/(Qk)+\frac{1}{2}mB\mu_k$
5	$\frac{1}{2}m^{-1}\{(uk)i(\gamma e)-(eu)\,i(\gamma k)\}$	+	1	$A(\frac{1}{2}+\mu_k)$
6	$\frac{1}{2}m^{-3}\{(Qk)i(\gamma e)-(eQ)i(\gamma k)\}(uk)-m^{-3}\{(qk)i(\gamma e)-(qe)i(\gamma k)\}(uq)$	+	2	$\frac{1}{2}mB\mu_k$
7	$\frac{1}{2}m^{-3}\{(qk)i(\gamma e)-(qe)i(\gamma k)\}(uk)+m^{-3}\{(Qk)i(\gamma e)-(Qe)i(\gamma k)\}(uq)$	-	2	0
8	$\frac{1}{4}m^{-2}[\gamma k,\gamma e](uk)$	+	1	$-\frac{1}{2}mB(\frac{1}{2}+\mu_k)$
9	$\frac{1}{2}m^{-2}[\gamma k,\gamma e](uq)$	-	2	$\frac{1}{4}mB$
10	$\frac{1}{2}m^{-2}\{(qk)[\gamma e,\gamma u]-(eq)[\gamma k,\gamma u]+2(eQ)(uk)-2(eu)(Qk)\}$	-	2	$\frac{1}{2}(A-mB)\mu_k$
11	$\frac{1}{2}m^{-2}\{(Qk)[\gamma e,\gamma u]-(eQ)[\gamma k,\gamma u]+2(eq)(uk)-2(eu)(qk)\}$	+	1	$\frac{1}{2}A\mu_k$
12	$\frac{1}{2}m^{-1}\{\epsilon^{\mu\nu\rho\tau}k_\rho\gamma_\tau\gamma_5 e_\mu u_\nu$	-	1	$-\frac{1}{2}A-(A-q^2\frac{B}{m})\mu_k$

The $\epsilon(i)=\pm1$ give the crossing behaviour of the listed invariants I_i which we have taken from ref.(2). In the t-channel the invariants have a asymptotic behaviour $\sim t^\alpha$. μ_k denotes μ_v in the isovector and μ_s in the isoscalar case. The given residua are the factors of $[(t-m^2)^{-1}+(-1)^I\epsilon(i)(u-m^2)^{-1}]$ in the nucleon pole contribution.