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AN UNAMBIGUOUS WAY OF AN ESTIMATION OF VECTOR-MESON-NUCLEON TENSOR COUPLING CONSTANTS

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By treating the vector-meson resonances as point-like stable particles in some approximation, which are described by a field operator $\vec{V}_\mu(x)$, the vector-meson-nucleon coupling of the form

$$L_{VNN} = i g_{VNN} \bar{\Phi}_N \gamma_\mu 1/2 \vec{\tau} \phi_N \vec{V}_\mu + \frac{t_{VNN}}{2m_N} \bar{\Phi}_N \sigma_{\mu\nu} 1/2 \vec{\tau} \phi_N (\partial_\mu \vec{V}_\nu - \partial_\nu \vec{V}_\mu) \qquad (1)$$

with the so-called vector g_{VNN} and tensor t_{VNN} coupling constants is usually constructed from symmetry principles in meson field theory [1-3]. The coupling constants g_{VNN} and t_{VNN} have been evaluated numerically (for a review see Ref.[4]) in an analysis of πN and NN scattering and in an optimal description of the nucleon electromagnetic (e.m.) form factor (ff) data. Nevertheless, the agreement between the results of different methods (see e.g.Table 9.2 in Ref.[4]) was poor and, unexpectedly, it did not improve as the input data became more and more accurate. Therefore in this paper we propose a new unambiguous way of estimates at least of t_{VNN} which methodically differs from all previous ones and finally it can prefer some of the values presented in Table 9.2 of Ref.[4].

The method consists in an employment of a vector-meson-dominance (VMD) parametrization of isoscalar and isovector Pauli nucleon e.m. ff's [5]

$$F_2^{(s)}(t) = \sum_{s=\omega,\phi,\phi'} \frac{m_s^2 (t_{sNN}/f_s)}{m_s^2 - t} \qquad (2a)$$

$$F_2^{(v)}(t) = \sum_{v=\rho,\rho',\rho''} \frac{m_v^2 (t_{vNN}/f_v)}{m_v^2 - t} \qquad (2b)$$

where $t = -Q^2$ is the four-momentum transfer squared, "m" is the mass of a vector meson under consideration and f_V is the universal vector-meson coupling constant determining the lepton width of a vector meson as follows

$$\Gamma(V \to e^+e^-) = (\alpha^2 m_V /3)(f_V^2/4\pi)^{-1}. \qquad (3)$$

The sums in (2a) and (2b) are saturated with only well established isoscalar and isovector mesons with quantum numbers of the photon, respectively.

The resonances $\rho(770)$, $\omega(783)$ and $\phi(1020)$, given by the Review of Particle Properties [6], are taken into account without any discussion. The $\phi'(1680)$ meson, though in [6] it is declared as a not well established resonance, however, just after a new experimental study [7] of the reaction $e^+e^- \to K^+K^-$ in the energy range 1350 MeV $\leq \sqrt{t} \leq$ 2400 MeV there is no doubt [8] in its existence now. Finally, $\rho'(1450)$ and $\rho''(1700)$ have been quite well confirmed [9-13] as the first and second radial excitations of the $\rho(770)$ meson in the recent analysis of various processes.

Then by transforming (2a) and (2b) to a common denominator separately and forcing the resultant expressions to have the QCD (up to log-corrections) asymptotic behaviour [14,15] $F_2^{(s)}(t) \equiv F_2^{(v)}(t) \to t^{-3}|_{|t|\to\infty}$ and also normalizations (see e.g. Ref.[5]) $F_2^{(s)}(0) = 1/2[\mu_p+\mu_n]$, $F_2^{(v)}(0) = 1/2[\mu_p-\mu_n]$, the following two systems of closed algebraic equations

$$\begin{gathered}(t_{\omega NN}/f_\omega)m_\omega^2(m_\phi^2+m_{\phi'}^2)+(t_{\phi NN}/f_\phi)m_\phi^2(m_\omega^2+m_{\phi'}^2)+(t_{\phi' NN}/f_{\phi'})m_{\phi'}^2(m_\omega^2+m_\phi^2)=0\\ (t_{\omega NN}/f_\omega)m_\omega^2 + (t_{\phi NN}/f_\phi)m_\phi^2 + (t_{\phi' NN}/f_{\phi'})m_{\phi'}^2 = 0 \qquad (4)\\ (t_{\omega NN}/f_\omega) + (t_{\phi NN}/f_\phi) + (t_{\phi' NN}/f_{\phi'}) = 1/2[\mu_p+\mu_n]\end{gathered}$$

$$\begin{gathered}(t_{\rho NN}/f_\rho)m_\rho^2(m_{\rho'}^2+m_{\rho''}^2)+(t_{\rho' NN}/f_{\rho'})m_{\rho'}^2(m_\rho^2+m_{\rho''}^2)+(t_{\rho'' NN}/f_{\rho''})m_{\rho''}^2(m_\rho^2+m_{\rho'})=0\\ (t_{\rho NN}/f_\rho)m_\rho^2 + (t_{\rho' NN}/f_{\rho'})m_{\rho'}^2 + (t_{\rho'' NN}/f_{\rho''})m_{\rho''}^2 = 0 \qquad (5)\\ (t_{\rho NN}/f_\rho) + (t_{\rho' NN}/f_{\rho'}) + (t_{\rho'' NN}/f_{\rho''}) = 1/2[\mu_p-\mu_n]\end{gathered}$$

are obtained. from which the coupling constants t_{VNN} can be found. These are deduced by the solutions of (4) and (5), using masses of the $\rho(770), \omega(783), \phi(1020), \phi'(1680)$ and anomalous magnetic moments of the proton μ_p and the neutron μ_n from the Review of Particle Properties [6], and masses of the $\rho'(1450)$ and $\rho''(1700)$ mesons from the paper by Donnachie and Mirzaie [9]. Numerical values of the universal ρ, ω, ϕ -meson coupling constants

$$f_\rho=4.9905\pm0.1089; \quad f_\omega=17.0550\pm0.2990; \quad f_\phi=12.8866\pm0.2368; \qquad (6)$$

are obtained from the corresponding lepton widths [6].

The lepton width of $\phi'(1680)$ is, however, not established (see Ref.[6]) experimentally. Therefore the value

$$f_{\phi'} = 27.9030 \pm 1.5978 \qquad (7)$$

has been estimated from measured combinations of several partial widths with the partial width of decay into e^+e^- and the total width (see Ref.[6]), by neglecting $K_s^0 K\pi$ and 3π channels at the same time. The universal ρ', ρ'' -meson coupling constants

$$f_{\rho'} = 13.6491\pm0.9521; \qquad f_{\rho''} = 22.4020\pm2.2728 \qquad (8)$$

have been found from lepton widths estimated by Donnachie and Clegg [16].

As a result, the following numerical values of the vector-meson-nucleon tensor coupling constants are obtained

$$\begin{array}{ll} t_{\omega NN} = -3.1739\pm0.0756; & t_{\rho NN} = 16.0744\pm1.7595; \\ t_{\phi NN} = 1.7461\pm0.0522; & t_{\rho' NN} = 37.5100\pm9.0783; \\ t_{\phi' NN} = -0.2651\pm0.0188; & t_{\rho'' NN} = 30.9170\pm7.\text{[illegible]}626; \end{array} \qquad (9)$$

where the errors have been evaluated from errors of all other quantities appearing in eqs.(4) and (5). For comparison of our results with values estimated by other authors see Table .

One finds there an unexpected agreement between (9) and phenomelogical estimates by Höhler et al [17,18], besides the value of $t^2_{\rho' NN}/4\pi$. However, the latter corresponds to an unexisting resonance $\rho'(1250)$ used in Höhler's nucleon e.m. ff analysis, now.

In conclusion we would like to emphasise that the unambiguous confirmation of Höhler's results on $t_{\rho NN}$ declared in Table particularly supports the conclusion of a recent paper by Weber [19] that relativistic effects in the constituent quark model of hadrons are large enough.

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Table

V	$t^2_{VNN}/4\pi$	Ref.
$\omega(783)$	0.8016±0.0382	this work
	≈ 1	[18]
	1.46	[20]
	0.16±0.45	[21]
$\phi(1020)$	0.2426±0.0145	this work
	0.2	[18]
$\phi'(1680)$	0.0056±0.0008	this work
$\rho(770)$	20.5617±4.5014	this work
	20.5±2.1	[17]
	10.92	[22]
	15.00	[20]
$\rho'(1450)$	111.9655±54.1966	this work
$\rho''(1700)$	76.0650±35.7363	this work

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