FIZIKA 10 (1978) 159 – 162 YU ISSN 0015 – 3206

CONTRIBUTION OF THE ψ(3,1) PARTICLE TO THE ELECTROMAGNETIC STRUCTURE OF NUCLEONS*

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RECEIVED 1 FEBRUARY 1978

In order to estimate the possible contribution of the recently discovered higher-mass vector meson ψ(3,1) to the electromagnetic structure of nucleons, we make an attempt in this paper to incorporate ψ(3,1) into the previously developed[1)] extended vector dominance model (VDM) of nucleon form factors. The VDM provides a good framework for treating various strong-interaction phenomena. In particular, the problem of nucleon electromagnetic form factors was expected to be treated within such models with reasonably accuracy. However, with only three vector mesons established – ρ, ω, ϕ – it was not possible to fit experimental data. It was shown in Ref. 1 that the full structure of nucleon form factors can be fitted using a model with six vector mesons. Dynamical constraints in the form of asymptotic conditions

$$tG(t) \to 0 , \quad t \to \infty \tag{1}$$

were assumed to be equally valid for all four Sachs form factors $G^{p,n}_{E,M}(t)$.

*Work supported by the RZNR of SRBiH.

In the previous paper[1], only four vector mesons ρ, ω, ϕ and $\rho''(1600)$ were used.

The discovery of heavier vector mesons $\psi(3,1)$ and $\psi(3,7)$ led us to reanalyze the six-pole model.

If applied to the Dirac and Pauli form factors, the condition (1) correlates the parameters entering the model, so that a two-parametric description is obtained

$$G_E(t) = [\tfrac{1}{2} + \frac{t}{4m^2}(\mu^S + 2m^2 b^S)]R^S(t) \pm$$

$$\pm [\tfrac{1}{2} + \frac{t}{4m^2}(\mu^V + 2m^2 b^V)]R^V(t) ,$$

$$G_M(t) = [\tfrac{1}{2} + \mu^S + \tfrac{1}{2} b^S t]R^S(t) \pm$$

$$\pm [\tfrac{1}{2} + \mu^V + \tfrac{1}{2} b^V t]R^V(t) .$$

Here the signs + and - correspond to the proton and the neutron, respectively, and b^S and b^V are free parameters. The following abbreviations have been introduced:

$$R^S(t) \equiv (1-t/t_\omega)^{-1}(1-t/t_\phi)^{-1}(1-t/t_{\omega'})^{-1} ,$$

$$R^V(t) \equiv (1-t/t_\rho)^{-1}(1-t/t_{\rho'})^{-1}(1-t/t_{\rho''})^{-1} ,$$

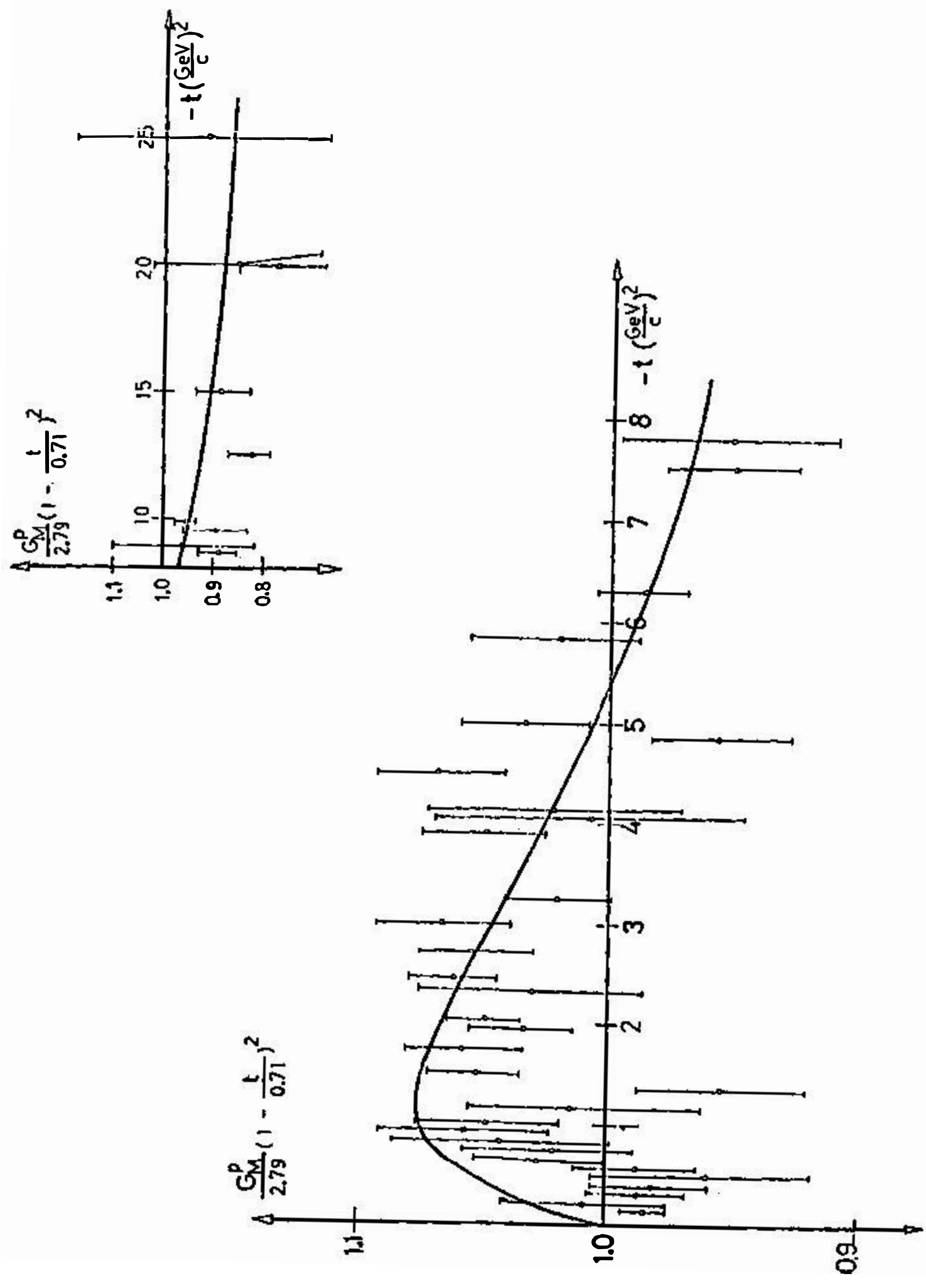
where

$$t_\omega = m_\omega^2 , \quad t_\phi = m_\phi^2 , \quad t_{\omega'} \equiv m^2_{\psi(3,1)} ,$$
$$t_\rho = m_\rho^2 , \quad t_{\rho'} = m^2_{\rho(1259)} , \quad t_{\rho''} = m^2_{\rho\ (1650)} .$$

Using the values of masses from Ref. 2 as input, we made a direct comparison with the available experimental data compiled in Ref. 1.

The results of fitting shown in Fig. 1 correspond to the following values of parameters (in GeV^{-2})

$$b^S = -0.02 , \qquad b^V = -1.15 .$$


$\frac{G_M^P}{2.79}(1-\frac{t}{0.71})^2$
$-t\,(\frac{GeV}{c})^2$
1.1
1.0
0.9
0.8
10
15
20
25
$\frac{G_M^P}{2.79}(1-\frac{t}{0.71})^2$
$-t\,(\frac{GeV}{c})^2$
1.1
1.0
0.9
1
2
3
4
5
6
7
8

The fitting was made by the standard procedure described in Ref. 1. The values of vector meson-nucleon coupling constants were estimated to be

$$\frac{g^{(2)}_{\rho N\bar{N}}}{g^{(1)}_{\rho N\bar{N}}} = 11.33 \; , \quad \frac{g^{(2)}_{\rho' N\bar{N}}}{g^{(1)}_{\rho' N\bar{N}}} = -5.09 \; , \quad \frac{g^{(2)}_{\rho'' N\bar{N}}}{g^{(1)}_{\rho'' N\bar{N}}} = -2.61 \; ,$$

$$\frac{g^{(2)}_{\omega N\bar{N}}}{g^{(1)}_{\omega N\bar{N}}} = -0.12 \; , \quad \frac{g^{(2)}_{\phi N\bar{N}}}{g^{(1)}_{\phi N\bar{N}}} = -0.12 \; , \quad \frac{g^{(2)}_{\psi N\bar{N}}}{g_{\psi N\bar{N}}} = -0.16 \; .$$

Comparison shows that the above values do not differ markedly from those of other authors[3] in the case of ω and ϕ ; in the case ρ, however, our estimate is considerably different.

We may conclude that the EVD model[1] with $\psi(3,1)$ incorporated, is more predictive in the sense that the number of free parameters has been reduced by two. The agreement with experimental data is still satisfactory.

We are grateful to Professor N. Zovko for valuable suggestions in this work.

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