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Magnetic-Transition Form Factor of the Δ(1236) in a Veneziano-Type Representation

C. A. Dominguez
Departmento de Física, Centro de Investigación y de Estudios Avanzados del Instituto Politecnico Nacional, Apdo. Postal 14-740, Mexico 14, D.F.
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A Veneziano-type expression is proposed for the magnetic-transition form factor of the Δ(1236). The agreement with present experimental data up to $-t = 2.34$ (GeV/c)^2 is found to be quite satisfactory.

In the past few years many efforts have been devoted to the study of Veneziano three-point functions. As a result of this it is now established that for a photon-hadron-hadron vertex a typical form factor can be represented by

$$F(t)=C\,\frac{\Gamma(1-\alpha_\rho(t))}{\Gamma(n-\alpha_\rho(t))}\,, \qquad (1)$$

where $\alpha_\rho(t)\sim 0.5+t$ is the ρ-meson Regge trajectory, C a normalization factor, and n a half-integer number that determines the correct asymptotic behavior of $F(t)$. Very satisfactory agreement with the experimental data has been obtained in the case of the pion,[1] nucleon,[2] K_{l3} decay,[3] and kaon[4] form factors. Moreover, it has been shown recently[5] that a Veneziano-type $NN\pi$ vertex function can account, in order of magnitude, for the corrections to the Goldberger-Treiman relation. Finally, we mention that an expression like Eq. (1) has been obtained for the pion electromagnetic form factor as a possible solution of the Omnés equation when the Veneziano formula for $\pi\pi$ scattering is used as an input.[6]

The physical picture behind Eq. (1) is indeed quite simple and appealing, i.e., the form factor is built up from the contribution of an infinite number of equally spaced poles. In other words the photon couples not only to the ρ meson but to all its (infinite) daughters. In a way this is like a generalization of the vector-meson-dominance model (ρ dominance). The recent discovery of the ρ' meson[7] lends further support to the above-mentioned picture.

The purpose of the present paper is to show that an expression like Eq. (1) can also represent quite well the Δ(1236) magnetic-transition form factor $G_M^*(t)$.

The available data[8-11] for $G_M^*(t)$ go up to $t=-2.34$ (GeV/c)^2 and there are more than 30 points. The most popular expression that fits the data well is the Gutbrod-Simon formula[12]

$$\frac{G_M^*(t)}{G_M^*(0)}=\frac{G_M^N(t)}{G_M^N(0)}\gamma_N\left(\frac{1}{1-t/\Omega_1^2}\right)+F_\pi(t)\gamma_\pi\left(\frac{1}{1-t/\Omega_2^2}\right), \qquad (2)$$

where $G_M^N(t)$ is the magnetic form factor of the nucleon, $F_\pi(t)$ is the pion form factor, and γ_N, γ_π, Ω_1^2 and Ω_2^2 are adjustable parameters. Using the dipole fit for $G_M(t)$, and for $F_\pi(t)$ the expression

$$F_\pi(t)=\frac{1}{1-t/m_\rho^2}\,,$$

and $\gamma_N=0.85$, $\gamma_\pi=0.15$, $\Omega_1^2=2.72$ (GeV/c)^2, and $\Omega_2^2=0.97$ (GeV/c)^2, a quite good agreement with experiment is obtained. As can be seen from Eq. (2), $G_M^*(t)$ falls faster than $G_M^N(t)$ and $F_\pi(t)$ by one power of t.

The starting point of our model is the Veneziano-type expression for[2] $G_M(t)$

$$G_M(t)=C\,\frac{\Gamma(1-\alpha_\rho(t))}{\Gamma(\frac{7}{2}-\alpha_\rho(t))}\,, \qquad (3)$$

which fits the present data very well up to $t=-25$ (GeV/c)^2.

In analogy with Eq. (3) we propose the following formula for $G_M^*(t)$:

$$\frac{G_M^*(t)}{G_M^*(0)} = \frac{\Gamma(n-\frac{1}{2})}{\sqrt{\pi}} \frac{\Gamma(1-\alpha_\rho(t))}{\Gamma(n-\alpha_\rho(t))} . \qquad (4)$$

The single free parameter n is fixed by requiring that

$$\frac{G_M^*(t)}{G_M^N(t)} \underset{t\to-\infty}{\sim} \frac{1}{t} ,$$

according to the trend of the present data. Hence $n=\frac{9}{2}$ and

$$\frac{G_M^*(t)}{G_M^*(0)} = \frac{6}{\sqrt{\pi}} \frac{\Gamma(1-\alpha_\rho(t))}{\Gamma(\frac{9}{2}-\alpha_\rho(t))} . \qquad (5)$$

In Fig. 1 we show the prediction of Eq. (5) compared with the experimental points, and the agreement is indeed seen to be quite good. In fact, the difference between the results of Eq. (5) and those of the Gutbrod-Simon formula [Eq. (2)] are rather small (typically less than 2–3%).

We have provided one more example in which a Veneziano three-point function can represent successfully a form factor. Though in general the predictions do not improve the dipole-type results, the obvious advantage is that Eq. (1) constitutes a general expression, with a single free parameter,[13] for any photon-hadron-hadron vertex function with a very appealing physical background.

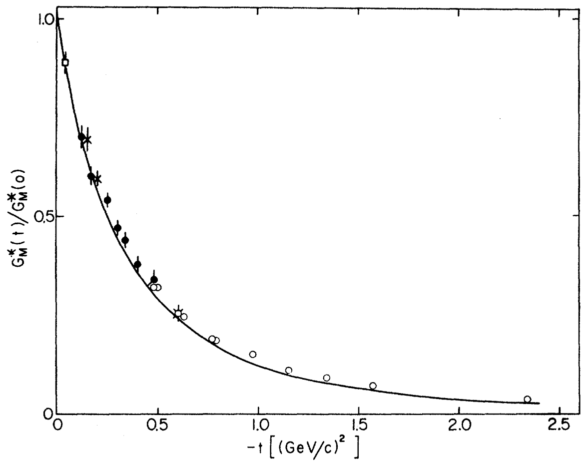

FIG. 1. Experimental data for $G_M^*(t)$ normalized as usual to $G_M^*(0)=3$. □ Ash *et al.* (Ref. 8); ○ Bartel *et al.* (Ref. 9); ● Bleckwenn *et al.* (Ref. 10); X Bätzner *et al.* (Ref. 11). The solid curve is the prediction of Eq. (5). When two or more points overlapped only one was drawn.

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