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THE REACTION $\gamma p \to \eta p$ AND THE DIP MECHANISM IN PHOTOPRODUCTION

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It is usually assumed that the amplitudes of the photoproduction of π^0 and η mesons on nucleons, $\gamma N \to \pi^0 N$ and $\gamma N \to \eta N$, are determined mainly by the contributions of the Regge poles of the ω and ρ mesons. The cross sections of both reactions (we have in mind the "nuclear part," excluding the Primakoff effect) have characteristic "dips," a fact naturally attributed to the vanishing of the residues of the ω and ρ poles as $t \to 0$. In addition, the cross section for π^0-meson photoproduction has a dip at $t \simeq -0.55$, which is well described [1] by the "nonsense" factor α in the residues of the ω and ρ poles. However, on going over to the η-meson photoproduction (the cross section of which has no dip at $t \simeq -0.55$), it is necessary to resort [2] to the artificial assumption that there is no factor α in the residues of the ω and ρ poles in the amplitude of the reaction $\gamma N \to \eta N$. As to the photoproduction of the π^0 mesons, in this case the inclusion of the factor α leads to contradictions. At $t \simeq -0.55$, where $\alpha \simeq 0$, the contributions of ω and ρ vanish, and the filling of the dip is due to the contribution of the B-meson pole, which leads, in contradiction to the experiment, to a deepening of the dip with increasing E and to a change in the sign of the asymmetry [1].

It was shown in [3] that the discrepancies with the experimental data on the photoproduction of π^0 mesons can be eliminated by assuming that the trajectories of the ω and ρ mesons become complex at $t < 0$ [4]. We shall show in this paper that when these very same assumptions are made for the photoproduction of η mesons it becomes possible to eliminate the contradiction and to reconcile the presence of the factor α in the residue of the poles with the absence of a dip in the cross section at $t \simeq -0.55$.

Since there are no polarization data at present, and only the differential cross section of the photoproduction of η on a proton has been measured, we shall use the simplest model that suffices to describe these data. We shall take into account only the contributions of the ω-meson pole. The contribution of the ω meson can be estimated by using the relations of SU(3) symmetry; however [3, 5], SU(3) gives an incorrect prediction for the ratio $[d\sigma(n)/dt]/[d\sigma(p)dt]$ in the reaction $\gamma N \to \pi^0 N$ (possibly owing to the violation of the factorization of the effective residues [6, 7]), and we do not consider it advisable to take into account the contribution of ω in the absence of data on the reaction $\gamma N \to \eta N$.

Out of the four helicity amplitudes describing the process $\gamma p \to \eta p$, we take into account only one, which we parametrize in the following manner [4, 7]:

$$-\frac{2}{k_t\sqrt{t}}\bar{f}^{+}_{\frac{1}{2}\frac{1}{2}10} = 2m\frac{i}{s}\left(a\alpha e^{-\frac{i\pi\alpha}{2}}s^{\alpha} + a^*\alpha^* e^{-\frac{i\pi\alpha^*}{2}}s^{\alpha^*}\right). \quad (1)$$

Here $a = |a|\exp(i\phi)$ is the complex residue and $\alpha = \alpha_R + i\alpha_I$ is the complex trajectory corresponding to the ρ meson. Assuming "universality" of the complex trajectories [7, 8], we use for $\alpha(t)$ the value obtained earlier [9] from an analysis of the reaction $\pi^- p \to \pi^0 n$:

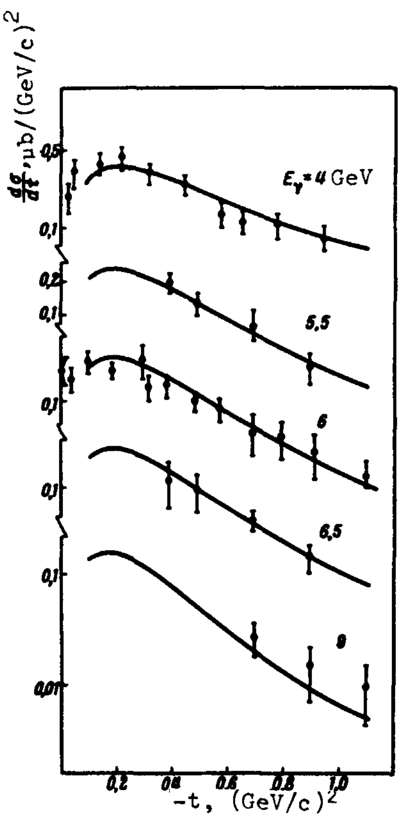
$$\alpha(t) = 0{,}55 + t + \frac{i}{2}\sqrt{\frac{t}{t - 4\mu^2}} \quad . \tag{2}$$

Since $\alpha_I \to 0$ as $t \to 0$ and we arrive at a real pole at $t = 0$, it is necessary to have also $\phi(0) = 0$. This condition can be satisfied by putting

$$\phi(t) = C\alpha_I(t) \, . \tag{3}$$

Thus, the model contains two unknown parameters, a and C, which can be obtained for a comparison with the data on the cross section of the process $\gamma p \to \eta p$:

$$\frac{d\sigma}{dt} = 4\pi t \, s^{2(\alpha_R - 1)} |a\alpha|^2 \Big\{ ch\, \pi\alpha_I + \cos\left(2\phi + 2\,\mathrm{arc\,tg}\,\frac{\alpha_I}{\alpha_R} + 2\alpha_I \ln s\right)\Big\}. \tag{4}$$



The factor $|\alpha|^2$ has a minimum at $t = -0.55$ and leads to a dip in the cross section. However, as shown by calculations, this dip can be compensated for, with a suitable choice of the phase ϕ, by the behavior of the cosine in the curly brackets, due to the t-dependence of the quantity $\tan^{-1}(\alpha_I/\alpha_R)$. A good description of the experimental data of [10] (see the figure) can be obtained for $|a|^2 = 3$ and $C = -5.2$.

In spite of the fact that the effective residues of the complex Regge poles takes into account the contributions of the cuts [4], the model does not reduce simply to addition of contributions of the cuts to contributions of the real poles, and contains specific features connected with the complexity of the trajectories. Thus, the parametrization found by us differs both from the model that takes into a ccount "strong" cuts [2], in which the factor α is artificially excluded, and also from the model with a "weak" cut [11], in which the contribution of a B meson from an unusually high trajectory must be taken into account in order to fill the dip. In our case the factor α is retained for the reaction $\gamma N \to \eta N$, just as for the reaction $\gamma N \to \pi^0 N$, and the filling of the dip is due to the contribution of the ρ meson itself, since $|\alpha|^2 \neq 0$ for $\alpha_I \neq 0$ at $t = -0.55$, where $\alpha_R = 0$.

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NOTE ON SEARCHES FOR INTERMEDIATE BOSONS

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Experimental searches for intermediate bosons of weak interactions are being planned for all the new high-energy accelerators. The main method for their observation is assumed to be detection of their decay, which correspond to the presently well-known leptonic and hadronic weak reactions in the current - virtual boson - current scheme. In view of the particular importance of the problem, it pays to call attention to the fact that the character of this correspondence between the picture of the decays of real intermediate bosons and the known weak interactions may be appreciably altered if one uses not the generally accepted theory of universal interaction but a "multicurrent" theory of weak interactions of the Gell-Mann - Goldberger - Kroll - Low type [1]. It will be shown here that in this case there appears a unique possibility of an appreciable difference between the intensities of the "diagonal" and "nondiagonal" reactions of the current - real boson - current type. This difference is analogous to the previously indicated [1] difference for current-current reactions with virtual intermediate bosons. In conclusion, another alternative possibility is also indicated.

We consider the simplest multicurrent model of weak interactions of charged currents in the first approximation of perturbation theory, starting from a Lagrangian of the type

$$L = g \sum_{k=0}^{N} J_k X_k + \text{h.c.} \qquad J_k \equiv \sum_{i=1}^{N+1} \epsilon_i^k j_i \, , \tag{1}$$

$$\epsilon_i^0 = 1, \qquad i = 1, 2, \dots (N+1), \tag{2}$$

where the 4-vector indices of the currents and the fields have been omitted; g and ϵ_i^k are real parameters, and j_i are different leptonic and hadronic current elements (both the well-known (V - A) elements of the type $e\gamma_\alpha(1 + \gamma_5)\nu_e$ etc., and possibly some that are still unknown, see below), and (N + 1) is their total number. Here X_k are local operators of intermediate boson fields, which, following [1], we shall assume to be certain superpositions of vector and scalar fields. Unlike [1], in the zeroth approximation in the interaction (1), the mass matrix of the intermediate bosons is assumed here to be diagonal. We stipulate that in the approximation where all the masses of the intermediate bosons are equal, the nondiagonal interactions of the current j_i