The author thanks M.Ya. Amus'ya and L.A. Sliv for discussions, and L.D. Faddeev for interest in the work.

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DIFFRACTION PRODUCTION OF A_1 MESON

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Submitted 29 May 1972
ZhETF Pis. Red. 16, No. 1, 54 - 57 (5 July 1972)

The problem of diffraction reactions and the role played in them by the pomeron (P) has recently attracted special interest. In particular, there is no explanation for the smallness of the diffraction-dissociation (DD) cross sections (~100 μb, whereas the corresponding elastic cross sections equal 4-6 mb). It is natural to explain these and other properties of DD by means of a conservation law that distinguishes the vertices of the diffraction production from the elastic vertices. This circumstance agrees with the presence of a structure in the differential distribution in dissociative production, for example in the production of N*(1400) and A_1(1080) one observes sharp forward peaks [1] with slopes 12 - 15 GeV^{-2} at small t. These properties of the DD can be explained within the framework of the tensor dominance model (TDM) [2], according to which the vertices of the pomeron and of the f meson are proportional to the corresponding matrix elements of the energy-momentum tensor, and consequently satisfy the conservation law

$$(p_a - p_b)_\alpha < b \mid \theta_{\alpha\beta}(0) \mid a > = 0. \tag{1}$$

In a diffraction transition of a pion into the state A_J ($J^P = 1^+, 2^-, \ldots$), the form factors of this matrix element, which are important for reggeization, turn out to be proportional to $t = (p_a - p_b)^2$. For a spin J < 2, this is a kinematic consequence of (1). When $J \geqslant 2$, a factor t appears when account is taken of the ρ - f exchange degeneracy [3], and an analogous conclusion with allowance for the ω - f exchange degeneracy can be made also in the case of baryon vertices. We assume that the P- and f-Regge contributions are proportional [4]. Then the presence of t in the Regge residues leads to a suppression of the DD cross section by a factor $(bm_a^2)^{-2} \sim 10^{-2}$ in comparison with the elastic cross sections (the amplitudes are parametrized as usual: $T = Ae^{bt/2}$, $b \sim 10$ GeV^{-2}). At very high energies the model predicts a decrease of the DD cross sections like $\ln^{-3}s$ and the appearance of dips at t = 0. However, at the presently accessible medium energies (p_L = 10 - 30 GeV/c) an important role is played by the contribution made to the imaginary part of the production amplitude by the two-reggeon branch cuts (see Fig. 1).

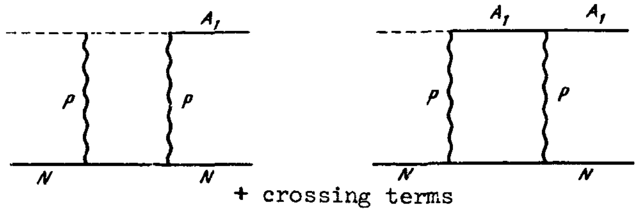

Fig. 1. Two-pomeron branch cuts.

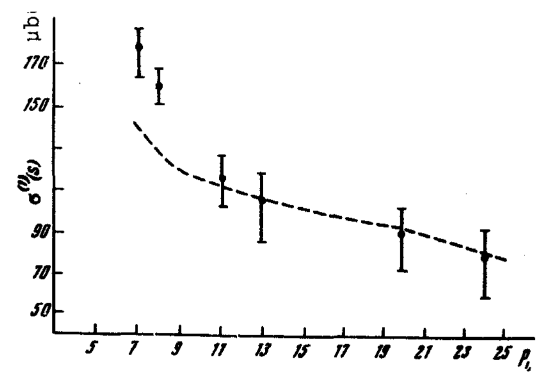

Fig. 2. Cross section of A_1 production. The dashed curve represents

$$-\frac{2}{(2m_A^2 b)^2}\left(\frac{g_S}{g_\rho}\right)^2 \frac{m_A}{m_\pi}\sigma^{(II)}(s)$$

Since the pole contributions are suppressed by the factor t, a very important role is assumed by the destructive interference between the pole contributions and the cuts, which leads to sharp peaks in the differential cross sections at $|t| < 0.1$, with a slope $\sim 2b$.

Let us consider from this point of view the reaction $\pi^{\pm}p \to A_1^{\pm}p$ (reaction I) at medium energies. The ρ – f exchange degeneracy leads here to a factor t in all the pole contributions. Therefore, just as in the elastic reaction, pomeron exchange predominates. Its residue can be obtained by assuming P – f proportionality and by specifying the decay constant A_1. Putting $g_D = 0$ and $\Gamma(A_1 \to \rho\pi) = 60$ MeV [5, 1] we can express the cross section of the reaction I in terms of the cross section of elastic $\pi^{\pm}p$ scattering (reaction II). This formula takes into account all the contributions:

$$\sigma^{I}(s) = \frac{1}{4m_A^2}\left(\frac{g_S}{g_{\rho\pi\pi}}\right)^2 \frac{m_A}{m_\pi}\int \frac{d\sigma^{II}}{dt} t^2\, dt = \frac{2}{[2m_A^2 b(s)]^2}\frac{m_A}{m_\pi}\left(\frac{g_S}{g_{\rho\pi\pi}}\right)^2 \sigma^{II}_{el}(s) . \quad (2)$$

The comparison with experiment is shown in Fig. 2. The experimental points are taken from [5, 8].

The imaginary part of the amplitude of $\pi^{\pm}p \to \pi^{\pm}\pi^{+}\pi^{-}p$ (reaction III) in the A_1 region, with allowance for rescattering, is given by

$$\mathrm{Im}\, T^{III} \approx \mathrm{Im}\, T^{I} = (7te^{bt/2} + e^{bt/4})\left[\frac{d\sigma^{I}}{dt}(t = 0)\right]^{1/2} . \quad (3)$$

The main contribution to the real part of T^{III} is made by the reggeized one-pion exchange [6], which is the background of the reaction I and is responsible for the majority of the total (80%) and differential (100% at $|t| \geq 0.15$) cross sections of the reaction III (see Fig. 3)

$$\frac{d\sigma^{III}}{dt} = \frac{d\sigma^{I}}{dt}(t = 0)\, e^{b_I t} + \frac{d\sigma^{OPE}}{dt}(t = 0)\, e^{b_{OPE} t} . \quad (4)$$

Figure 3 shows $d\sigma^{III}/dt$ at $p_L = 16$. The experimental data are taken from [1], $b_{OPE} = 6.5$ GeV^{-2}. The effective slope of the differential cross section of A_1 production, calculated from formula (3), yields $b_1 = 19$ GeV at $|t| \leq 0.05$. At a ratio $d\sigma^{OPE}(t = 0/d\sigma^{I}(t = 0) = 2$ [1], formula (4) results in very good agreement with experiment. The total slope of (4) at $|t| \leq 0.05$ is 11 GeV^{-2} (experiment [1] yields 11.5 ± 1 GeV^{-2}). Here

$$\frac{d\sigma^{I}}{dt}(t = 0) \approx 1.2 \text{ mb/GeV}^2, \quad \frac{d\sigma^{OPE}}{dt}(t = 0) \approx 2.4 \text{ mb/GeV}^2$$

and the total cross section of reaction III is of the order of 500 μb, which is in agreement with experiment [1].

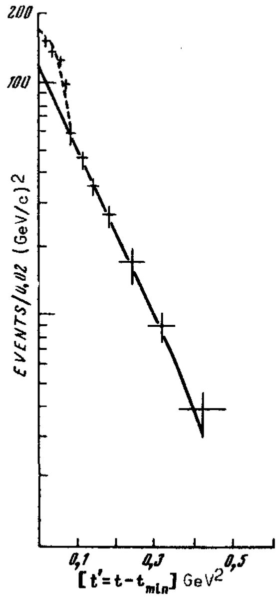

Fig. 3. Differential cross section of $\pi^- p \to \pi^-\pi^+\pi^- p$. Dashed curve - cross section at $|t'| \leq 0.15$. Solid curve - one-pion-exchange cross section [6].

We note in conclusion that an analogous comparison with the experimental data on diffraction production of $N^*_{1/2}$ is complicated to a considerable degree by the fact that, in addition to the already mentioned effects, an appreciable contribution can be made by Regge poles not connected with the f-meson exchange degeneracy in the baryon vertices (for example, ρ). The qualitative picture may correspond in this case to that considered in [7].

We are grateful to V.M. Budnev and I.F. Ginzburg for a discussion.

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DO THE EXPERIMENTS WITH SOLAR NEUTRINOS POINT TO THE EXISTENCE OF A RESONANCE IN THE $He^3 + He^3$ SYSTEM?

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Submitted 30 May 1972
ZhETF Pis. Red. 16, No. 1, 58 - 60 (5 July 1972)

In their last series of experiments, Davis et al. [1], who registered neutrino fluxes from the sun with the aid of the reaction $Cl^{37}(\nu, e^-)Ar^{37}$, revealed a noticeable deviation from the predictions of the theory of solar evolution. The experimental counting rate of the Ar^{37} atoms is $(1.5 \pm 1) \times 10^{-36}$ sec^{-1} per Cl^{37} atom. The corresponding theoretical value obtained in the most realistic model of the sun for the product of the neutrino flux φ, averaged over the particle spectrum by the cross section of the reaction $Cl^{37}(\nu, e^-)Ar^{37}$