[6] D. Redfild and M.A. Afromovitz, Appl. Phys. Lett. 11, 138 (1967).
[7] B.I. Shklovskii and A.L. Efros, Zh. Eksp. Teor. Fiz. 59, 1343 (1970) [Sov. Phys.-JETP 32, 733 (1971)].
[8] Yu.N. Berozashvili, A.V. Dundua, and D.Sh. Lordkipanidze, Fiz. Tverd. Tela 13, 3172 (1971) [Sov. Phys.-Solid State 13, No. 10 (1972)].
[9] V.K. Subashiev and G.A. Chalikyan, ibid. 11, 2495 (1969) [11, 2014 (1970)].
[10] R.M. Akopyan, Yu.N. Berozashvili, A.V. Dundua, and D.Sh. Lordkipanidze, in press.
[11] V.S. Bagaev, Yu.N. Berozashvili, and L.V. Keldysh, ZhETF Pis. Red. 9, 185 (1969) [JETP Lett. 9, 108 (1969)].

COMPLEX REGGE POLES AND NEW APPROACH TO THE PROBLEM OF ALLOWANCE FOR THE CONTRIBUTIONS OF THE CUTS

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A number of authors have shown recently [1, 2] that the existing models of Regge cuts do not satisfy the limitations that follow from a wide range of experimental data and certain general notions concerning the mechanism of scattering at high energies. In this connection, attempts to improve these models and to find new approaches become particularly important.

We show in this article that a new approach to the problem of accounting for the cut contribution can be formulated on the basis of complex Regge poles (CRP) [3 - 6] and duality. Two circumstances are of importance here: first, unlike the usual models, allowance for the cuts in the form of CRP makes it possible to determine the contribution of the cuts with the aid of sum rules; second, in the CRP model it is easy to satisfy the aforementioned limitations, formulated by Harari [7] in the dual-absorptive scattering picture. We recall that complex cuts result from the influence exerted on the Regge poles by their "accompanying" cuts. Collision with a pole in turn, modifies the cut and the amplitude that takes into account the contributions of both the pole and the cut is effectively described by a complex-conjugate pole pair:

$$T(\nu, t) \sim (\beta_{\text{pole}}(t) + \beta_{\text{cut}}(t))\nu^{\alpha(t)} + \text{c.c.} \tag{1}$$

Without a special model we cannot separate explicitly the contributions of the pole and of the cut, but this is not compulsory for our purposes. Since both contributions depend in some way on ν, it is possible to find the parameters of the CRP model by using the duality condition written in the form of sum rules [8]. In analogy with the case of real Regge poles, the functions $\alpha(t)$ and $\beta_{\text{eff}}(t) = \beta_{\text{pole}} + \beta_{\text{cut}}$ can be determined directly from experiment [6], so that the amplitude at high energies can be completely constructed. At the same time, the application of sum rules to the ordinary models that take poles and cuts into account encounters fundamental difficulties [1]. The right-hand sides of the sum rules contain in this case convolutions with $\alpha(t)$ and $\beta(t)$ under the integral sign. It is thus impossible to determine these functions of t "directly by points" as in the case of real (and complex) Regge pole. In place of simple connection we obtain a system of equations that include different channels. Finally, a fact of particular importance for the usual models in which the cuts are taken into account, it is not clear which part of the

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resonances is dual to the poles and which to the cuts[2]).

It is not obvious beforehand whether one can hope that the approach proposed above, based on CRP and duality, can yield a correct description of a wide range of experimental data. The first calculations performed on the basis of the CRP and sum rules [6, 10] are promising in this sense. General arguments can also be presented.

A large amount of experimental information, which imposes a number of limitations on the existing models, has by now been accumulated. Recently Harari [7] systematized the most important experimental facts and formulated, on the basis of duality and the absorptive picture of scattering, the following limitations on the amplitudes[3]):

$$\mathrm{Im}\ T_{\Delta\lambda} \sim \nu^{\alpha} J_{\Delta\lambda}(r\sqrt{-t}), \tag{2a}$$

$$\mathrm{Re}\ T_1^{\pm} \sim \begin{pmatrix} -\mathrm{ctg}\,\frac{\pi\alpha}{2} \\ \mathrm{tg}\,\frac{\pi\alpha}{2} \end{pmatrix} \mathrm{Im}\ T_1, \tag{2b}$$

where $\Delta\lambda = 0$ or 1 is the change of helicity in the s-channel, $J_{\Delta\lambda}$ is a Bessel function, and $r \sim 1$ F. As shown by analysis [1, 2], the popular cut models do not satisfy these requirements, but the CRP model, to the contrary, can satisfy them. Indeed, assume that in the case of real poles the amplitude is given by

$$T_{\Delta\lambda}^{\pm} = \begin{pmatrix} 1 \\ i \end{pmatrix} (\sqrt{-t})^{\Delta\lambda} \beta(t) \nu^{\alpha} e^{-i\pi\alpha/2}, \quad \beta(t) = G e^{Dt}. \tag{3}$$

The changeover to the CRP can be effected formally by replacing the real parameters in (3) by complex ones and taking the contribution of α^* into account. Then

$$\mathrm{Im}\ T_{\Delta\lambda} \sim (\sqrt{-t})^{\Delta\lambda}\,\mathrm{Re}\,(\beta\nu^{\alpha}) \sim (\sqrt{-t})^{\Delta\lambda}\ |G|\,\nu^{\mathrm{Re}\,\alpha_e + t\,\mathrm{Re}D} \times \tag{3a}$$

$$\times \cos(\arg G + \alpha_I \ln\nu + t\,\mathrm{Im}\,D),$$

$$\mathrm{Re}\ T_1^{\pm} \sim \sqrt{-t}\ \mathrm{Re}\left\{ \begin{pmatrix} -\mathrm{ctg}\,\frac{\pi\alpha}{2} \\ \mathrm{tg}\,\frac{\pi\alpha}{2} \end{pmatrix} \beta\nu^{\alpha} \right\}. \tag{3b}$$

Recognizing that the first zeroes of J_0 occur at $t_0 = -0.23$ and $t_0' = -1.22$, and those of J_1 at $t_1 = -0.59$ and $t_1' = -1.97$, we can readily find that condition (2a) is satisfied, for example, at $\mathrm{Im}\ D_0 \sim \pi$, $\arg G_0 \sim -\pi/2$ and $\mathrm{Im} D_1 \sim 0.7\pi$, $\arg G_1 \sim -0.3\pi$ (we chose $\nu = \bar{\nu} = 10$ GeV; the positions of the zeroes change slowly with changing ν). It is easy to verify that condition (2b) is also

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[2])The possibility of such a separation with the aid of the K-matrix was discussed in [9]. These exists, however, serious objections to such an approach, since the analytic properties of the K- and T-matrices are essentially different.

[3])We have in mind here the manifestation of the main qualitative features of Bessel functions, particularly the first zeroes, maxima, and minima.

satisfied[4]).

The connection between the CRP and the Harari model was recently considered also by Desai [1, 2], who showed that if we assume the formula (2a) for Im $T_{\Delta\lambda}$, then the total amplitude $T_{\Delta\lambda}$ can be represented in the form of contributions of a pair of complex-conjugate poles.

In conclusion we note that, within the framework of two-component duality, the procedure proposed above for using the sum rules can be applied also to contributions connected with the Pomeranchon in the case when the effective contribution of P and of its "accompanying" cut can be represented in CRP form.

[1] B. Schrempp-Otto and F. Schrempp, Preprint DE3V 71/46, 1971.
[2] R.J.N. Phillips, Paper at the Amsterdam International Conference on Elementary Particles, 1971.
[3] G.F. Chew and D.R. Snider, Phys. Lett. 31B, 75 (1970); J.S. Ball, G. Marchesini, and F. Zachariasen, Phys. Rev. Lett. 25, 1389 (1970).
[4] V.A. Tsarev, Paper at International Seminar on Binary Hadron Reactions, Dubna, 1971.
[5] B.R. Desai et al., Phys. Rev. Lett. 25, 1389 (1970).
[6] N.P. Zotov and V.A. Tsarev, Yad. Fiz. 14, 806 (1971) [Sov. J. Nuc. Phys. 14, No. 4 (1972)].
[7] H. Harari, Phys. Rev. Lett. 26, 1400 (1971); SLAC-PUB-914, 1971.
[8] A. Logunov, L. Soloviev, and A. Tavkhelidze, Phys. Lett. 24B, 181 (1967).
[9] F. Schrempp, Phys. Lett. 29B, 598 (1969).
[10] N.P. Zotov, S.V. Tarasevich, and V.A. Tsarev, ZhETF Pis. Red. 14, 120 (1971) [JETP Lett. 14, 79 (1971)]. N.P. Zotov, O. Suguhashi, and V.A. Tsarev, Kratkie soobshcheniya po fizike (Brief Physics Communications), FIAN No. 9, 1971.
[11] P. Sonderegger, Paper at International Seminar on Binary Hadron Reactions, Dubna, 1971.
[12] B.R. Desai, Preprint RLO 1388-614, 1971.

NEGATIVE DIFFERENTIAL CONDUCTIVITY OF A TWO-VALLEY SEMICONDUCTOR HAVING NO NEGATIVE SECTION OF THE V(E) CHARACTERISTIC

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It is known that the negative differential conductivity of a two-valley semiconductor in which the Gunn effect is observed depends on the carrier mobility μ_1 in a weak electric field. At low carrier mobility (e.g., ~2000 - 3000 cm^2/V-sec for GaAs), the negative section in the static V(E) characteristic vanishes [1]. The ensuing current instability should also vanish.

We show below that in such a semiconductor, i.e., when the V(E) characteristic has no negative section, there appears under certain conditions and in a definite frequency band a negative differential conductivity due to the inertia of the carrier redistribution among the conduction subbands.

[4])We note that the amplitudes obtained by us with the aid of the sum rules for [6] for the reaction $\pi^- p \to \pi^0 n$ satisfy the conditions (2) and have correctly predicted the polarization [11].