Title
COMPLEX REGGE POLES AND THE SIGN OF THE TWO-POMERANCHON DISCONTINUITY

Author
Chew, G.F.

Publication Date
1973-02-01

Submitted to Physics Letters B

LBL-1701
Preprint c.2

COMPLEX REGGE POLES AND THE SIGN OF THE TWO-POMERANCHON DISCONTINUITY

G. F. Chew

February 21, 1973

Prepared for the U.S. Atomic Energy Commission
under Contract W-7405-ENG-48

DISCLAIMER

COMPLEX REGGE POLES AND THE SIGN OF THE TWO-POMERANCHON DISCONTINUITY*

G. F. Chew

Department of Physics and Lawrence Berkeley Laboratory
University of California, Berkeley, CA 94720

February 21, 1973

ABSTRACT

The threshold increase of the two-fireball cross section, with one fireball of large mass and one of small, is discussed in terms of complex Regge poles and the sign of the two-Pomeranchon discontinuity. It is shown that even though the cut in the complete amplitude is positive, an approximate Regge representation without complex poles, suitable for a limited energy region, may contain a negative cut. A connection is made between the triple Pomeranchon coupling and the amplitude of the cross-section oscillation associated with the complex poles.

* The work was supported in part by the U. S. Atomic Energy Commission.

It has recently been pointed out that the two-fireball cross section, with one fireball of large mass and one of small, will increase near threshold† roughly linearly with the logarithm of the energy [1]. The slope of this threshold increase is proportional to the triple-pomeron coupling g_P and must consequently be small, but a rate of increase of a few mb per unit of $\ell n\ s$ is allowed by current estimates of g_P [2]. In Ref. 1 it was conjectured that this gentle increase might accidentally compensate a slow decrease in the elastic pp cross section (as well in the remainder of the low-mass two-fireball cross section) and lead to an almost constant total pp cross section. But if the decrease in the elastic cross section is much slower in this threshold region than has been observed at lower energies, the one-large-mass, one-small-mass two-fireball threshold effect may cause the total cross section to increase. The purpose of the present note is to discuss the interpretation of such an increase from the point of view of Regge singularities. We shall argue a connection both with complex Regge poles and with the sign of the discontinuity across the two-Pomeranchon branch point.

Our argument depends on the systematic fireball expansion described in Refs. 1, 3, and 4, which when augmented by the assumption that the single-fireball component contains only Regge poles, is closely related to Abarbanel's decomposition [5]. In the fireball expansion the terms of zeroth order in g_P constitute the "two-component" model, while the increasing component described above is of first order in g_P. Now by summing the series to all orders Abarbanel [5] has shown for the fireball model that the two-Pomeranchon discontinuity is unequivocally positive, a result that seems to

† The threshold is expected to occur in the neighborhood of $\ell n\ s \approx 4\text{-}6$.

preclude an increasing tendency in the total cross section. On the other hand, the fireball model certainly contains the component linear in g_P and (because the Pomeranchon slope is arbitrary) is consistent with an arbitrarily slow decrease of the elastic cross section. Somehow, therefore, the fireball model must be compatible with the possibility of an increasing total cross section in the threshold region under consideration.

We suggest that compatibility is achieved by the development of physical-sheet complex poles, whose contribution to an asymptotic expansion must be explicitly added to those from the Pomeranchon (real) pole and the two-Pomeranchon branch point. These complex poles produce long wavelength oscillations in the total cross section, so that for restricted intervals of energy it is possible for the total cross section to increase. The mechanism for generation of complex poles from the infinite fireball expansion is essentially the same as that discussed in Ref. 6, where the associated oscillation-wavelength is the period in $\ell n\ s$ required to add one link of the multiperipheral chain. The link in question here is one fireball, which requires a substantial increment of $\ell n\ s$ -- 2-3 units for low-mass fireballs and 4-6 units for large.†

The residue of the leading complex poles should be proportional to g_P, as should be the amplitude of the associated cross-

† The model of Ref. 6 suggests that there will occur an infinite sequence of complex poles, the real parts of whose positions in the complex J plane decrease as the imaginary part increases. Thus the shorter-wavelength oscillations are damped with increasing energy, the longest wavelengths being the most persistent.

section oscillation. For example, if a pair of complex poles is located at α_1 and α_1^*, with residues r_1 and r_1^*, the corresponding cross section contribution is of the form

$$r_1\, s^{\alpha_1 - 1} + r_1^*\, s^{\alpha_1^* - 1} = 2|r|\, s^{\mathrm{Re}\,\alpha_1 - 1} \cos[\mathrm{Im}\,\alpha_1\ \ell n\ s + \arg r_1] \ . \tag{1}$$

If $\mathrm{Im}\,\alpha_1 > 1 - \mathrm{Re}\,\alpha_1$, there will be a roughly linear increase with $\ell n\ s$ when the argument of the cosine factor falls into the appropriate quadrant. In such an energy region, that is,

$$\frac{d\sigma^{tot}}{d\ \ell n\ s} \approx 2|r|\, s^{\mathrm{Re}\,\alpha_1 - 1} (\mathrm{Im}\,\alpha_1 + \mathrm{Re}\,\alpha_1 - 1) \ . \tag{2}$$

According to our hypothesis, one such region is that where there first develops the possibility of a large-mass fireball at the same time as a fireball of small mass. In this threshold region we may roughly match Formula (2) against Formula (12) of Ref. 1 in which g_P appears explicitly as a proportionality factor.

As explained in Refs. 1 and 4 it is a good approximation at any finite energy, because of the smallness of g_P, to truncate the fireball expansion. On the other hand a truncated expansion does not contain any complex poles, so how does it represent an increasing cross section? Let us consider the special case of truncation after terms linear in g_P. Reference 4 shows that the components of zeroth order in g_P correspond to a pole (single fireball) plus a two-Pomeranchon cut with a positive discontinuity (two low-mass fireballs). The component linear in g_P contains a positive pole plus a cancelling negative cut, each of these two singularities being separately larger than their combination. It is possible, even with g_P small, for the negative cut linear in g_P to overbalance the positive cut of zeroth order in g_P, if the Pomeranchon slope is sufficiently small. Such an overcompensation is precisely what is required to achieve an increase in σ^{tot}. Truncation after terms linear in g_P is capable, in other words, of leading to a negative two-Pomeranchon cut, even though the untruncated series necessarily has a positive cut. The same energy dependence over a limited region may be given by both truncated and complete expansions because the latter contains complex poles while the former does not.

Our complex Regge-pole conjecture is capable of experimental test in a variety of ways. Three obvious tests are: (1) The total cross section should oscillate and not increase indefinitely. (2) The amplitude of the oscillation should be correlated, as explained above, with the magnitude of g_P. (3) The period of the oscillation (although not the phase) should be universal, being the same, e.g., for $K^{\pm}p$, pp, $\pi^{\pm}p$, etc.

The author is grateful to M. Bishari and J. Koplik for stimulating conversations.

REFERENCES

1. G. F. Chew, An Estimate of the Magnitude of Triple Pomeron Coupling From the Observed Energy Dependence of Total and Elastic pp Cross Sections, Lawrence Berkeley Laboratory Report LBL-1556, January, 1973 (submitted to Phys. Rev. Letters).
2. See Formulas (12) and (14) of Ref. (1), remembering that the small-mass fireball may be associated with either of the two incident protons and may consist either of a stable proton or an unstable N^*.
3. G. F. Chew, Phys. Rev. D7, 934 (1973).
4. M. Bishari and J. Koplik, A Perturbative Description of the Pomeron Suggested by the Two-Component Model of Multiparticle Production, Lawrence Berkeley Laboratory Report LBL-1702, February, 1973.
5. H. D. I. Abarbanel, Phys. Rev. D6, 2788 (1972).
6. G. F. Chew and D. R. Snider, Physics Letters 31B, 75 (1970).

TECHNICAL INFORMATION DIVISION
LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA 94720