NOTAS DE FÍSICA

VOLUME XIII

Nº 16

SUPERCONVERGENT SUM RULE FOR PION PHOTOPRODUCTION ON Λ^{0}

by

P. P. Srivastava

CENTRO BRASILEIRO DE PESQUISAS FÍSICAS

Av. Wenceslau Braz, 71

RIO DE JANEIRO

1968

Notas de Física - Volume XIII - Nº 16

SUPERCONVERGENT SUM RULE FOR PION PHOTOPRODUCTION ON Λ^o. *

P. P. Srivastava **
Centro Brasileiro de Pesquisas Físicas
Rio de Janeiro, Brazil

(Received March 6, 1968)

"Superconvergent" sum rules for certain strong-interaction amplitudes have recently been derived by using the current algebra technique together with the assumption of unsubtracted dispersion relations [1] or on the basis of analyticity and appropriate high-energy behaviour of the amplitude [2]. The Regge-pole model has frequently been invoked in deriving such sum rules [3,4].

In the present work we study a superconvergent sum rule in the photoproduction of pions on Λ^o. The sum rules obtained for photoproduction of pions on nucleons, discussed recently [4], are in fair agreement with the experimental data.

---

* Submitted for publication in Il Nuovo Cimento.

** This work was accomplished while the author was at the International Center for Theoretical Physics - Trieste.

The invariant amplitude in the photoproduction process can be decomposed in terms of four invariant amplitudes [5], A, B, C, D. They are functions of the two invariants $\nu = - k\cdot(p_1 + p_2)/2M$ and $t = -(k-q)^2$ where k, q, p_1, p_2 are the four-momenta of the photon, meson, the initial baryon and the final baryon, respectively. From the Regge-pole theory, we assume that the high-energy behaviour of each amplitude is determined by the leading Regge trajectory which can be exchanged in the t-channel. The recent Regge-pole analysis [6] of high-energy scattering data suggests, if only 0^-, 1^- and 2^+ trajectories are assumed to be important in our case, that the invariant amplitude C behaves like $\nu^{\alpha(t)-2}$ for large ν. Here $\alpha(t)$ refers to the leading trajectory, the ω-trajectory in our case, and for which $\alpha(0)<1$ for $t\sim 0$. The amplitude C is odd under crossing symmetry, i.e. $C^*(\nu,t) = -C(-\nu, t)$ and consequently leads to the nontrivial sum rule

$$\int_{-\infty}^{\infty} \mathrm{Im}\, C(\nu,t)d\nu = 2\int_{0}^{\infty} \mathrm{Im}\, C(\nu,t)d\nu = 0 , \qquad \text{fixed } t.$$

The pole term contribution to the integral due to the Σ intermediate state is readily evaluated while the continuum contributions may be approximated using the isobaric model retaining only the $Y_1^*(1385)$ contribution [7,8]. The crossing symmetry relation implies that we need consider only the direct uncrossed graphs in the s-channel. Assuming that in the contribution coming from Y_1^* only the M_{1+} multipole is important ($E_{1+}\simeq 0$), and making the narrow-width approximation, we obtain the following sum rule for $t \sim 0$:

$$g_{\mathcal{N}\mathcal{N}\pi}(1-\alpha) + 39.4\, C_3\, \lambda_1 = 0 \ ,$$

where we have used the SU_3 values for the coupling constant

$$g_{\Sigma\Lambda\pi} = 2/\sqrt{3}\ (1-\alpha)\ g_{\mathcal{N}\mathcal{N}\pi}$$

and the transition magnetic moment $\mu_{\Sigma\Lambda}$. The parameter is related to the D/F ratio for the $\bar{B}BP$ vertex, $g^2_{\mathcal{N}\mathcal{N}\pi}/4\pi \sim 15$ and the coupling constants C_3 and λ_1 are defined as in ref. [8].

Calculating λ_1 from the experimental width of the decays $Y_1^{*\pm} \longrightarrow \Lambda\pi^{\pm}$ we obtain [9] from the sum rule

$$C_3 = -\,0.3(1-\alpha)\ .$$

The constant C_3 can be related [10] to the transition magnetic moment of $Y_1^* \rightarrow \Lambda\gamma$. Its calculated value turns out to be $\sim -\frac{2}{3}\sqrt{2}\,\mu\ (1.15)$, where μ_p is the total proton magnetic moment and we have used $\alpha \sim 0.4$. SU_3 symmetry further leads [11] to a relation between this magnetic moment and the $\mathcal{N}^{+*}_{3/2} \longrightarrow p\gamma$ transition magnetic moment. The latter is then predicted to be $+\frac{2}{3}\sqrt{2}\,\mu_p(1.30)$, which compares very well with its experimental value [10] $+\frac{2}{3}\sqrt{2}\,\mu_p(1.28 \pm 0.02)$.

Thus the sum rule derived above is very well satisfied within the framework of SU_3 symmetry and predicts for the transition magnetic moment of $Y_1^*\,\Lambda^0\gamma$ the value $-\frac{2}{3}\sqrt{2}\,\mu_p(1.15)$.

Similar sum rules can also be derived for photoproduction on Σ and Ξ .

ACKNOWLEDGEMENTS

The author is grateful to Professors A. Salam and P. Budini and to the IAEA for the hospitality extended to him at the International Centre for Theoretical Physics, Trieste. Acknowledgements are due to the John Simon Guggenheim Memorial Foundation for a fellowship grant. He also acknowledges with thanks discussions with Drs. L. Pande, K. Wali and B. Sakita.

* * *

REFERENCES:

1. V. De Alfaro, S. Fubini, G. Furlan and C. Rossetti: Phys. Letters 21, 576 (1966).

2. L. D. Soloviev: Sov. Journal Nucl. Phys. 3, 131 (1966).

3. B. Sakita and K. C. Wali: Phys. Rev. Letters 18, 29 (1967); P. Babu, F. J. Gilman and M. Suzuki: Phys. Letters 24, B 65 (1967); G. Altarelli, F. Buccella and R. Gatto: Phys. Letters 24, B 57 (1967).

4. L. Pande: Nuovo Cimento, 48 A, 839 (1967); G. Altarelli and M. Colocci: Nuovo Cimento, 48 A, 573 (1967).

5. G. F. Chew, M. Goldberger, F. Low and Y. Nambu: Phys. Rev. 106, 1345 (1957). We follow the notation of this paper.

6. R. W. Childers and W. G. Holladay: Phys. Rev. 132, 1809 (1963); G. Zweig: Nuovo Cimento, 32, 689 (1964); G. Kramer and P. Stichel: Zeits. Phys., 178, 519 (1964); J. S. Ball: Phys. Rev. 124, 2014 (1961).

7. The next higher resonance $Y_1^*(1660)$ has very small decay width for $\Lambda\pi$ decay and thus may be ignored. The contributions due to other higher resonances are expected to be smaller for photoproduction than for scattering. See ref. 8.

8. M. Gourdin and P. Salin: Nuovo Cimento, 27, 193 (1963); P. Salin: Nuovo Cimento, 28, 1294 (1963); See also S. Fubini, G. Furlan and C. Rossetti: Nuovo Cimento, 53, 161 (1966).

9. The λ_1 is taken with positive sign in accord with SU_6 symmetry. See, for example, B. Sakita and K. C. Wali: Phys. Rev., 139, B 1355 (1965).

10. See, for example, M. A. B. Bég, B. W. Lee and A. Pais: Phys. Rev. Letters, 13, 514 (1964); R. H. Dalitz and D. G. Sutherland: Phys. Rev., 146, 1180 (1966).

11. A. J. McFarlane and E. C. G. Sudarshan: Proceedings of the International Conference, Stanford University, June 1963, p. 306; see also Nuovo Cimento, 31, 1176 (1964).