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A TEST OF MODELS FOR THE ASYMPTOTIC BEHAVIOUR OF THE $K^{\pm}p$ SCATTERING AMPLITUDES

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Experimental data on the K^-p total cross section above 20 GeV[1] disagree with the extrapolations of most fits to the data at lower energies based on the sum of several Regge poles[2,3]. More recent models which give a good fit to these data require additional contributions from either Regge cuts[4] or terms which violate the Pomeranchuk theorem[5-8]. Since many different parametrizations have been proposed, considerable ambiguity remains in the theoretical description of $K^{\pm}p$ scattering at high energies. In this paper we show that a simple sum rule provides a strong consistency test of such parametrizations.

Let $F_{\pm}(\omega)$ be forward $K^{\pm}p$ scattering amplitudes in the laboratory system, satisfying the optical theorem

$$\sigma_{\pm}(\omega) = 4\pi \, \mathrm{Im}\, F_{\pm}(\omega)/k,$$

where $\omega^2 = k^2 + m_K^2$. Using the well known analyticity and crossing properties of the amplitudes[9] and applying Cauchy's theorem to $F_-(\omega)$ around the closed contour consisting of the line segment $-W + i\epsilon \le \omega \le W + i\epsilon$ ($\epsilon \to 0^+$) and the semicircle $S(W)$ given by $\omega = W\exp(i\phi)$, $0 \le \phi \le \pi$, we obtain the sum rule

$$\frac{1}{4\pi}\int_{m_K}^{W} k\,[\sigma_-(\omega) - \sigma_+(\omega)]\,d\omega + \int_{\omega_{\pi\Lambda}}^{m_K} \mathrm{Im}\,F_-(\omega)\,d\omega - 0.19\,G^2 = R(W), \qquad (1)$$

where $G^2 = g_\Lambda^2 + 0.84\, g_\Sigma^2$, the g_Y are the KNY coupling constants, and

$$R(W) = -\mathrm{Im} \int_{S(W)} F_-(\omega)\, d\omega . \qquad (2)$$

Eq. (1) is analogous to the standard finite energy sum rule [10], but its derivation requires no assumptions about the asymptotic behaviour of the amplitudes.

For $W \leq 20$ GeV the first integral in (1) may be evaluated in terms of the existing $\sigma_\pm$ data, references to which are given in [9]. For $W \geq 10$ GeV, the second and third terms in (1) contribute not more than a few per cent of the first term, so that the left-hand side of (1) is insensitive to the choice of the models used to evaluate these terms. For definiteness, we calculate the integral over the unphysical region $\omega_{\pi\Lambda} \leq \omega \leq m_K$ in terms of the $K^- p$ scattering lengths of ref. [11]. For the coupling constants, we use the most recent determination [12] $G^2 = 8.8 \pm 3.0$, which is consistent with most earlier estimates [9].

Any given model for $F_\pm(\omega)$ for $|\omega| \geq W$ leads to a definite prediction for $R(W)$ from eq. (2). In the table we compare the values of $R(W)$ (in natural units) corresponding to various models with the left-hand side of (1), for three values of W. The extent to which each model violates the Pomeranchuk theorem is indicated in the table by the predicted asymptotic cross section difference $\Delta\sigma \equiv \sigma_-(\infty) - \sigma_+(\infty)$. From the results, it is clear that $R(W)$ is rather sensitive to the choice of the model. In particular, the sum rule is clearly inconsistent with the hypothesis [7,8] that the cross sections $\sigma_\pm$ have already reached their asymptotic limits $\sigma_\pm(\infty)$ at 20 GeV. This extreme hypothesis also gives the poorest agreement with a recent model-independent determination of a certain parameter describing the asymptotic behaviour of $F_\pm(\omega)$ [13].

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R e f e r e n c e s

1. J.V. Allaby et al. Phys.Letters, 30B, 500 (1969).
2. R.J.N. Phillips and W. Rarita. Phys.Rev., 139B, 1336 (1965).
3. G.V. Dass, C. Michael and R.J.N. Phillips. Nucl.Phys., B9, 549 (1969).
4. V. Barger and R.J.N. Phillips. Phys.Rev.Letters, 24, 291 (1970).
5. V. Barger and R.J.N. Phillips. Phys.Letters, 31B, 643 (1970).
6. R. Arnowitt and P. Rotelli. Imperial College (London) preprint ICTP/69/14.
7. D. Horn. Phys.Letters, 31B, 30 (1970).
8. O.V. Dumbrais and N.M. Queen. Phys.Letters., 32B, 65 (1970).
9. N.M. Queen, M. Restignoli and G. Violini . Fortschritte der Physik. 17, 467 (1969).
10. В.И. Журавлев, К.В. Рерих. ЯФ, 6, 165 (1967).
11. J.K. Kim. Phys.Rev.Letters., 14, 29 (1965).
12. A.D. Martin and R. Perrin. Nucl.Phys., B20, 287 (1970).
13. O.V. Dumbrais, T.Yu. Dumbrais and N.M. Queen. JINR preprint, E2-5216, Dubna (1970).

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Table

Reference	$\Delta\sigma$ (mb)	R(10 GeV)	R(16 GeV)	R(20 GeV)
[2]*	0	82	168	236
[3]*	0	75	145	198
[4]*	0	78	150	205
[5]*	2.5	91	193	277
[6]	2.1 ± 0.3	64 ± 6	137 ± 13	198 ± 18
[7,8]**	3.7 ± 0.5	——	——	152 ± 21
Left-hand side of (1)		73 ± 2	176 ± 3	234 ± 7

* Errors on the parameter values are not given in these analyses.

** The sum rule is inapplicable in this case for $W < 20$ GeV.