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PREDICTIONS FOR $\pi^- + p \to \eta^0 + n$ FROM REGGE POLES AND SU_3*

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ABSTRACT

It is assumed that the charge exchange process $\pi^- + p \to \eta^0 + n$ is dominated by the R Regge pole. A prediction for the cross section is then made, by taking Regge pole parameters from a previous analysis of πN and KN scattering, and by invoking SU_3 symmetry.

There has recently been renewed interest in Regge pole models for high-energy scattering, especially for processes in which the number of poles in the crossed channel is severely limited by selection rules.[1-4] One such process is $\pi^- + p \rightarrow \pi^0 + n$ charge exchange, where of the known Regge poles only ρ can contribute; another is $K^- + p \rightarrow \bar{K}^0 + n$, where only ρ and R contribute;[5] another is $\pi^- + p \rightarrow \eta^0 + n$, where only R contributes. Explicit models have already been constructed for the first two processes, and the ρ couplings are found to obey the expected SU_3 symmetry.[4] The present note is to show that, by requiring SU_3 symmetry for the R couplings, we get a prediction for the third process, $\pi^- + p \rightarrow \eta^0 + n$.

The models of reference 4 fit available πN data, using the P, P', and ρ Regge poles. KN and $\bar{K}N$ data are then fitted, with P, P', and ρ contributions restricted by the factorization principle, and with the ω and R poles added. The best solutions are found to obey SU_3 symmetry for the P and ρ couplings. The πN and $\bar{K}N$ charge-exchange data are particularly valuable in determining the ρ and R contributions, although the other data are also important in this.

Now, R is supposed to belong to an SU_3 octet. The coupling between this particular octet and the octet containing π, η, K, and $\bar{K}$ must be pure D-type, to preserve charge-conjugation invariance.[6] Hence, at high energies, at which the η-π mass difference has negligible effect the amplitude for $\pi^- + p \rightarrow \eta^0 + n$ is essentially the same--apart from an extra factor $2/\sqrt{3}$--as the R contribution to $K^- + p \rightarrow \bar{K}^0 + n$.

Consider therefore the R contributions to $K^- + p \rightarrow \bar{K}^0 + n$, as given in reference 4. There is a helicity-flip amplitude B and a nonflip amplitude A (following reference 7, where, however, the notation is B and A'). The differential cross section is

$$\frac{d\sigma}{dt} = \frac{1}{\pi s}\left(\frac{m_N}{4K}\right)^2\left\{\left(1 - \frac{t}{4m_N^2}\right)|A|^2 + \frac{t}{4m_N^2}\left(s - \frac{s + p^2}{1 - \frac{t}{4m_N^2}}\right)|B|^2\right\} , \qquad (1)$$

where s and t are the invariant squares of energy and momentum transfer, p is the kaon lab momentum, k is the c.m. momentum, and m_N is the nucleon mass. The R contributions to A and B are written[4]

$$A_R = -2C_0 \exp(C_1 t)\alpha(2\alpha + 1)\frac{1 + \exp(-i\pi\alpha)}{\sin \pi\alpha}\left(\frac{E}{E_0}\right)^{\alpha} , \qquad (2)$$

$$B_R = -2D_0 \exp(D_1 t)\alpha \frac{1 + \exp(-i\pi\alpha)}{\sin \pi\alpha}\left(\frac{E}{E_0}\right)^{\alpha-1} . \qquad (3)$$

Here α is the R trajectory, $E = (p^2 + m_K^2)^{1/2}$ is the total kaon lab energy, and E_0 is an arbitrary scale parameter, taken for convenience to be 1 GeV; C_0, C_1, D_0, and D_1 are coefficients which parameterize the residue functions. The trajectory α is given the form

$$\alpha(t) = -1 + [1 + \alpha(0)]^2/[1 + \alpha(0) - \alpha'(0)t] , \qquad (4)$$

where $\alpha(0)$ and $\alpha'(0)$ are the value and slope at $t = 0$. In reference 4, the various parameters for R, as well as other relevant Regge poles, are determined by least-squares fitting to πN, KN, and $\bar{K}N$ data.

Using these R Regge pole parameters, a prediction for $\pi^- + p \to \eta^0 + n$ can immediately be made. Table I shows a set of parameters, representing a slightly modified[8] form of Solution I of reference 4; Fig. 1 shows the predicted cross section at 10 GeV/c.

Let us consider how much uncertainity attaches to this prediction.

(i) SU_3 Symmetry

If SU_3 symmetry fails for the R couplings by 10%, we may expect a 20% effect in the predicted cross section. This symmetry also enters indirectly, via the analysis of pole parameters. The numbers in Table I are a best fit if exact SU_3 symmetry is assumed for the $\rho\bar{K}K$ and $\rho\pi\pi$ couplings: if this relation is relaxed by 10%, the best fits predict cross sections that differ by less than 20% on the whole.

(ii) The Helicity-Flip Amplitude

The cross-section predictions are rather sensitive to this amplitude. If it increases by 20%, the dip at $t = 0$ becomes more pronounced; if it decreases by 20% the dip vanishes. Our solution happens to lie in a rather sensitive intermediate region.

(iii) Model Dependence

The four different models in reference 4 all give similar predictions for the R contribution, which suggests there is not much uncertainity in this respect.

(iv) Energy-dependence

The cross section $d\sigma/dt$ behaves like $E^{2\alpha-2}$; hence for our model it behaves like $E^{-1.4}$ at $t = 0$ and like E^{-2} near $t = -0.5(\text{GeV}/c)^2$. There is some uncertainity in α, and hence in the energy dependence, but this should scarcely affect our prediction at 10 GeV/c, which is effectively normalized to the nearby K^-p charge-exchange measurements at 9.5 GeV/c.

We understand that experimental data on $\pi^- + p \rightarrow n^0 + n$ have recently been taken and are being analyzed, by the MIT/Pisa and Saclay/Orsay groups.[9] The results should throw much light, both on the R-Regge pole model and on the applicability of SU_3 symmetry in this context.

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FOOTNOTES AND REFERENCES

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Table I. Parameters for the R-Regge pole in K-N scattering

$\alpha(0)$	$\alpha'(0)$ $[(GeV/c)^{-2}]$	C_0 (mb x GeV)	C_1 (GeV^{-2})	D_0 (mb)	D_1 (GeV^{-2})
0.32	0.80	3.1	0.4	-29	2.4

FIGURE CAPTION

Fig. 1. Predicted $\pi^- + p \rightarrow \eta^0 + n$ cross section at 10 GeV/c.

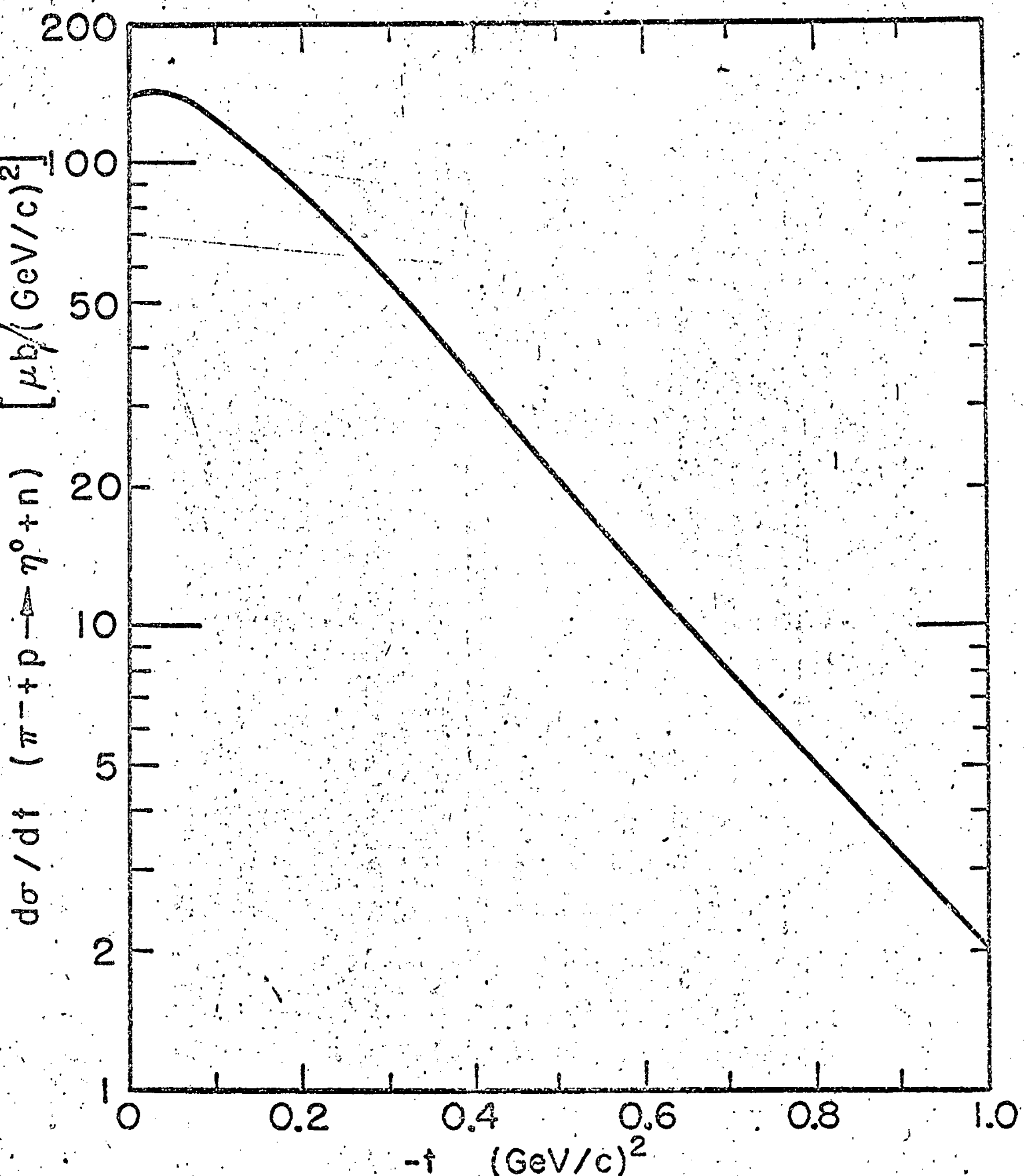

Fig. 1

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