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MODEL FOR LOW ENERGY KAON-NUCLEON INTERACTION IN THE I = 0 STATE*

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Unitary Padé approximants were recently used[1] to build a model for the low energy kaon-nucleon interaction. The model is based on a Lagrangian

$$\mathscr{L}_{int} = \{-ig_{N\Lambda K}(\bar{p}\gamma^5\Lambda K^+ + \bar{n}\gamma^5\Lambda K^o) + h.c.\} + \{-ig_{N\Sigma K}(-\bar{p}\gamma^5\Sigma^o K^+ + \sqrt{2}\bar{p}\gamma^5\Sigma^+ K^o$$

$$+\bar{n}\gamma^5\Sigma^o K^o - \sqrt{2}\bar{n}\gamma^5\Sigma^- K^+) + h.c.\} + \lambda\{\bar{p}p\bar{K}^+K^+ + \frac{1}{2}(\bar{p}n\bar{K}^o K^+ + \bar{n}n\bar{K}^+K^+ + \bar{p}p\bar{K}^o K^o)\} \qquad (1)$$

written in terms of nucleon, hyperon, and kaon fields, and consisting of the usual Yukawa terms ($g_{N\Lambda K}$ and $g_{N\Sigma K}$) and of the contact interaction (coupling constant λ) acting directly only on the I = 1 state of the KN system. The amplitudes are calculated starting from the first diagonal Padé approximant to each partial wave amplitude. This procedure guarantees the S-matrix unitarity, and the model achieved remarkable success when applied to the I = 1 state of the kaon-nucleon system.

As an extension of that work, we have now applied the model to study the KN interaction in the isospin I = 0 state. To obtain the [1,1] Padé approximant we must evaluate all Feynman diagrams up to fourth order. The Yukawa coupling constants occur in the final expressions only through the effective coupling constant

$$g^2 = (g^2_{N\Lambda K} - 3\eta\, g^2_{N\Sigma K})/4\pi$$

with $\eta \simeq 0.97$. Once the scattering length $a_s^{(0)} = -0.3f$ in the I = 1 state is given, λ is fixed in terms of an effective coupling G^2 defined by the combination

$$G^2 = (g^2_{N\Lambda K} + \eta g^2_{N\Sigma K})/4\pi$$

and then G^2 can be determined by fitting the other K^+p scattering data. It is commonly accepted that the value of G^2 lies somewhere in the interval from 10 to 20. Thus g^2 becomes the only free parameter for the description of the I = 0 interaction. The present knowledge of the values of the Yukawa coupling constants indicates that $0 < g^2 < G^2$.

We have obtained for the I = 0 state an s-wave scattering length of about -0.4 fermi, and positive $p_{1/2}$ and negative $p_{3/2}$ phase shifts, with typical scattering lengths $a^{(0)}_{p_{1/2}} = +0.08$ and $a^{(0)}_{p_{3/2}} = -0.02$ (fermi)^3 for $G^2 = g^2 = 15$. These results may be compared to the solutions of phase shift analysis by B. C. Wilson et al.[2] Their preferred sets present also negative s-wave shifts while both $p_{1/2}$ and $p_{3/2}$ phases are positive.

Figure 1 shows the values of the differential cross section for elastic $K^+n \to K^+n$ scattering, as extracted from results of K^+d scattering experiments,[2] together with the predictions from our model. The differential

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polarization observed[3] in $K^+d \rightarrow K^0pp$ at 600 MeV/c is well reproduced by our calculations, as shown in Fig. 2. Figure 3 shows the experimental results on K^+d total cross section,[4] together with our results.

Some of the noted discrepancies can be attributed to the way K^+p and K^+d experiments have been analyzed to produce the I=0 data, but we must also point out the deficiencies of the model, which does not include pions explicitly and represents all kinds of short range forces by the contact term in the Lagrangian.

On the whole, however, we think that the model reaches relative success. Without free parameters, we have predicted the correct sign of the s-wave amplitude, and the approximate magnitude of the K^+n cross section, which are the most reliable data available at the present in the I=0 state of the KN system.

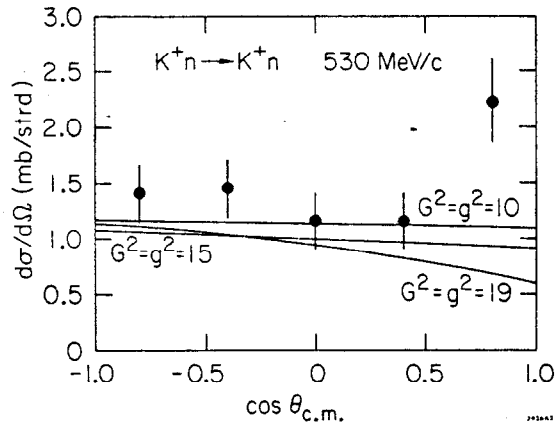

Fig. 1--Predicted differential cross section for $K^+n \rightarrow K^+n$ at 530 MeV/c for some values of G^2 and g^2. Data from K^+d experiments.[2]

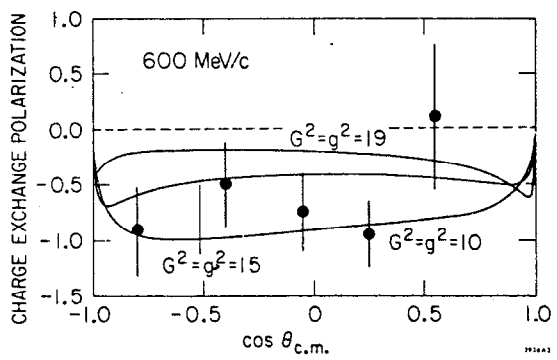

Fig. 2--Differential polarization for $K^+n \rightarrow K^0p$ compared to experimental data.[3]

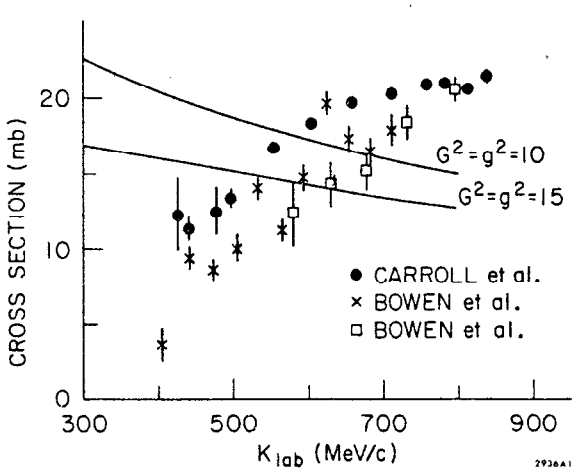

Fig. 3--Calculated cross section in the KN, I=0 state, compared to experiments.[4]

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4. A. S. Carrol et al., Phys. Lett. B 45, 531 (1973).