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Possibility for a Large Spin-Flip Part in the Scattering Amplitudes of K$^-$$p$ Charge Exchange at 9,5 GeV/c

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An experiment on $K^- p$ charge exchange, carried out recently at CERN[1]), shows a momentum transfer distribution in which the cross section bends downwards towards $t = 0$, while the maximum is situated at $t = -0.1$. The same behaviour appears also in $\pi^- p$ charge exchange[2]). This is incompatible with pure exponential behaviour of the elastic scattering at small t. In this letter, which must be considered as an additional remark to the already published paper of the CERN/ETH group[1]), we try to explain this somewhat strange behaviour of the momentum transfer distribution by a strong spin-flip part in the scattering amplitude.

Consider now the reaction

$$K^- + p \to \overline{K}^0 + n\,.$$

Convenient variables for the description of this system are the squares of the centre-of-mass total energies in the three channels s, u, and t, with

$$s + u + t = 2\,M^2 + 2\,m^2.$$

We denote the nucleon and K mass by M and m, respectively. The differential cross section in the c.m. is given by:

$$\frac{d\sigma}{dt} = \frac{1}{\pi}\left(\frac{M}{4\,W k}\right)^2 \sum |\,\overline{u}_2\, T\, u_1\,|^2$$

where the sum is taken over final spin states and the average over the initial spin states and

$$T = -A(s,t) + \frac{i}{2}\,\gamma_\mu\,(q_1 + q_2)_\mu\, B(s,t)$$

k is the c.m. momentum and W the c.m. energy. q_1 and q_2 are the c.m.four-momenta of the K^- and the $\overline{K}^0$, respectively.

Omitting the modification due to Coulomb interaction, the barycentric kaon-nucleon differential cross section is also given by:

$$\frac{d\sigma}{dt} = \frac{\pi}{k^2}\,|\,f_1(k\cos\vartheta) + \cos\vartheta\, f_2(k\cos\vartheta)\,|^2 + \sin^2\vartheta\,|\,f_2(k\cos\vartheta)\,|^2$$

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where the first term of the right-hand side is the non-spin-flip part and the second the spin-flip part of the amplitude. ϑ is the scattering angle in the barycentric system.

In terms of helicity state amplitudes

$$f_{\lambda\lambda'} = -\frac{M}{4\pi W}\,\bar{u}\,(-p_2, \lambda)\left(-A + \frac{i}{2}\,\gamma_\mu\,(q_1 + q_2)_\mu\,B\right) u\,(p_1, \lambda')$$

one gets the differential cross section

$$\frac{d\sigma}{dt} = \frac{\pi}{k^2}\left[\left(1 - \frac{t}{4\,M^2}\right)|f_{1/2\,1/2}|^2 - \frac{t\,(t+4\,q^2)\,s}{4\,(4\,M^2 - t^2)\,M^2}\,|f_{1/2\,-1/2}|^2\right].$$

Fitting this formula to the experimental cross section and assuming that

$$|f_{1/2 1/2}|^2 = a\,e^{\alpha t} \text{ and } |f_{1/2-1/2}|^2 = b\,e^{\alpha t}$$

we get for the three parameters

$$a = 229\,\frac{\mu b}{\text{ster}}\,,\quad b = 114\,\frac{\mu b}{\text{ster}}\,, \alpha = 7.4\,(GeV/c)^{-2}\,.$$

Of course these parameters have a meaning only for momentum transfer $|t| < 0.8$. For higher values the parametrization no longer fits the experimental distribution, as one can see in Figure 1. These results were published before[1]) in order to explain the maximum in the experimental differential cross section at small momentum transfer.

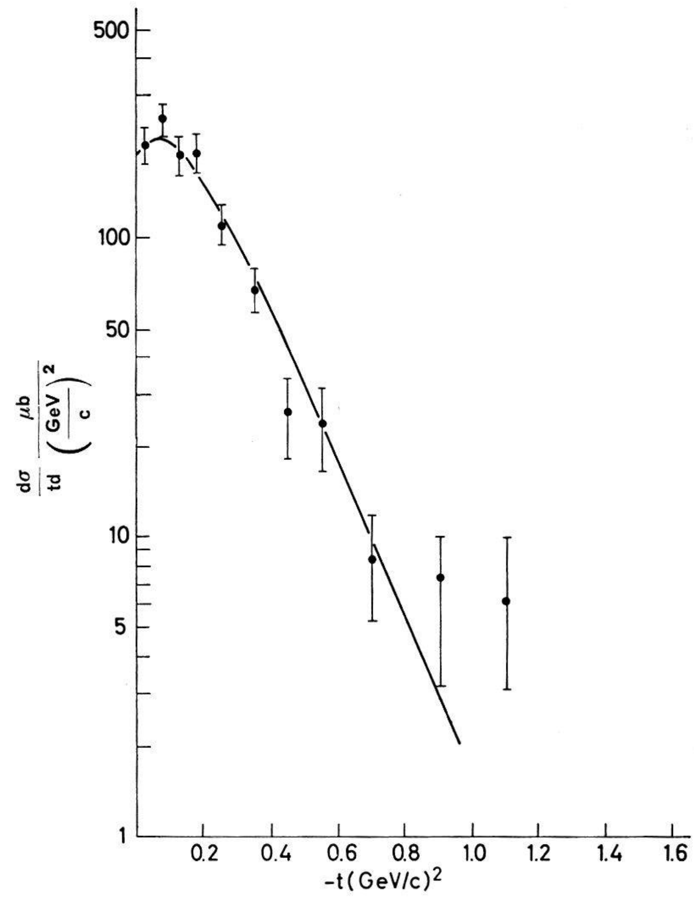

Figure 1

Experimental momentum transfer distribution and parametrization fit

It is now interesting to see what this parametrisation means in terms of spin-flip and non spin-flip amplitudes. The ratio of spin-flip to non spin-flip terms as a function of the momentum transfer can be seen in Figure 2.

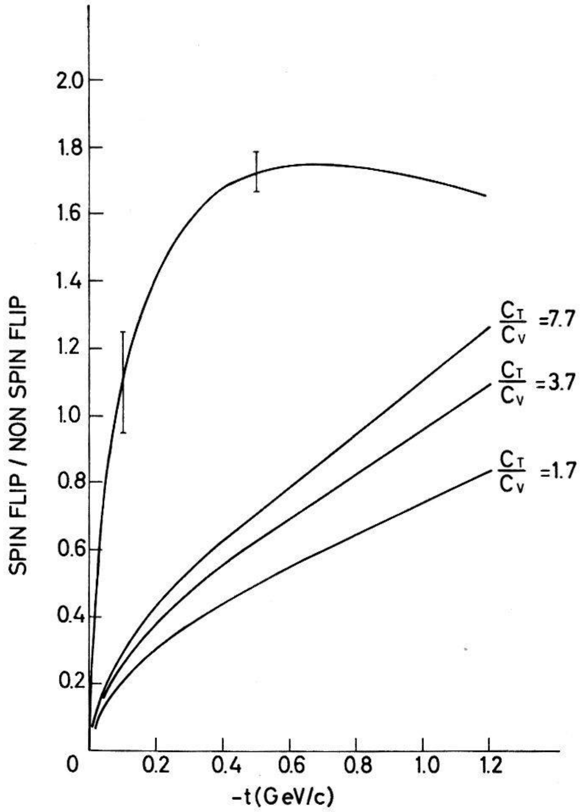

Figure 2

Spin-flip to non-spin-flip ratio for the parametrization and for a $N \varrho N$ coupling model

We compare now this result with the peripheral model. Assuming that this charge-exchange reaction is dominated by a ϱ-exchange, we define the $N \varrho N$-coupling with the Lagrangian

$$\mathfrak{L} = \frac{i}{2} \gamma_{N \varrho N} (\bar{N} \gamma_\mu N) \varrho^\mu + \frac{\mu_{N \varrho N}}{8 M} (\bar{N} \sigma_{\mu\nu} N) (\partial_\mu \varrho^\nu - \partial_\nu \varrho^\mu)$$

where $\gamma_{N \varrho N}$ is the $N \varrho N$-coupling constant and $\mu_{N \varrho N}$ the difference of the anomalous magnetic moments of the nucleons. If we believe in a ϱ-photon analogy, we take

$$\frac{\mu_{N \varrho N}}{\gamma_{N \varrho N}} = 3.7$$

which is just the ratio of the tensor to the vector coupling in the $N \varrho N$-coupling. The pseudoscalars K^- and $\bar{K}^0$ are coupled to the ϱ-meson by

$$L = \gamma_{K \varrho K} (\phi\, \partial_\mu \phi^* - \phi^* \partial_\mu \phi) \varrho^\mu$$

ϕ and ϱ^μ are the pseudoscalar- and vector-field operators respectively. $\gamma_{K \varrho K}$ is the coupling constant of the ϱ-meson to the K-mesons. With this model we get the following matrix T,

$$T = \gamma_{K \varrho K} \frac{1}{m_\varrho^2 - t} \bar{u}_2(-p_2) \left\{ \frac{u-s}{4 M} \mu_{N \varrho N} + \frac{i}{2} \gamma_\mu (q_1 + q_2)_\mu (\gamma_{N \varrho N} + \mu_{N \varrho N}) \right\} u_1(p_1)$$

$\bar{u}_2$ and u_1 are the Dirac-spinors of the neutron and the proton. $1/(m_\varrho^2 - t)$ of course comes from the ϱ-meson propagator.

It is now an easy thing to calculate the spin-flip to non spin-flip ratio for this matrix. Since we are only interested in this ratio, we are not bothered by the somewhat unknown $K\,\varrho\,K$-coupling constant. This ratio is also plotted in Figure 2. One sees that the relatively strong spin-flip term in this coupling is still smaller than demanded by the parametrisation. Therefore it is hopeless to try to reproduce the momentum transfer distribution with a first order perturbation model of the ϱ-exchange type.

Apart from this, there also arises the difficulty that the ϱ-meson propagator is too flat if one does not introduce a form factor which is strongly t dependent. One also sees that a change of the ratio C_T/C_V does not improve the situation. Even if we go over to the model of GOTTFRIED and JACKSON[3]) and take into account the absorption effects in the incoming and outgoing channels, the model is still not able to reproduce the experimental momentum transfer distribution, although the spin-flip to non spin-flip ratio is shifted in the right direction[4]). Although there is a spin-flip contribution in the $N\,\varrho\,N$-coupling the recoil neutron is not polarized. (Both, the electric and magnetic part of the coupling are real.) In our parametrisation, however, the relative phase of the amplitudes a and b can be such that, due to the large spin-flip term, a polarisation of the recoil neutron is required. This could be checked by an experiment on polarized target[5]).

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References

[1]) P. ASTBURY, G. FINOCCHIARO, A. MICHELINI, C. VERKERK, D. WEBSDALE, C. H. WEST, W. BEUSCH, B. GOBBI, M. PEPIN, E. POLGAR, M. POUCHON, Submitted to Physics Letters.

[2]) P. BORGEAUD, C. BRUNETON, P. FALK-VAIRANT, O. GUISAN, J. KIRZ, P. SONDEREGGER, A. V. STIRLING, B. AMBLARD, C. CAVERZASIO, J. P. GUILLAUD, M. YVERT, Phys. Rev. Letters *14*, 763 (1965).

[3]) K. GOTTFRFRIED and J. D. JACKSON, Nuovo Cimento *34*, 735 (1964).

[4]) T. H. HÖGAASEN, private communication.

[5]) An experiment of this kind for $\pi\,p$-charge exchange is now prepared at CERN, by the Saclay-Orsay group (see Ref. [2]).