Analysis of K^+-^{40}Ca elastic scattering at 800 MeV/c

Deeksha Chauhan[1], Z. A. Khan[2], Minita Singh[3], and G. K. Upadhyaya[4]
[1]*Department of Physics,University of Allahabad, Allahabad(U.P.) India*
[2]*Department of Physics, Aligarh Muslim University, Aligarh(U.P.) India*
[3]*Department of Physics, Mangalayatan University, Beswan, Aligarh(U.P.) India*
[4]*School of studies in Physics, Vikram University, Ujjain(M.P.) India*

Introduction

The appearance of kaon-nucleus scattering data [1,2] at intermediate energies has added a new dimension to carry out microscopic studies of nuclei. The motivation for such studies stems from the fact that, below 800 MeV/c, the K^+ N strong interaction, as characterized by total cross section, is relatively weak on the hadronic scale. Because of this K^+ meson has fairly long mean free path in nuclear matter and is therefore capable of penetrating deeply in the nuclear interior. It is, thus, expected that the analysis of K^+-nucleus scattering data could add some valuable information about the interior region of the nucleus and possibly more accurate information about the neutron density distribution for which other intermediate energy hadrons (proton, pion, α-particle) are not very helpful, due to their large absorption. Moreover, there is also a theoretical advantage in working with K^+ meson, as the contributions to the K^+-nucleus scattering arising from the multiple scattering of K^+ meson from individual target nucleons become less important.

Our primary concern, in this work, is the free K^+N amplitude, which forms the basis of the Glauber model calculations. In fact, we are interested to have that form of the K^+N amplitude which can reproduce the K^+p and K^+n scattering data for incident momentum $k \le 800$ MeV/c. The analysis also considers phase variation in the K^+N amplitude, and tests the neutron distribution extracted from the study of intermediate energy proton-nucleus scattering [3]. Using the proton distribution, as obtained from the electron scattering experiment [4], it is found that inclusion of the different density distributions for protons and neutrons in the nuclear interior, and the phase variation in the K^+N amplitude helps in providing a satisfactory account of the data up to the available range of momentum transfer.

Formulation

The correlation expansion for the Glauber amplitude [5] for describing the elastic scattering of kaons with momentum $\vec{k}$ from a target nucleus in the ground state ($|\psi_0\rangle$) takes the form

$$F_{00}(\vec{q}) = F_0(\vec{q}) + \sum_{l=1}^{A} F_l(\vec{q}), \qquad (1)$$

where

$$F_0(\vec{q}) = \frac{ik}{2\pi}\int d^2b\, e^{i\vec{q}.\vec{b}}[1-(1-\Gamma_0)^A], \qquad (2)$$

and

$$F_l(\vec{q}) = -\frac{ik}{2\pi}\int d^2b\, e^{i\vec{q}.\vec{b}} \langle\psi_0|(1-\Gamma_0)^{A-l}. \cdot \sum_{i\langle j\ldots\langle k} \gamma_i\gamma_j\ldots\gamma_k|\psi_0\rangle, \qquad (3)$$

with

$$\gamma_j = \Gamma_0(\vec{b}) - \Gamma_{KN}(\vec{b}-\vec{s}_j), \qquad (4)$$

and

$$\Gamma_0(\vec{b}) = \langle\psi_0|\Gamma_{KN}(\vec{b}-\vec{s}_j)|\psi_0\rangle, \qquad (5)$$

where $\vec{s}_j$ is the projection of jth target nucleon coordinate $\vec{r}_j$ on to a plane perpendicular to $\vec{k}$, and the KN profile function Γ_{KN} is related to the KN amplitude f_{KN} as:

$$\Gamma_{KN}(\vec{q}) = \frac{1}{2\pi i k}\int d^2 q\, e^{-i\vec{q}.\vec{b}} f_{KN}(\vec{q}) \quad (6)$$

In the present work, we restrict ourselves up to F_2 in the expression for F_{00} as it may provide a leading correction to the uncorrelated part (F_0) of the Glauber amplitude (1). Moreover, we have also included Coulomb effects.

Results and discussion

Following the above mentioned approach, we analyze the elastic angular distribution of K^+-^{40}Ca at 800 MeV/c. The inputs needed in the calculation are the elementary K^+N amplitude, and the form factors for proton and neutron distributions.

For the K^+N amplitude we use the same parametrization as used in Ref. [3]. This parametrization has six adjustable parameters. The values of these parameters, given in Table 1, are obtained from the phase shift analysis of K^+p and K^+n scattering[6] . For obtaining the proton and neutron form factors, we have used the analyses of electron[4] and proton[3] scattering experiments.

The results of the calculations for K^+-^{40}Ca elastic scattering at 800 MeV/c are presented in Fig. 1. The solid and dotted curves in Fig. 1(a) are, respectively, the predictions with and without the two-body correlations. As expected, the effects of two-body correlations are found to be only marginal. We find that our results agree with some earlier calculations (see e.g. Ref. [7,8]) which have used first-order optical model potentials.

Keeping in view the increased penetrability of K^+ meson into the nuclear interior, it would be interesting to see whether the similar proton and neutron density distributions still favor the K^+-^{40}Ca results or something more could be inferred about the matter distribution. In Fig. 1(b) the solid curve is the same as in Fig. 1(a), which considers similar distributions for protons and neutrons[4], while the dotted curve considers the neutron distribution as obtained from the proton-nucleus scattering experiments[3]. It is found that the different density distributions for protons and neutrons in the nuclear interior region push the theory closer to the experiment.

The effect of phase variation on the results presented in Fig. 1(b) is depicted in Fig. 1(c) It is found that the phase variation, with phase variation parameter = 0.39 fm^2, along with different proton and neutron density distributions provide a satisfactory account of the data up to the available range of momentum transfer.

Table 1: **K^+N amplitude parameters at 800 MeV/c**

K^+p(scaler)→	σ=1.21fm^2	ρ=0.35	β=0.097fm^2
K^+p (spin)→	ρ_s=1.047	D_s=1.99	β_s=0.25fm^2
K^+n(scaler)→	σ=1.52fm^2	ρ=-0.48	β=0.239fm^2
K^+n (spin)→	ρ_s=1.167	D_s=0.33	β_s=0.055fm^2

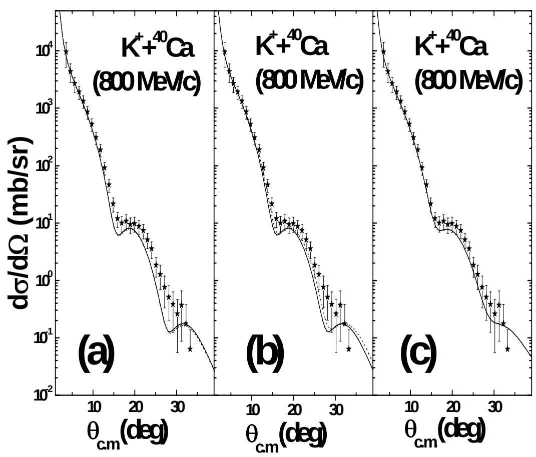

Figure 1

References

[1] D. Marlow et al., Phys. Rev. C**25**(1982)2619

[2] R. E. Chrien et al., Nucl. Phys. A**625** (1997) 251

[3] Z. A. Khan and M. Singh, Int. J. Mod. Phys. E **16**(2007) 1741.

[4] I. Sick et al., Phys. Lett. B**88**(1979)245

[5] I. Ahmad and J. P. Auger, Nucl. Phys. A**352** (1981)425

[6] J. S. Hyslop et al., Phys. Rev. D**46**(1992)961

[7] P. B. Siegel et al., Phys. Rev. C**30** (1984) 1256; Phys. Rev. C**31**(1985)2184

[8] C. M. Chen and D. J. Ernst, Phys. Rev. C**45** (1992)2019