EFFECT OF NUCLEAR STRUCTURE ON VECTOR ANALYSING POWER OF π^+ SCATTERING ON ^{7}Li NUCLEUS IN THE REGION OF THE Δ_{33} –RESONANCE

[1]Ibraeva E.T., [2]Imambekov O., [3]Prmantaeva B.A., [1]Zaykin A.Yu.
[1]*Institute of Nuclear Physic, Almaty, Kazakhstan*
[2]*Al-Farabi Kazakh National University, Almaty, Kazakhstan*
[3]*Gumilev Eurasian State University*

ABSTRACT

Within the framework of the Glauber diffraction theory vector analyzing power iT_{11} is calculated for two values of π^+ -meson energy: 134 and 164 MeV. These energy values lie in the region of the Δ_{33} – resonance of $\pi^{\pm}$N-interaction with the maximum at 180 MeV. iT_{11} have been calculated using several model wave functions of ^{7}Li nucleus (αt- cluster and shell). Sensitivity of π-^{7}Li scattering parameters to structural characteristics of the target nucleus was studied. A comparison of the calculations results and experimental data have lead to conclusion on validity of wave functions and adequacy of potentials used in calculations.

Progress in understanding of pion-nuclear interactions during last decades is associated with experiments at meson laboratories. However, those experiments based on measurements of differential cross sections (DCS) are sensitive only to the spin-independent (i.e. central) part of the amplitude. The experiments where spin-dependent quantities are observed could be more useful for a well-founded verification of theoretical models. Due to the fact that pions have a zero spin, observation of spin-dependent variables can be realized only by application of polarized targets that can be produced using a special technique.

For nucleons 1p-shell nuclei, such as ^{6}Li, ^{7}Li, are most convenient for theoretical estimation. On one hand, they have low number of nucleons that allows WF calculation for such systems with a good accuracy in frames of different models (shell, cluster, MRG, and other models). On the other hand, this approach can be used for simulation of heavier nuclei properties when it is important to take into account such factors as the Pauli principle, spin-orbital level splitting, and interaction of valence nucleons with α-particle core.

In this paper we have calculated the vector analyzing power iT_{11} and DCS in the framework of the Glauber theory for two π^+ -meson energy values: 134 and 164 MeV. These energy values lie in the region of the Δ_{33}- resonance of $\pi^{\pm}N$ – interaction with the maximum at 180 MeV. The resonance is characterized by strong $\pi^{\pm}$- absorption through the elastic channel that leads to predominant interaction in the surface layer of nucleus.

We compared results of our calculations with experimental data (DCS and iT_{11}) from paper [1]. This experiment had both some advantages and disadvantages. The advantages come from rather large cross section (~10^2 mb/sr) and high polarization of the target (~50%). The disadvantages were low resolving capacity of the magnetic spectrometer SUSI (the energy resolution in the lost-energy spectrum was ~1,8 MeV in target depth); and a limited range of angle measurements (50-110^0). The latter is essential in the Glauber diffraction theory used in calculations, since the most accurate results can be obtained in this theory for the region of lower scattering angles.

The main objective of this work is to find out how sensitive are the characteristics of π-^{7}Li scattering in respect to structural features of a target nucleus. In this connection we have calculated DCS and iT_{11} using several models WFs of the ^{7}Li nucleus: WFs obtained in αt-cluster [2] and shell models [3]. Comparison of results with experimental data [1] is the base for conclusions on WFs validity and adequacy of the potentials used in calculations.

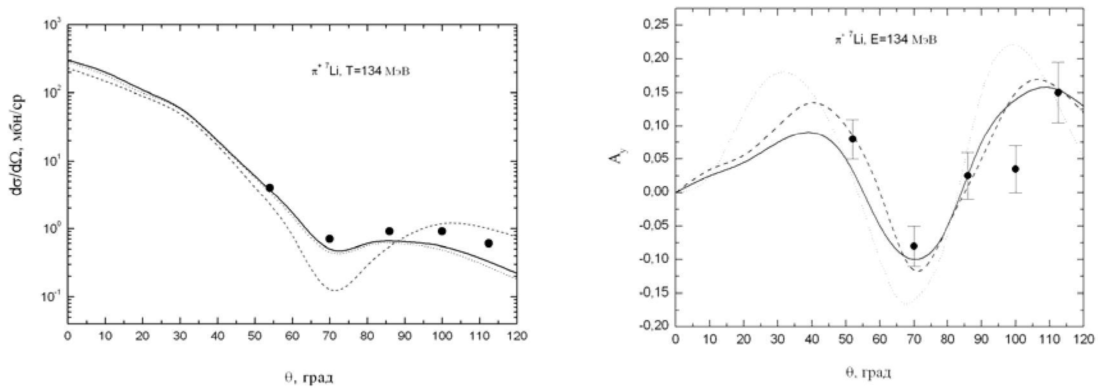

Fig.1. Differential cross section (a) and vector analyzing power iT_{11} (b) at E_π=134 MeV. Solid and dash curves – calculation using cluster WFs with different potentials of αt-interactions, dotted curve – calculation using oscillatory WF. Dots – experimental values [2].

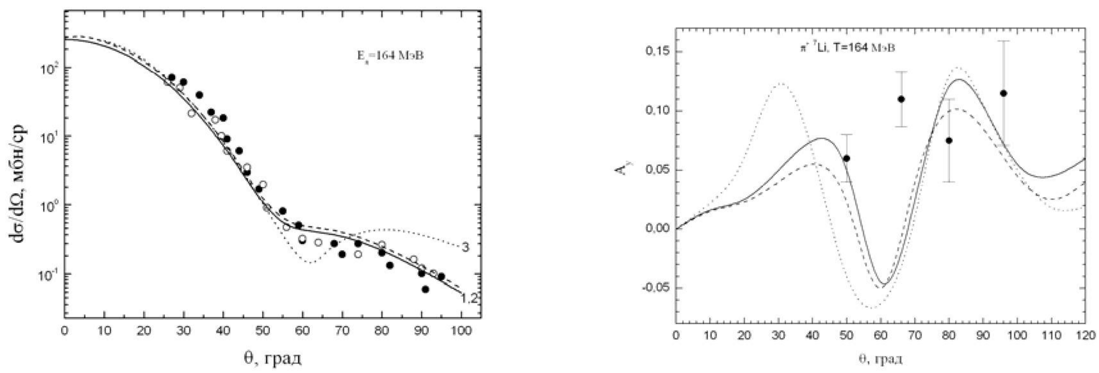

Fig.2. The same as Fig.1 for E_π=164 MeV.

Figs. 1 and 2 demonstrate results of DCS (a) and iT_{11} (b) calculations for E_π=134 and 164 MeV together with experimental data taken from the paper [1]. Solid and dash curves illustrate calculations using cluster WFs with different potentials of αt-interactions: solid – WF calculated on the base of Woods-Saxon potential, dash – WF calculated on the base of Buck potential. Dotted curve represents calculations with a shell WF computed with the harmonic oscillator potential.

All the calculated curves of DCS adequately reproduce experimental data. Differential cross sections with cluster WFs are smoother and have filled minima, generally they are closer to experimental values. It is apparent that solid and dash curves are close to each other for all energies that testifies to low DCS sensitivity to the type of potential used in cluster WFs calculations. The difference in cluster WFs computed with Woods-Saxon and Buck potentials is negligible as it was shown in the paper [2]. The calculation using shell WF has deeper DCS minimum and more pronounced second maximum in both cases that does not correspond to experimental data. There are some minor differences in curves behavior at small scattering angles and considerable differences at greater angles. The cross section at 0^o calculated using oscillator WF has a lower absolute value than that with a cluster WFs, therefore dotted curve lies lower than solid and dash curves up to the angles $\theta\sim25^o$. Such behavior is explained by different forms of cluster and oscillation WFs at distances far from the nucleus center (asymptotic). In the momentum space this asymptotic corresponds to low transferred momentum and, therefore, small scattering angles. Asymptotic of the oscillator WF is characterized by its rapid decrease that does not correspond to the real behavior of the nuclear WF. Cluster WFs have not this defect, they are more expanded in asymptotics. Thus DCSs determined by means of cluster WFs are greater than those using oscillatory WF. Discrepancies in calculations for large values of scattering angles, that correspond to small distances in the coordinate space, are explained by the fact that oscillator WF (on contrast to cluster WFs) does not take into account short-range nucleon correlations inside the nucleus.

Generally, analysis of characteristics calculated in the framework of Glauber theory for large scattering angles is not quite acceptable since the theory is limited by small scattering angles; the observed coincidence of calculations and experimental data could be accidental. As a basement for calculations at relatively low energies (under 200 MeV) we can use a fact that the front peak is available in the elementary $\pi^{\pm}N$-amplitude. This peak is responsible for predominantly forward scattering that provides validity of the main condition of the Glauber theory – the eikonal approach allowing an expansion of energy and angular ranges of its application.

Now we shall proceed to consideration of the vector analyzing power iT_{11}, shown in Figs. 1b and 2b. Description of experiment is not so accurate in this case as that illustrated by a–Figs (especially for E_π=164MeV where experimental data are monotonous and theory predicts a curve with maxima and minima). Compared with DCSs all the three curves noticeably differ from each other. Solid and dash curves are not quite identical now. Although their first minimum is near the value θ~60^o for all energies (that correlates with DCS minimum), however, behavior of the curves becomes different for the angles θ>70^o. This fact visually demonstrates the higher iT_{11} sensitivity to the nucleus structural characteristics (represented by different WFs), compared with DCSs. Dotted curve differs from the first two curves in the whole angular range: its maxima are higher and minima are deeper and are shifted to the region of forward scattering angles.

Analysis of theoretical calculations and their comparison with experimental data lead to the following conclusions.

- Glauber theory adequately describes DCS (in contrast to iT_{11}) in the range of π^+ – meson energies from 134 to 194 MeV even for large values of scattering angles, that can be explained by strong front peak in the elementary π^+N –amplitude. However, theoretical description of iT_{11} is not quite satisfactory, so it needs some further improvements.
- Calculations using cluster αt-WFs of Li^7 nucleus describe experimental data better than calculations using oscillatory WF. It is known that $\pi^{\pm}$-mesons are subjected to strong absorption in the region of the Δ_{33}-resonance where scattering proceeds. It causes predominant interaction on the nucleus surface, and the latter can be better described by cluster WFs with extended asymptotic.
- Vector analyzing power iT_{11} is more sensitive to the nucleus structural characteristics than DCS that explains its dependence not only on central but also on spin orbital interaction.

REFERENCES

1. R.Meier et al. Phys.Rev.C., 1994, 49, 320
2. S.B. Dubovichenko, M.A. Zhusupov. Yad. Fizika, 1984, 39, 1378; Izv. Acad. Nauk Kazakh Rep., ser.phys.-math., 1984, 4, 44.
3. A.N. Boyarkina. Structure of 1h-shell Nuclei. Moscow: MSU., 1973