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COMMENT ON THE S WAVE IN π^4He SCATTERING

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К вопросу о S -волне в π ^{4}He -рассеянии

Показано, что при фазовом анализе π ^{4}He -рассеяния траектория S -волны на диаграмме Аргана идет по часовой стрелке только при низких энергиях (до ~100 МэВ). Обращается внимание на то, что в работе Ф.Бинона и др. делаются неправильные выводы о поведении S -волны.

Работа выполнена в Лаборатории ядерных проблем ОИЯИ.

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On S -Wave in π ^{4}He -Scattering

It is shown, that in the phase shift analysis of π ^{4}He -scattering the S -wave shows a clockwise trajectory in the Argand diagram only in the low energy interval (up to ~100 MeV). A special attention is given to the fact that in the paper by F.Binon et al. the incorrect conclusion about the behaviour of the S -wave has been drawn.

The investigation has been performed at the Laboratory of Nuclear Problems, JINR.

Communication of the Joint Institute for Nuclear Research. Dubna 1977

Because of an accumulation of a lot of experimental data on elastic differential cross sections and total cross sections for π ^{4}He scattering, some attempts have been made for an energy dependent /1,2/ and independent phase shift analysis /3,4,5/. Such analysis is welcome not only due to the physical information which can be extracted from model independent conclusions but also for a better choice and understanding of the model dependent calculations.

Although different models for pion-nucleus scattering produce cross sections which are remarkably similar, they can differ very strongly in the phase shifts which they produce.

In ref. /2/ is shown the behaviour of the partial waves obtained in the energy dependent phase shift analysis and of those produced by the optical model calculations with the Kisslinger and Laplasian potentials. The most sensitive wave in such comparison turned out to be the S wave. This wave obtained from the energy dependent phase shift analysis shows a clockwise trajectory in the Argand diagram only in the low energy interval (up to ~100 MeV) and a general behaviour very similar to that obtained from the optical model calculations with the Kisslinger potential.

In a recent work /5/ an energy independent phase shift analysis of the $\pi^- {}^4He$ scattering has been carried out with an opposite conclusion for the behaviour of the S wave. The authors of this work claim a clockwise trajectory up to 260 MeV and intersection of this trajectory with the imaginary axis in the Argand diagram around 165 MeV.

They have fitted the experimental data with the formula:

$$\frac{d\sigma}{d\Omega} = |f_C + e^{-2i\delta} f_N|^2, \qquad (1)$$

where f_C is the Coulomb amplitude, δ is the "Bethe phase" and f_N is the nuclear amplitude parametrized as:

$$f_N = \frac{k\sigma_{tot}}{4\pi}(i+\rho)\, e^{-R^2 t/6} \cdot \prod_j (1 - \frac{t}{t_j}) \qquad (2)$$

with the parameters obtained from the fit. The authors of ref. /5/ have expanded the eq. (2) in Legendre polynomials using some tedious algebra in order to obtain the phase shifts:

$$f_N = \frac{1}{k} \sum (2\ell + 1) \cdot f_\ell \cdot P_\ell(\cos\theta). \qquad (3)$$

We were able to obtain exactly the same results for all energies except for the S wave at 180, 220 and 260 MeV. At these energies the $\mathrm{Re} f_{\ell=0} < 0$ and the $\mathrm{Im} f_{\ell=0} > 0.5$ and so the corresponding points should be in the second quadrant of the Argand plot (not in the first one as in ref. /5/). The corrected values of the S phase shift at these energies should be $(\delta_0 - 90°)$, where δ_0 is the value of the S wave published in ref. /5/ (with conventional $\delta_\ell \gtrless 0$ for $\mathrm{Re} f_\ell \gtrless 0$) and η_0 should remain the same.

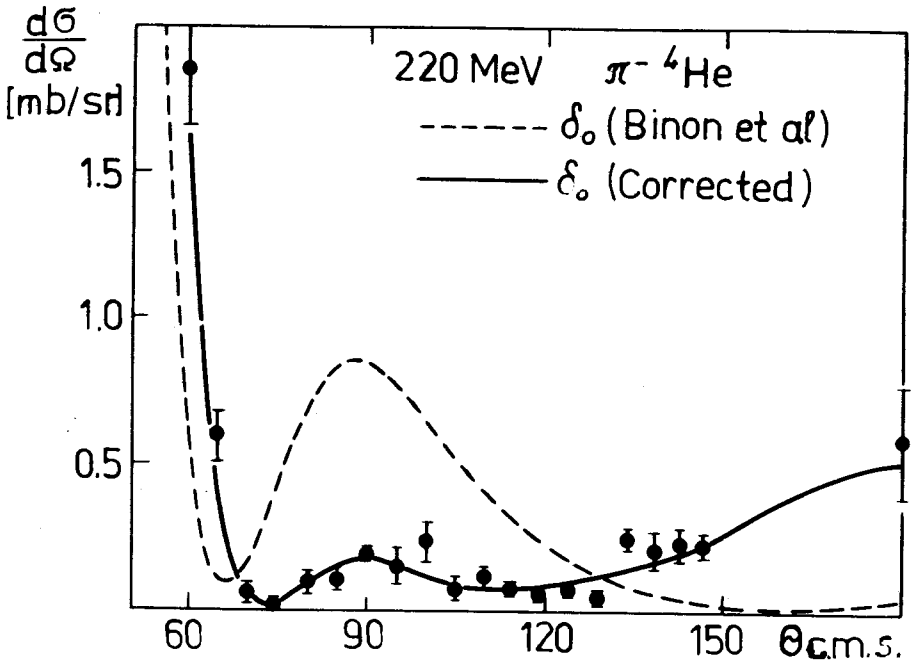

Fig. 1. The reconstructed differential cross section for $\pi^- {}^4He$ scattering at 220 MeV. The solid line - with the corrected S wave.

In fig.1 the reconstructed differential cross section for $\pi^- {}^4He$ at 220MeV (using eq. (3) for nuclear amplitude) is shown. The dashed line represents the $d\sigma/d\Omega$ calculated with the value of the S wave taken from table 5 of ref. /5/ - $\delta_0 = 15.5°$, and the solid line is the $d\sigma/d\Omega$ with corrected value for the S wave - $\delta_0 = -74.5°$. All other phases were unchanged.

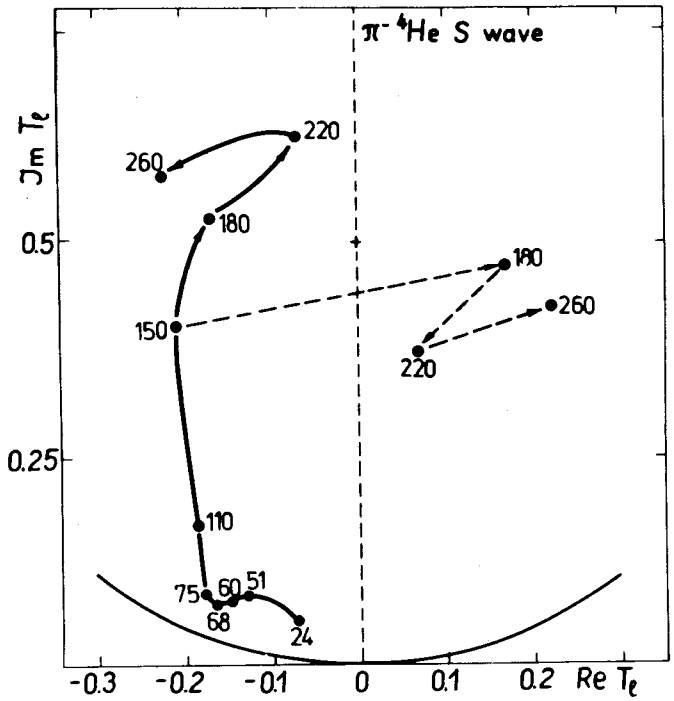

Fig. 2. The Argand plot for the S wave. The dashed line is the incorrect trajectory /5/ and the solid line is the corrected trajectory.

Figure 2 shows the Argand diagram of the S wave from π^- ^{4}He scattering. The corrected trajectory of this wave (the solid line) does not intersect the imaginary axis and is in a good agreement with the general behaviour of the S wave obtained in our previous energy dependent phase shift analysis.

From the above it is clear that the conclusion of ref. /5/ concerning the "first" indication to the formation of the Δ_{33} inside the

^{4}He nucleus "is most likely a hazard"and not only because the trajectory for the S wave doesn't intersect the imaginary axis.

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