PHYSICAL REVIEW C VOLUME 23, NUMBER 1 JANUARY 1981

Calculation of the elastic scattering of pions from light nuclei at 450 MeV

Alan K. Dozier* and Joseph S. Chalmers
Department of Physics, University of Louisville, Louisville, Kentucky 40292
(Received 6 June 1980)

A calculation is made of the elastic scattering of pions from ^{4}He and ^{16}O at an energy of 450 MeV. A single scattering optical potential is used with nuclear and nucleon form factors as determined elsewhere and the πN scattering amplitude expressed in terms of phase parameters. It is found that several of the N phase parameter sets can be readily distinguished by means of the π-nuclear scattering which they predict at this energy.

[NUCLEAR REACTIONS π^--^{4}He, ^{16}O elastic scattering, calculated $\sigma(\theta)$, compared phase shift sets, $E=450$ MeV.]

Multiple scattering theory has been very successful in extracting nuclear structure information from pion-nuclear scattering. This is particularly true at energies below 400 MeV.[1] One reason for this success is the fact that the πN scattering amplitude is so well known in this energy range that recent representations[2,3] of the πN amplitude are very similar. There is, in fact, so much agreement among current πN amplitude representations that it now makes sense to construct an "average" set of phase parameters in this energy range.[4] The convergence of the πN amplitude representations has as one of its consequences, the fact that π-nuclear scattering calculated with πN input is unable to strongly distinguish among the several πN amplitude representations.[5] This is in contrast to the situation near 1 GeV, where there is much less agreement among the available πN amplitude representations,[6] and where these πN representations are more readily distinguished by means of the π-nuclear scattering which they predict.

The energy range between 400 MeV and 1 GeV is marked by little π-nuclear scattering data. It is the purpose of this work to suggest an energy, just outside the well-explored (3,3) energy range, at which π-nuclear data would be most helpful in resolving uncertainties in π-nucleon amplitude representations.

The energy which we have chosen to investigate is 450 MeV. This is an energy which lies well within the range covered by energy-dependent searches such as CERN TH,[7] and the search due to Davies.[8] There is also available a single-energy search by Bekrenev *et al.*[9] available at 450 MeV. Finally, there is also an energy-dependent phase shift analysis due to Rowe, Salomon, and Landau[4] which averages several phase parameter sets over the range 0 – 400 MeV. We take the liberty of extrapolating this representation to 450 MeV. This variety of approaches in obtaining the πN phase parameter representation makes this a particularly interesting energy for investigation.

We compare these phase parameter representations by calculating the scattering due to single-scattering optical potential in momentum space,

$$V(q)=At(q)F(q).$$

The πN information is contained in the scattering amplitude t. The nuclear form factor is obtained from the nuclear charge form factor and the proton form factor by means of the relation

$$F(q)=F_{\rm ch}(q)/F_p(q)\,.$$

For the proton form factor, we use the form due to Littauer *et al.*[10] The nuclear charge form factors used are, for ^{4}He, the modified Gaussian form due to Frosch *et al.*[11] and, for ^{16}O, the parabolic Gaussian form due to Ehrenberg *et al.*[12] The potential is then used in the solution of the partial wave scattering equation in momentum space.[13]

The results for π^--^{4}He are shown in Fig. 1; CT is for the CERN TH set, RSL is from Ref. 4, D is from Ref. 8, and S III is from Ref. 9. Only the RSL set predicts a true diffraction minimum. The other sets, which are difficult to distinguish in this plot, predict only a point of inflection. For the π^--^{4}He calculation, the RSL plot can be distinguished, but CERN TH, Davies, and S III predict essentially identical π-He scattering and cannot be distinguished.

Figure 2 shows the results for π^--^{16}O scattering. While CERN TH and Davies are still difficult to separate, these sets lead to scattering which is quite different from that predicted by either RSL or S III. This indicates that π^--^{16}O data near 450 MeV could be very effective in helping to choose among πN amplitude representations at

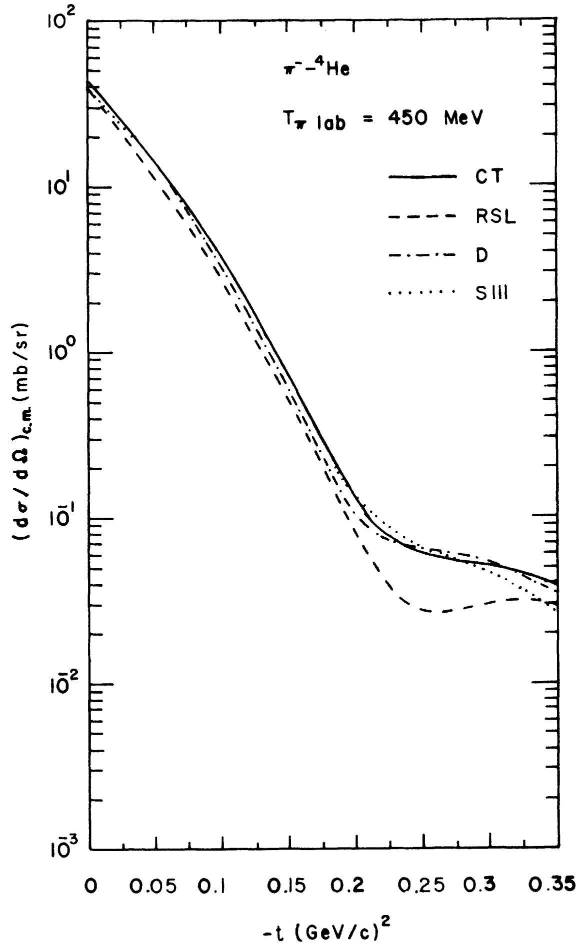

FIG. 1. Comparison of π^--^{4}He elastic scattering at 450 MeV as calculated with various scattering amplitude representations. Designations of representations given in text.

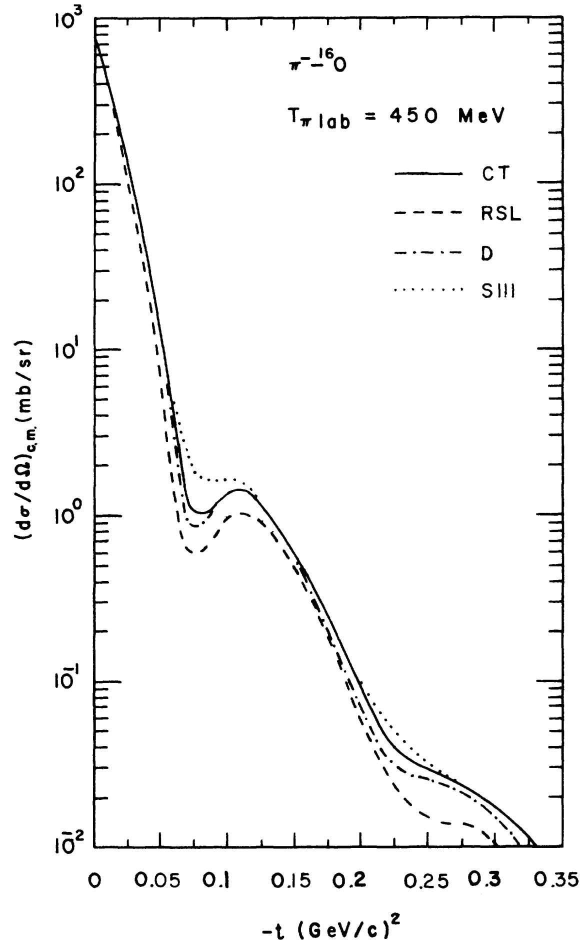

FIG. 2. Comparison of π^--^{16}O elastic scattering at 450 MeV as calculated with various scattering amplitude representations. Designations of representations given in text.

this energy.

As we have seen, π-nuclear scattering data at 450 MeV would be most useful at resolving disagreements among the various phase parameter representations. This is true for both π^--^{4}He and π^--^{16}O scattering but is especially true in the latter case. It is hoped that this calculation might provide some interest in the acquisition of π-nuclear data at this energy.

---

*Present address: Department of Physics, Washington University, St. Louis, Missouri 63130.

[1]A. W. Thomas and R. H. Landau, Phys. Rep. 58, 121 (1980).
[2]J. R. Carter, D. V. Bugg, and A. A. Carter, Nucl. Phys. B58, 378 (1973).
[3]R. Koch and E. Pietarinen, Nucl. Phys. A336, 331 (1980).
[4]G. Rowe, M. Salomon, and R. H. Landau, Phys. Rev. C 18, 584 (1978).
[5]J. S. Chalmers and S. K. Longley, Bull. Am. Phys. Soc. 24, 63 (1979).
[6]A. K. Dozier and J. S. Chalmers, Phys. Rev. C (to be published).
[7]D. J. Herndon, A. Barbaro-Galtieri, and A. H. Rosenfeld, LRL Report No. UCRL-20030 N, 1970 (unpublished).
[8]A. T. Davies, Nucl. Phys. B21, 359 (1970).
[9]V. S. Bekrenev *et al.*, Yad Fiz. 24, 91 (1976) [Sov. J. Nucl. Phys. 24, 45 (1976)].
[10]R. M. Littauer, H. F. Schopper, and R. R. Wilson, Phys. Rev. Lett. 7, 141 (1961).

[11]R. F. Frosch, J. S. McCarty, R. E. Rand, and M. R. Yearian, Phys. Rev. 160, 874 (1967).
[12]H. F. Ehrenberg, R. Hofstadter, U. Meyer-Berkhout, D. G. Ravenhall, and S. E. Sabottka, Phys. Rev. 113, 666 (1959).
[13]M. L. Goldberger and K. M. Watson, *Collision Theory* (Wiley, New York, 1964).