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Pion-nucleon phase shifts and pion-nucleus scattering

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It is shown that, contrary to a recent suggestion, pion-nucleus scattering is not likely to distinguish among different π-N phase shift sets which are in agreement with the π-N data.

[NUCLEAR REACTIONS Calculated π^--^{4}He, ^{16}O elastic scattering, effects of π-N phase shift sets.]

Dozier and Chalmers have suggested recently[1] that the elastic scattering of pions by light nuclei at 450 MeV could be used to distinguish among several sets of pion-nucleon phase shifts. This is an interesting idea, but it raises an important question: How well do the four sets of pion-nucleon parameters[2–5] used in the calculations reproduce the two body data? Before one attempts to use many-body systems to study two-body interactions, one should ascertain that the descriptions are really equivalent in the two-body case. This is, in fact, not true here.

Three of the parameter sets represent fits to the pion-nucleon scattering data: the CERN-TH set of Almehed and Lovelace,[2] the SIII set of Bekrenev *et al.*,[3] and the Davies set.[4] However, the fourth set (RSL) is an *extrapolation* of analytic formulas fitted by Rowe, Salomon, and Landau[5] to "recent S, P, and larger D wave πN phase shifts determined by various groups for energies below 400 MeV." Since all the absorption parameters were set equal to unity and not all the necessary waves were included, it is inappropriate and unreliable to extrapolate their results to 450 MeV. This can easily be seen from plots of the RSL and CERN-TH differential cross section for π^--p elastic scattering at 450 MeV, shown in Fig. 1 along with the measured values. It is obvious that the RSL curve is inconsistent with the data, while the CERN-TH fit is excellent. It is apparent from Fig. 3 of Ref. 3 that the SIII phase shifts also fit this same data

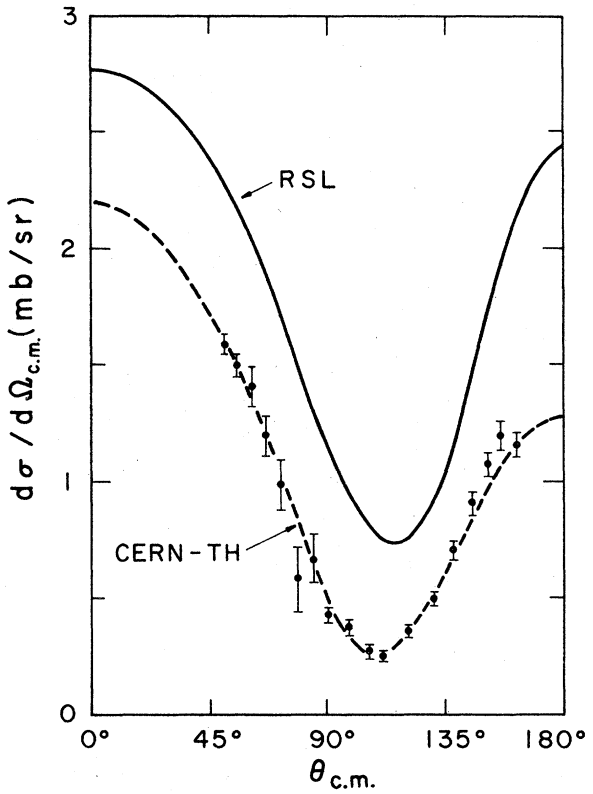

FIG. 1. π^--p scattering at lab kinetic energy 450 MeV. The broken curve is calculated using the phase shifts of Ref. 2, and the solid curve is obtained by extrapolating the analytic formulas given in Ref. 5 for use only up to 400 MeV. Experimental data are from Ref. 6.

quite well, but the calculated curve differs somewhat from the CERN-TH curve shown in our paper, especially at small and large scattering angles. Presumably, the Davies phase shifts[4] also fit the data, since they were the result of a search precedure somewhat similar to that employed in constructing the CERN-TH phases.

In Ref. 1, it is found that only the RSL parameter set gives results which differ significantly from the others in a lowest order optical model calculation of π^--^{4}He elastic scattering. Given its failure to fit the π-N data, this difference is not surprising. Similar calculations for π^--^{16}O show that the SIII set also generates a somewhat different cross section near the diffraction minimum. The depths of diffraction minima are notorious for their sensitivity to small nuclear effects, and it is unlikely that one could ever use such information to sort out π-N phase shift sets.

In conclusion, we see that when π-N phase shifts are used which fit the two-body data, the pion-nucleus predictions are not significantly different. Attempts to improve our knowledge of these phase shifts would be most productive if they were focused on improved measurements and analyses of the pion-nucleon system itself.

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[5]G. Rowe, M. Salomon, and R. H. Landau, Phys. Rev. C 18, 584 (1978).

[6]P. M. Odgen *et al.*, Phys. Rev. 137, B1115 (1965).