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FEW ASPECTS OF PION-NUCLEUS SCATTERING

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It is well known that in the very near future meson factories will be able to give very good beams of π^+ and π^- mesons of high intensity and energy resolution. The energy region available will be extended from 10 MeV up to 350 MeV. For this interval of energies a number of accurate experiments is now proposed in order to fill up the gap of experimental points for few ''physical observables''.

The general feature of these proposals is that they are uncorrelated, and, I will try, in the next few minutes, to show you some few new problems of pion-light nuclei physics in order to convince you of the necessity of ''priority'' for experiments in this field.

New experimental data on the total cross section of π^+ and π^- on nuclei are now available from CERN /1/ and Rutherford Laboratory /2/ (for ^4He, ^6Li, ^7Li, ^9Be, ^{12}C, ^{16}O, ^{32}S). The total cross section has a maximum around the Δ_{33} resonance but shifted downward in energy (the shift seems to increase with the number of nucleons).

The new interesting aspect is in the large differences between $\sigma^{\pi^-}_{tot}$ and $\sigma^{\pi^+}_{tot}$ for zero isospin nuclei. The effect seems to be caused by the Coulomb barrier /3/ but the different shape or radii of the neutron and proton densities /4/ of these nuclei may produce the same effect.

On the other hand, these data on $\sigma^{\pi^\pm}_{tot}$ are obtained from transmission type experiments, where the knowledge of Ref(0) in the extrapolation procedure is very important. The values of Ref(0) were taken from optical models or forward dispersion relation calculations.

The problem is that there are still large discrepancies between the results of different model calculations [2], and there are also, for example for π^4He, discrepancies between experimental values of Ref(0) and dispersion relation or forward finite sum rules calculations [5].

In order to have unambiguous and accurate experimental data it is necessary to carry out a series of, I would say, ''correlated experiments''.

The first experiment of this series would include measurements of differential cross sections $d\sigma/d\Omega$ for both π^+ and π^- in an as large as possible angular interval, including special measurements in a very forward direction. In this way we may get some ideas about the Coulomb interference, the general behaviour of elastic cross section, and, I suppose, a good determination of Ref(0).

The second experiment would be the measurement of the total cross section by the transmission method (a very fast and ''statistically accurate'' method) using information from the first experiment.

To control the experimental data obtained by the transmission method (the possible systematical errors) the second experiment should be accompanied by measurements (only at few energies) of the total cross sections by ''classical'' methods (with visualizing track chambers).

And the third experiment would be measurements at very low energy - up to the break-up threshold (~ 28 MeV for ^4He) where it is possible to use some information continuing (for example by phase shift analysis) the results from medium energies.

The aim of this series of correlated experiments - combined into one ''total'' experiment - is to obtain as model independent as possible experimental results.

Accurate total cross sections and differential cross sections over a large angular interval will help in phase shift analysis, in understanding the Coulomb corrections and will permit detailed nuclear structure analysis. Comparison of these results with the dispersion relation calculations will give useful information about the unphysical region. For example it would be interesting to determine the effective pion-nucleus coupling constant. The theoretical estimations with different models give for ^3He nucleus the values [6,7]

$$f^2_{\pi\, ^3He\, ^3H} = (1. - 1.94)\, f^2_{\pi NN}$$

whilst its determination for heavier nuclei is [8,9]

$$f^2_{\pi\, ^9Be} \simeq f^2_{\pi\, ^7Li} \approx 0.05.$$

Now new experimental data on this field are available for $\pi^\pm\, ^4He$ elastic scattering differential cross sections up to 180 MeV [10] (angular interval: 27° - 165°), $d\sigma/d\Omega$ for backward $\pi^-\, ^{12}C$ elastic scattering [11] (60 - 100 MeV) - very important in phase shift analysis, and $d\sigma/d\Omega$ for $\pi^\pm\, ^3He$ at few energies [10,12] (100, 135, 154 MeV).

In order to have useful and accurate experimental measurements one should continue the analysis of ''old'' type experimental data and use their results to plan the future series of experiments (maybe for different meson facilities) taking into account ''physical priority''.

References

1. C.Wilkin, C.R.Cox, J.J.Domingo, K.Gabathuler, E.Pedroni, J.Rohlin, P.Schwaller, N.W.Tauner. Nucl. Phys., B62, 61 (1973).
2. B.W.Allardyce, C.J.Batty, D.J.Baugh, W.J.McDonald, R.A.J.Riddle, L.H.Watson, M.E.Cage, G.J.Pyle, G.T.A.Squier, A.S.Clough, G.K.Turner. Preprint RL-73-038, Rutherford Lab. (1973).
3. G.Faldt, H.Pilkuhn. Phys.Lett., 40B, 613 (1972); Phys. Lett., 46B, 337 (1973).
4. F.Becker, Yu.A.Batusov. Revista del Nuovo Cimento, 1, 309, (1971).
5. L.Alexandrov, T.Angelescu, I.V.Falomkin, F.Nichitiu, Yu.A.Shcherbakov. Contribution to the Conference on Few Body Problems in Nuclear Physics, Quebec, Canada, 1974.
6. T.Erocson, M.Locher. Nucl.Phys., A178, 1 (1970).
7. B.Z.Kopeliovitsch. Preprint JINR, P2-7086, Dubna, 1973.
8. P.Osland. Ref. Th-1613, CERN (1973).

9. G.T.A.Squier, M.E.Cage, G.I.Pyle, A.S.Clough, G.K.Turner, B.W.Allardyce, C.J.Batty, D.J.Baugh. Preprint RL-73-037, Rutherford Lab.. (1973).
10. T.Angelescu. Private communication.
11. C.Guaraldo and G.Piragino. Private communication.
12. M.Albu, T.Besliu, R.Garfagnini, M.M.Kulyukin, V.I.Lyashenko, A.Mihul, F.Nichitiu, G.Piragino, G.Pontecorvo, I.V.Falomkin, Yu.A.Shcherbakov. Lett. Nuovo Cim., 5, 1121 (1972); Preprint JINR, P1-7742, Dubna, 1974.

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