Title

PROTON POLARIZATION IN SMALL ANGLE p-He4

Authors

Boschitz, E.
Chabre, M.
Conzett, H.E.
et al.

Publication Date

1965-02-26

UCRL-11964

University of California

Ernest O. Lawrence Radiation Laboratory

PROTON POLARIZATION IN SMALL ANGLE P-He^4 SCATTERING AT 38.7 MeV

Berkeley, California

Submitted to Physics Letters

UCRL-11964

UNIVERSITY OF CALIFORNIA

Lawrence Radiation Laboratory
Berkeley, California

PROTON POLARIZATION IN SMALL ANGLE p-He^4 SCATTERING AT 38.7 MeV

E. Boschitz, M. Chabre, H. E. Conzett, E. Shield, and R. J. Slobodrian

February 26, 1965

PROTON POLARIZATION IN SMALL ANGLE p-He^4 SCATTERING AT 38.7 MeV*

E. Boschitz†, M. Chabre‡, H. E. Conzett, E. Shield, and R. J. Slobodrian

Lawrence Radiation Laboratory
University of California
Berkeley, California

February 26, 1965

In the last two years different phase shift analyses[1,2] of the p-He^4 cross section and polarization data[3,4] around 38 MeV have been published. Recently Giamati and Thaler[5] have discussed the possibility of determining a unique phase-shift solution by means of further double or triple scattering experiments. They point out that sufficient information can be obtained by a double scattering experiment, obviously more easy and precise than a triple scattering experiment, carried out in the region of interference between the Coulomb and the nuclear scattering amplitude. In this region, significantly different polarizations (about 0.20) are calculated from the different sets of phase shifts. Therefore small angle polarization measurements with an absolute precision of about ± 0.03 should allow one to decide between them. Recently the rotation of the polarization has been measured at 48 MeV.[6] The results seem to favor the GM[5] type of solution, although not very strongly, and moreover the energy of the measurement differs appreciably from the energy of the phase shift solutions.

We have measured the polarization at small angles with a standard double scattering technique. The experimental setup was basically the same as was described in an earlier paper.[6] The polarized protons were produced as recoils from a hydrogen target bombarded by a beam of alpha particles at approximately 80 MeV. The proton polarization was taken to be $P_1 = +.83 \pm .03$, with the probable error arising principally from counting statistics.[7] The protons were scattered from the He-gas target at a mean energy of 38.7 ± 0.6

MeV. The intensity distribution and location of the beam at the gas target center, as well as its alignment with respect to the precision scattering table, were determined by beam profile measurements. For this purpose an ionization chamber with a tantalum slit 0.16 cm. wide was used as a scanner. Beam radiographs on X-ray film were also obtained in order to get information on the actual beam shape. The beam width was 0.9 cm. at the target center, and its divergence in the horizontal plane was $\pm 0.10^{\circ}$. The maximum angular error in positioning the detectors, determined by beam alignment, was $\pm 0.12^{\circ}$; this corresponds in first order, to an instrumental asymmetry $\epsilon \leq \pm 0.003$ calculated from the known data for the cross section in the small angle region.

Four CsI detectors mounted on DuMond 6363 phototubes were used. Two of them were fitted with collimation systems, designed especially for small angle measurements, which provided an angular resolution of $\pm 0.3^{\circ}$. The two remaining ones were used for check measurements at larger angles with the usual angular resolution ($\pm 1.5^{\circ}$).

In making the measurements, instrumental asymmetries were minimized by interchanging assemblies (and associated electronics). The smallest angle at which measurements were taken was 8° Lab, and checks were carried out to insure that no scattering from the target window was detected. At smaller angles a large background counting rate produced results with a large uncertainty. The background was determined by reducing the pressure of the He gas from the operating pressure of 8 atmospheres down to 1 atmosphere, and obtaining spectra for equal charge collected in the monitoring system, and, alternatively, by inserting brass absorbers in front of the CsI crystals.

Figure 1 shows the existing experimental data up to 100° CM and including the results of the present investigation. The latter are contained in Table I, where the listed errors arise solely from counting statistics.

The present measurements at 63.4 and 99.4° CM served as check points. With the exception of the polarization value at 10° CM all small angle data favors the Sy-A[1] phase shift solution. However, the 10° CM data point, which is closest to the Coulomb interference minimum in the differential cross section, suggests that an intermediate phase shift set between SY-A and GMT-B[5] might be found to better represent the experimental data to date. Also, in view of the data points between 50 and 90° CM, it is interesting to notice that the SY solution, containing partial waves only up to $\ell = 3$, behaves too smoothly in this angular region, while the GMT($\ell_{max} = 5$) solution provides oscillations of larger amplitude than are present in the data. The SY-A solution does not include g waves, which could be contributing to the scattering at this energy (kR $\simeq$ 4.25). This possibility is supported by the Harwell polarization data[8] at 29, 40 and 48 MeV. While the 29 MeV data behave quite smoothly around 70° CM, a "kink" appears at 40 MeV and finally develops into a new oscillation at 48 MeV. Thus, we feel that a complex phase shift analysis of the 38 MeV data should definitely include at least $\ell = 4$ partial waves, and we expect that the small angle values of the polarization will help to establish a unique solution.

FOOTNOTES AND REFERENCES

*Work done under the auspices of the U. S. Atomic Energy Commission.

†On leave from NASA Lewis Research Center, Cleveland, Ohio.

‡NATO Fellow on leave from CNRS, Institut Fourier, Grenoble, France.

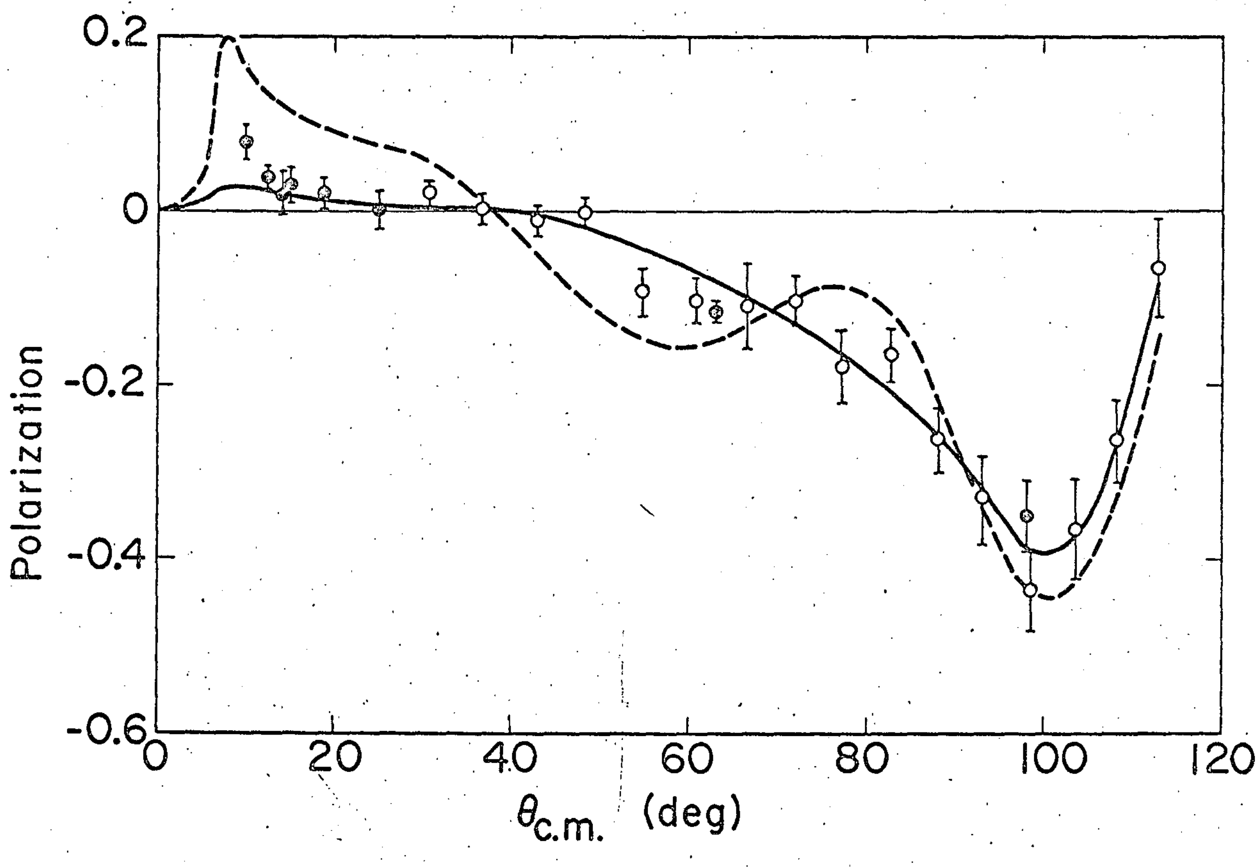
1. S. Suwa and A. Yokosawa, Phys. Letters 5, 351 (1963).
2. C. C. Giamati, V.A. Madsen and R. M. Thaler, Phys. Rev. Letters 11, 163 (1963).
3. M. K. Brussel and J. H. Williams, Phys. Rev. 106, 286 (1957).
4. C. F. Hwang, D. H. Nordby, S. Suwa and J. H. Williams, Phys. Rev. Letters 9, 104 (1962).
5. C. C. Giamati and R. M. Thaler, Nucl. Phys. 59, 159 (1964).
6. T. H. Griffith, D. C. Imrie, G. J. Lush and L. A. Robbins, Congrès International de Physique Nucléaire, Paris, July 1964, Abstract No. 1 bis/C 80, p. 19, and private communication.
7. H. E. Conzett, H. S. Goldberg, E. Shield, R. J. Slobodrian and S. Yamabe, Phys. Letters 11, 68 (1964).
8. An additional uncertainty of 5 to 10% in P_1 will be resolved in a future measurement, but this uncertainty does not affect the conclusions stated in this letter.
9. M. K. Craddock, R. C. Hanna, L. P. Robertson and B. W. Davies, Phys. Letters 5, 335 (1963).

FIGURE CAPTION

Fig. 1. Polarization P as function of center-of-mass scattering angle. The open circles shown are the data taken from ref. 4, the full circles are the result of the present investigation. The solid curve is the prediction of the SY-A[1] phase shift solution, the dashed line corresponds to the GMT-B[5] solution.

Table I. Polarization in p-He^4 elastic scattering at 38.7 MeV.

θ_{Lab}	θ_{CM}	$P(\theta)$
8.0	10.0	+0.082 ± .021
10.0	12.5	+0.041 ± .014
11.0	13.7	+0.019 ± .024
12.0	15.0	+0.030 ± .023
15.0	18.7	+0.022 ± .023
20.0	24.9	+0.005 ± .025
52.0	63.4	-0.115 ± .011
85.0	99.4	-0.350 ± .040



MUB-5307