Lawrence Berkeley National Laboratory
Recent Work

Title
SMALL ANGLE BEHAVIOUR OF THE POLARIZATION IN P-D ELASTIC SCATTERING

Permalink
https://escholarship.org/uc/item/1f51j6pv

Authors
McKee, J.S.C.
Luccio, A.U.
Slobodrian, R.J.
et al.

Publication Date
1967-08-01

eScholarship.org Powered by the California Digital Library
University of California

UCRL-17755

University of California

Ernest O. Lawrence Radiation Laboratory

SMALL ANGLE BEHAVIOUR OF THE POLARIZATION IN P-D ELASTIC SCATTERING

J. S. C. McKee, A. U. Luccio, R. J. Slobodrian
and W. F. Tivol

August 1967

RECEIVED
LAWRENCE
RADIATION LABORATORY
LIBRARY AND
DOCUMENTS SEC

TWO-WEEK LOAN COPY

This is a Library Circulating Copy which may be borrowed for two weeks. For a personal retention copy, call Tech. Info. Division, Ext. 5545

Berkeley, California

UCRL-17755

DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.

Submitted to Physics Letters

UCRL-17755
Preprint

UNIVERSITY OF CALIFORNIA

Lawrence Radiation Laboratory
Berkeley, California

AEC Contract No. W-7405-eng-48

SMALL ANGLE BEHAVIOUR OF THE POLARIZATION IN P-D ELASTIC SCATTERING

J. S. C. McKee, A. U. Luccio, R. J. Slobodrian and W. F. Tivol

August 1967

SMALL ANGLE BEHAVIOUR OF THE POLARIZATION IN P-D ELASTIC SCATTERING[†]

J. S. C. McKee[‡], A. U. Luccio, R. J. Slobodrian, and W. F. Tivol

Lawrence Radiation Laboratory
University of California
Berkeley, California

August 1967

Abstract: Measurements of the polarization in p-d scattering at 11.6 MeV show a minimum in the asymmetry distribution at 29° centre of mass. This observation seems to be consistent with spin orbit effects in the p-d interaction at this energy.

Recent data from this laboratory[1] on the polarization of protons elastically scattered from deuterium in the energy range from 11.0 to 19.1 MeV, indicated the development of a negative polarization close to the known minimum in the elastic scattering cross section at 120° in the centre of mass.

A negative polarization was also observed at the lowest angles investigated in the data obtained at 11.0 and 13.2 MeV, in contrast to Wisconsin measurements[2] in the same energy interval.

The present experiment was carried out as an investigation into the small angle behaviour of the polarization, and results are shown in fig. 1. Figure 1(a) shows previous data from this laboratory at 11.0 MeV, fig. 1(b) shows the present data obtained at 11.6 MeV, while fig. 1(c) shows the previous results for an energy of 13.2 MeV.

[†]This work performed under the auspices of the U. S. Atomic Energy Commission.

[‡] On study leave from the University of Birmingham, England.

The context of the small angle points in fig. 1(b) is such as to indicate a minimum in the observed asymmetry distribution at around 29° centre of mass angle, for this energy. These data interpolate well between the results shown in figs. 1(a) and 1(c). Comparison with the earlier results indicates that the minimum moves forward with increasing energy.

The present experiment was carried out using the polarized beam facility of the 88" variable energy cyclotron at Berkeley, which provides protons of approximately 100% polarization.

For measurement of the asymmetry distribution in p-d scattering at large angles (greater than 22° Lab.), the equipment used was similar to that already described.[1)]

The target pressure was three atmospheres absolute, and pulses from all telescopes were routed to quadrants of a Nuclear Data 4096-channel pulse height analyser. At forward angles extended counter arms were used to support small geometry collimators and additional ΔE counters of 0.004-in. CsI(Tl). The coincidence requirement between pulses from E and ΔE counters produced very clean spectra. The E counters were 0.030-in. thick for small angle work, and the collimation system defined an angular acceptance of $\theta_{LAB} \sim 1^{o}$. A spin precession magnet was used to reverse the spin of the incident proton beam at each angle investigated. Background from sources other than charged particles was found to be entirely negligible.

The study of p-d interactions is experimentally the simplest of the nuclear three body systems. None the less, there is as yet no adequate theory to describe the interactions involved, and no predictions of p-d polarizations are presently available below 40 MeV. In the n-d case, however, the theoretical

work of Purrington[3] including tensor forces suggests a negative polarization for angles forward of 45° centre of mass, at 10.0-MeV neutron energy. The inclusion of Coulomb and spin orbit effects in the p-d case might well add an oscillatory behaviour to the present form of this distribution. An interesting observation can be made from an examination of small angle p-d elastic scattering data in the energy range from 9.7 to 13.9 MeV[4,5,6], and near the minimum seen in fig. 1. Rodberg[7] has pointed out that there may be a relation between the zeros of polarization and the maxima and minima in cross-section data. He has discussed observed polarization in terms of the optical model, and found that a spin orbit interaction when introduced as a small additional part to the real central potential, can reasonably predict observed asymmetries when these are mainly due to such an interaction.

The present results have been examined from this point of view, and data on elastic scattering and polarization at 90° centre of mass are used to predict a value for the depth of the spin orbit potential (V_{so}) using an interaction radius of 1.56 fm. and a value of -43 MeV[8] for the real part of the central interaction (V_c).

The value obtained for V_{so} is 1.0 MeV for an incident nucleon energy of 11.6-MeV. When this value is further used to predict the polarization in p-d scattering at 30° centre of mass, a result of 0.014 is obtained, in reasonable agreement with our observed results. The position of the two zeros in polarization at small angles is also well reproduced from a study of the shape of the elastic scattering cross section in this angular region. Our results are thus consistent with spin orbit effects in the p-d interaction.

References

1) J. S. C. McKee, D. J. Clark, R. J. Slobodrian and W. F. Tivol, Phys. Letters 24B (1967) 240

2) T. B. Clegg and W. Haeberli, Nucl. Phys. A95 (1967) 608

3) R. D. Purrington, Ph.D. Thesis, Texas A and M. University (1966) (We learned of this work through a private communication from J. D. Seagrave, for which we are grateful.)

4) J. C. Allred, A. H. Armstrong, R. O. Bondelid and L. Rosen, Phys. Rev. 88 (1952) 433

5) S. Kikuchi, J. Sanada, S. Suwa, I. Hayashi, K. Nisimura and K. Fukunaga, Jour. Phys. Soc. (Japan) 15 (1960) 9

6) W. T. H. Van Oers and K. W. Brockman, Jr., Nucl. Phys. 21 (1960) 189

7) L. S. Rodberg, Nucl. Phys. 15 (1959) 72

8) F. Bjorklund and S. Fernbach, Phys. Rev. 109 (1958) 1295

Figure Caption

Fig. 1. shows data obtained at three energies: 11.0, 11.6 and 13.2 MeV for the asymmetry (ϵ) in p-d scattering. Parts 1(a) and 1(c) are previous data contained in ref. 1) Part 1(b) is the data from this experiment. The open circles are obtained using the small angle collimation and coincidence system, while all other data are obtained by the methods of ref. 1). Error shown are statistical. The dashed lines indicate comparable positions for a zero in polarization at each energy.

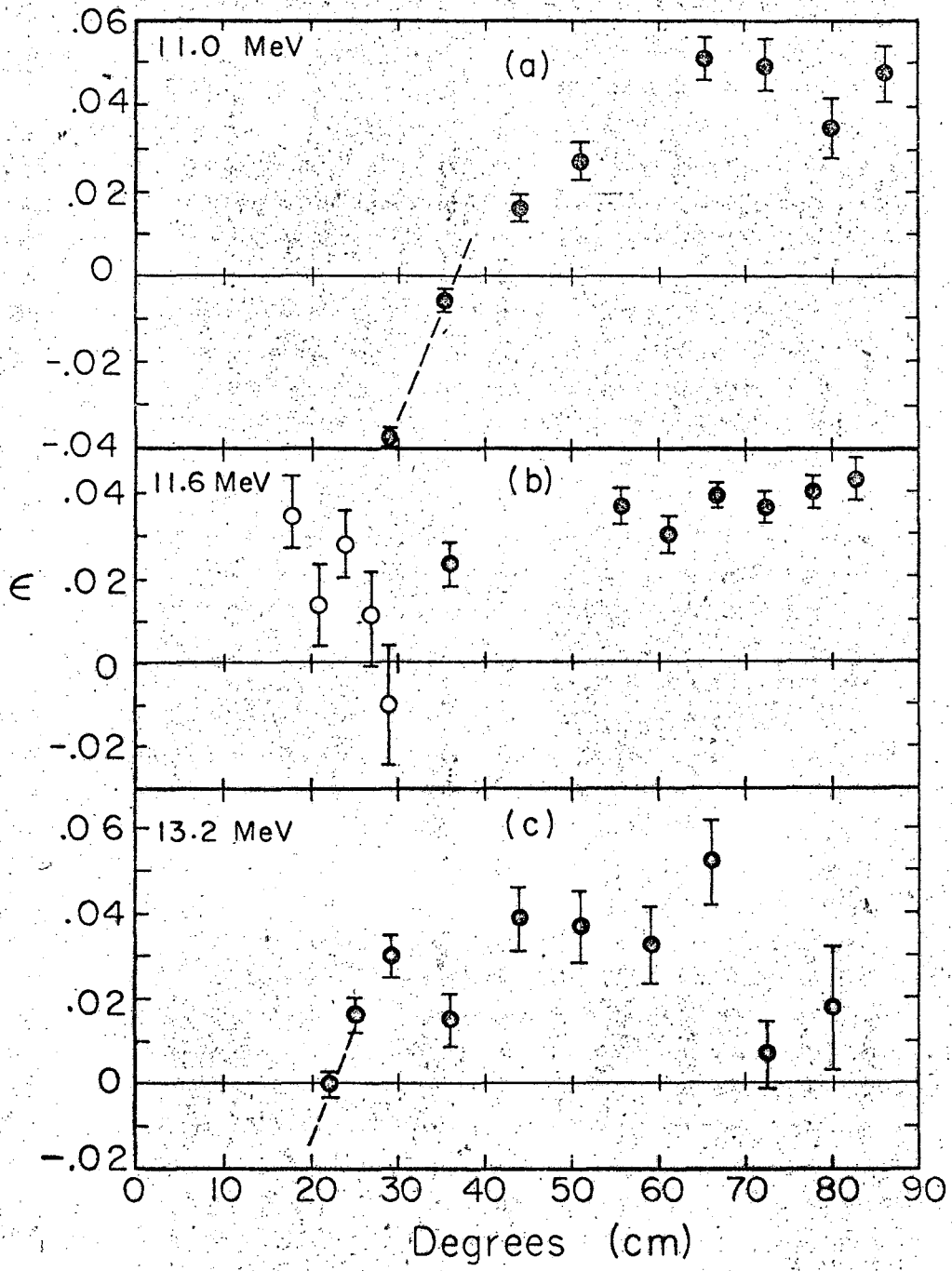

Fig. 1.

XBL678-3898

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.