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

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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.

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‡ 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 $\theta_{LAB} \sim 1^{\circ}$. 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.

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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.

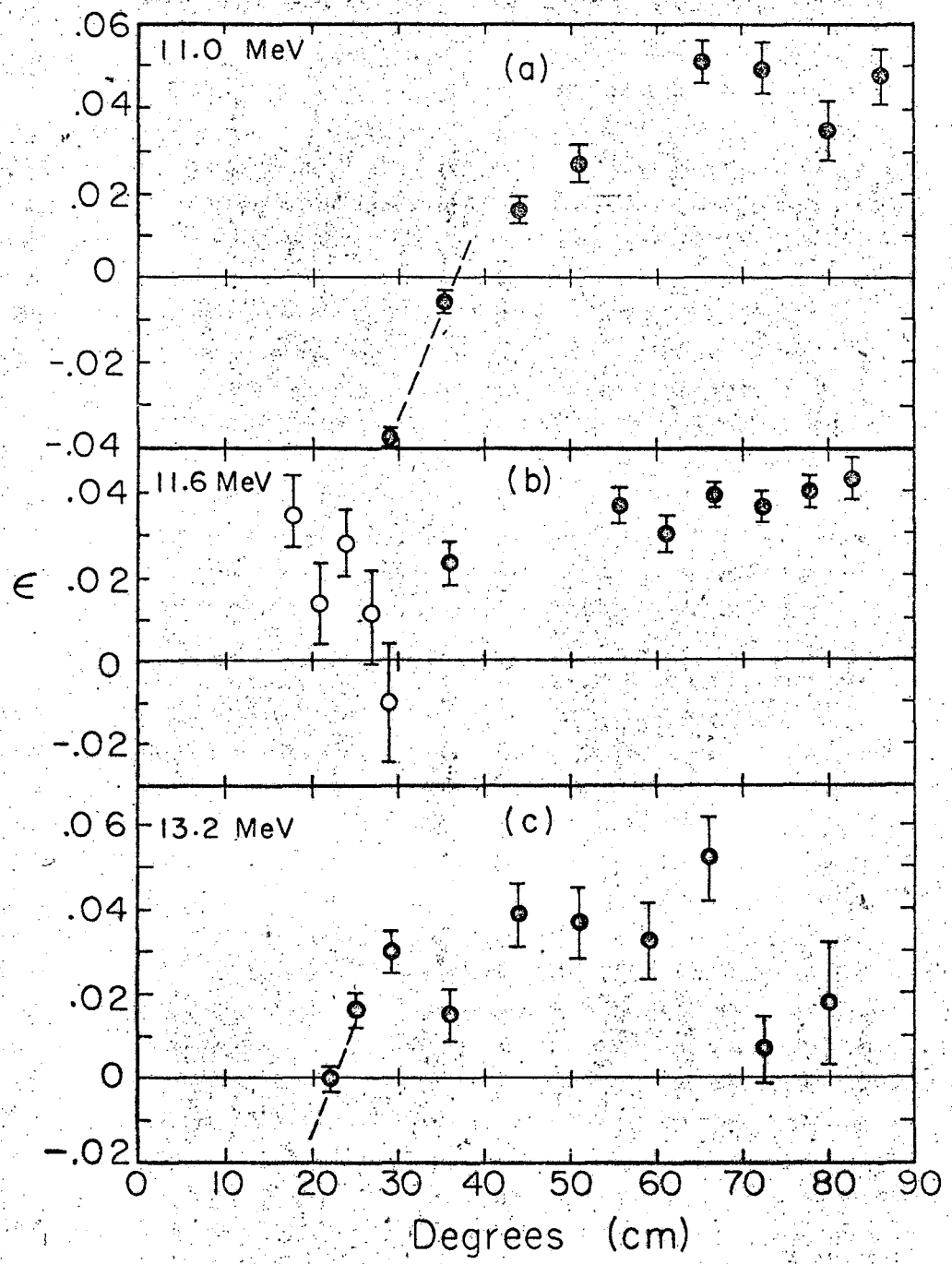

Fig. 1.

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