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Polarization in Proton-Helium and Proton-Carbon Elastic Scattering

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Proton-Helium Scattering

We have made measurements of the polarization in proton-helium scattering near 10 MeV with the INSJ 160 cm variable energy cyclotron [1][1]) and an usual double scattering chamber [2]. Three interdependent polarization products, $P_1 P_2$, $P_2 P_3$ and $P_3 P_1$, were measured. The individual polarizations may be stated in terms of observed quantities [3] as:

$$P_1 = \left(\frac{P_1P_2 \cdot P_3P_1}{P_2P_3}\right)^{1/2}, \quad P_2 = \left(\frac{P_1P_2 \cdot P_2P_3}{P_3P_1}\right)^{1/2}, \quad P_3 = \left(\frac{P_2P_3 \cdot P_3P_1}{P_1P_2}\right)^{1/2}.$$

The results of the individual polarizations are: P (7.8 MeV, 117°) $= 0.92 \pm 0.11$, P (11.4 MeV, 50°) $= -0.45 \pm 0.06$ and P (14.4 MeV, 50°) $= -0.45 \pm 0.06$, where energies and angles are those in the laboratory system. The measurements of the differential cross sections in the same energy region [4] showed that there is no D-state resonance and the differential cross sections are fitted almost with S- and P-waves, from the phase shift analysis. The values of the polarization calculated from phase shifts are: P (7.8 MeV, 117°) $= 1.00$, P (11.4 MeV, 50°) $= -0.47$, P (14.4 MeV, 50°) $= -0.39$, which agree with experimental values. Thus we can use the proton-helium scattering as a standard analyzer of the polarization of protons even up to 15 MeV.

Series Polarimeter

As the next step, we have investigated the polarization in proton-carbon elastic scattering. At that time, we devised a series polarimeter, which is composed of two polarimeters in a row, the one for carbon target and the other for helium target. Figure 1 shows its photograph. The main

[1]) Numbers in brackets refer to References, page 252.

purpose of this device is the saving of time in taking data. In general, data concerning an unknown target are taken and the analysing of the polarization of the incident beam are made simultaneously.

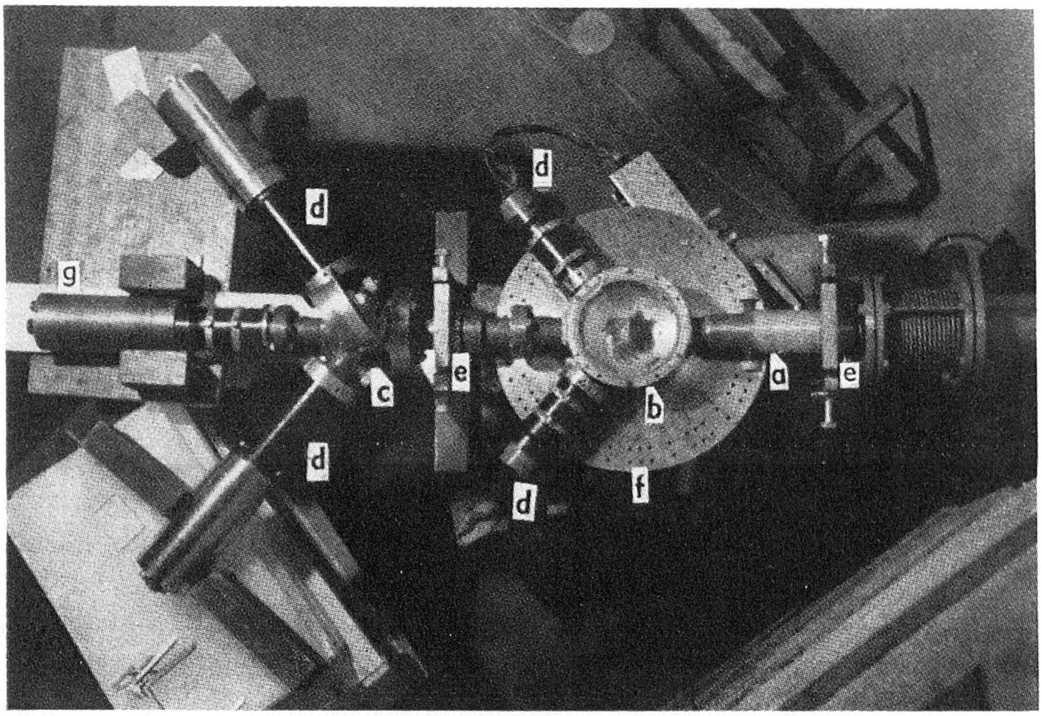

Figure 1

The photograph of the 'Series polarimeter'.

a: collimator tube, b: target chamber, c: gas chamber, d: scintillation detector, e: ball bearing, f: disk for setting detectors, g: monitor counter.

The polarized beam, which was obtained from some kind of the first scattering, entered the collimator. The collimator has two slits of 10 mm wide and 20 mm high. Each is separated by 300 mm. Behind the collimator, a target chamber is installed. A graphite target foil was set at its center. The chamber has in its inside an annular slit ring, which has 9 pairs of slit holes arranged symmetrically about the direction of the beam. A gas chamber is attached to the end of the target chamber. Between these two chambers, a stainless steel foil of 35 microns thick is inserted and sustains the high gas pressure. The gas chamber and this foil were tested up to 15 atmospheric pressure. A pair of double slits, which defines the scattering angle, the target thickness and the solid angle, of the proton-helium scattering, was set at an angle of 50°.

The whole instruments above described, including the scintillation counters, can be rotated through 180° about its own axis, in order to eliminate the asymmetry due to instrumentation.

Proton-Carbon Scattering

The measurements of the differential cross sections in the energy range of 7 to 16 MeV [5] showed a sharp resonance at 9 MeV and a broad resonance at 10.5 MeV. The shape of the angular distribution of the differential cross sections resembled those derived from the optical potential, except at the resonances above described. Then, it is in interesting to investigate the polarization in the same energy region.

The measurements of the angular distribution of the polarization in proton-carbon elastic scattering were made by Rosen *et al.* [6] at 11.5 MeV, by Yamabe *et al.* [7] at 14 and 16 MeV, and by Brockman at 17.7 MeV [8]. The main feature of these results resemble also those derived from the optical potential [9].

In the present work, we have made a measurement of the angular distribution of the polarization at 10.5 MeV, with the series polarimeter. Figure 2 shows the result. Scince the width of the energy of protons in the scattering was not so small, $\pm$ 0.5 MeV, some averaging effects may occur over the resonance region. But the result shows the pattern, which is essentially different from the one derived from the optical potential.

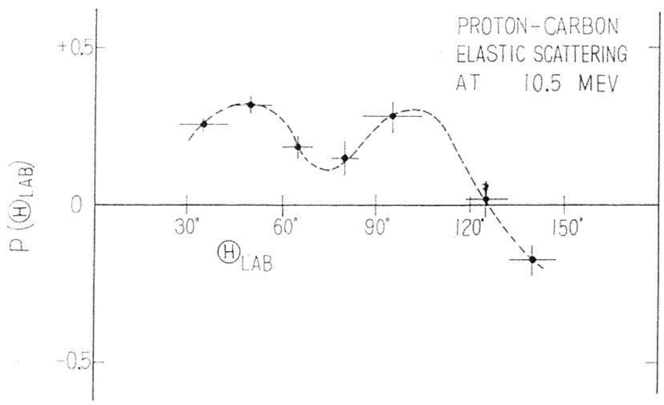

Figure 2
The angular distribution of the polarization.

To determine the energy dependence of the polarization, we have measured the polarization at an angle of 50° in the laboratory system, varying the energy of protons. The result is shown in figure 3. P (50°) is almost constant and about 70 percent from 12 MeV to 17 MeV. This character may show the usefulness of proton-carbon elastic scattering as the sub-standard analyser in the energy region above. Below 12 MeV, the energy dependence of the polarization is remarkable. P (50°) changes its sign at 11 MeV.

The present work has been done by the collaboration with Drs. S. SUWA, I. HAYASHI, K. NISIMURA, N. RYU and H. HASAI. The more details will be given in elswhere.

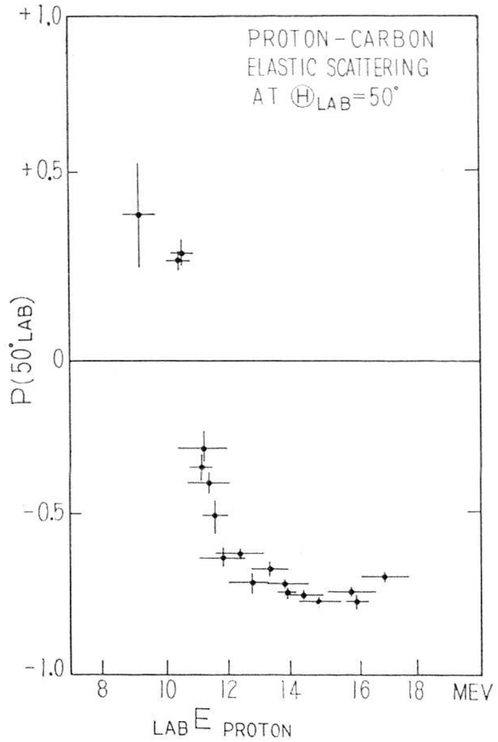

Figure 3
The energy dependence of $P(50°_{LAB})$.

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