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POLARIZATION AND CROSS-SECTION MEASUREMENTS IN  
 $p$ - ${}^4\text{He}$  SCATTERING FROM 20 TO 40 MeV

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POLARIZATION AND CROSS-SECTION MEASUREMENTS IN  $p\text{-}^4\text{He}$  SCATTERING FROM 20 TO 40 MeV\*

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The scattering of protons from  $^4\text{He}$  has been particularly useful as a proton polarization analyzer since it produces large polarizations over a wide range of energies. Also, analysis of resonance effects corresponding to states in  $^5\text{Li}$  above the deuteron threshold are simplified if observed in the proton channel because of the single channel-spin available. In particular, a broad anomaly near an excitation energy of 20 MeV, which has been seen in the  $^3\text{He}(d,p)^4\text{He}$  reaction<sup>1</sup> and in  $d\text{-}^3\text{He}$  elastic scattering,<sup>2</sup> has not yet been explained unambiguously. Even though no effect has been seen in  $p\text{-}^4\text{He}$  cross-section excitation functions,<sup>3</sup> the  $^3\text{He}(d,p)^4\text{He}$  data show that if the anomaly results from a state in  $^5\text{Li}$  the state must have a proton width. Thus, because of the greater sensitivity to small changes in a partial-wave amplitude that is possible to polarizations than to cross sections,  $p\text{-}^4\text{He}$  polarization excitation functions could provide information important to the explanation of this anomaly.

We have used the new axially-injected polarized proton beam from the 88-inch cyclotron to supplement and to improve previous  $p\text{-}^4\text{He}$  elastic scattering data between 20 and 40 MeV. External beams of 80-120 nA with polarization  $\approx 0.75$  were available. Angular distributions of cross sections and polarizations were measured at 2 MeV intervals at 20 laboratory angles between  $17.5^\circ$  and  $150^\circ$ . At each energy the relative uncertainty of the polarization is less than  $\pm 0.010$ . An absolute normalization with an uncertainty of less than 3% at all energies has been obtained by using the analyzing power of  $p\text{-}^4\text{He}$  scattering near 14.5 MeV.<sup>4</sup> Absolute cross sections were obtained by normalizing to the data of Ref. 3. As examples, Fig. 1 shows our results near 24 and 26 MeV. Additional measurements of comparable precision were made in the region between 20 and 30 MeV to search for an effect corresponding to the anomaly discussed above.

A contour plot of the experimental proton polarization is shown in Fig. 2. Measurements for the region between 16 and 20 MeV are taken from Ref. 4. The effect of the 16.65 MeV  $3/2^+$  state of  $^5\text{Li}$  is clearly seen near 23 MeV. Excitation functions were taken across this resonance to provide data for an improved determination of the resonance parameters<sup>5</sup> and to aid in the continuation of a phase-shift analysis to the higher energies. With the exception of this narrow

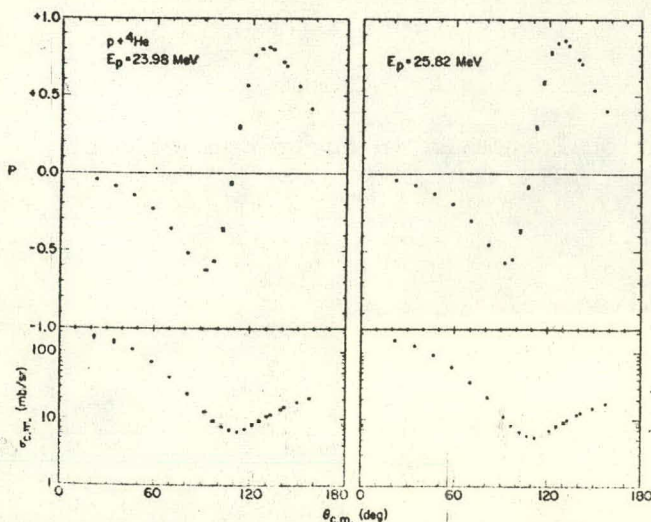


Fig. 1

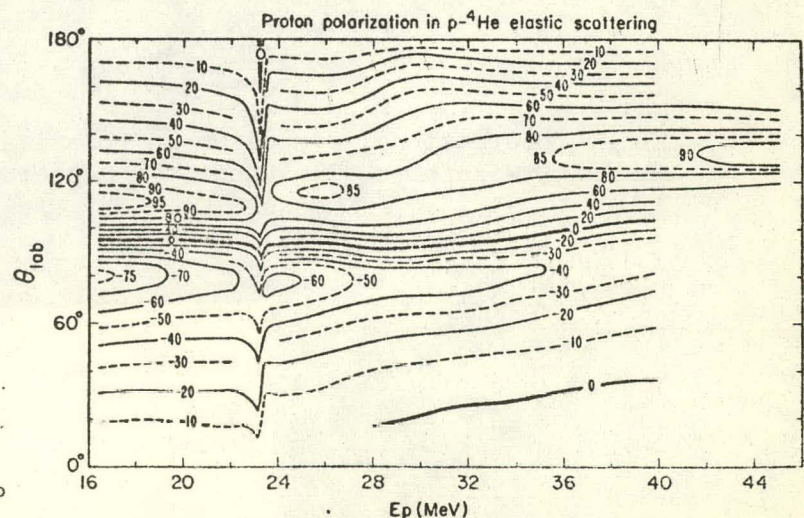


Fig. 2



resonance region, the analyzing power near  $\theta_{lab} = 120^\circ - 130^\circ$  remains large, and these measurements provide an accurate proton polarization analyzer up to 40 MeV. A broad bump between 26 and 32 MeV is apparent in the contour plot at backward angles. This can be seen more clearly in Fig. 3, which shows an excitation function of the proton polarization at  $\theta_{cm} = 102.2^\circ$  ( $87.5^\circ$  lab). The sharp structure near 23 MeV is due to the  $3/2^+$  level, and the broad anomaly between 26 and 32 MeV is seen to correspond in energy to that seen in the  $d-^3\text{He}$  elastic scattering cross-section data<sup>2</sup> at  $\theta_{cm} = 90^\circ$ , which is plotted in the insert.

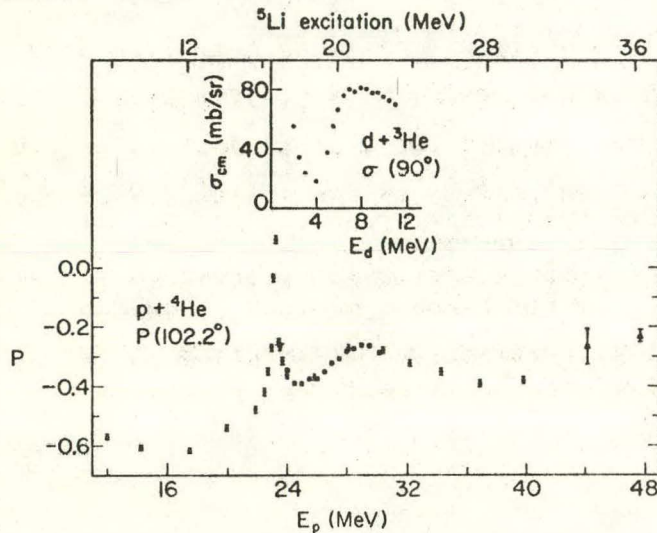


Fig. 3

A phase shift analysis of these data is underway, but only qualitative preliminary results based on the data at 2-MeV intervals are presently available. Above 30 MeV the phase shifts vary quite smoothly with energy, and the addition of a small  $g$ -wave contribution provides significantly better fits to the data than is possible with analyses limited to  $s$ ,  $p$ ,  $d$ , and  $f$  waves. Analysis of the data in the region between 24 and 32 MeV has not yet progressed to the point where a clear explanation of the anomaly can be reported here.

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