THE ASYMPTOTIC D- TO S-STATE RATIO FOR ^{3}He

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The rotating scattering table became available in July of this year, permitting us to make initial measurements of the cross section and two tensor analyzing powers (A_{yy} and A_{xx}) for deuteron elastic scattering from ^{3}He at 80-MeV bombarding energy. Trial runs for this experiment have been reported previously.[1] During those runs, we found that a two element telescope was not adequate for observing both deuterons and recoil ^{3}He. For this run we changed to a three element telescope, the middle element being a 2 mm Ge detector. The electronics were also changed from a fast timing coincidence to a slow coincidence among the telescope elements, since in earlier tests a fast timing coincidence had proven to be inefficient.

During the August run, the germanium detector vacuum system was faulty, and it was impossible to maintain bias voltage on all of the detectors. Consequently, the data are incomplete, and systematic errors are likely to be quite large. Measurements of the cross section and the T_{22} tensor analyzing power are shown in Fig. 1. The errors reflect counting statistics only. Previous measurements of the cross section during test runs were low by about 15%.

The analysis of these measurements in terms of the proton exchange singularity has been described previously.[1] With the present data, we can calculate the extrapolation function (see Fig. 2)

$$F(z) = k^2 \, \sigma \, T_{22} \, \frac{(z - z_p)^2 \, (z - 1)}{(1 - z^2) \, (z_p - 1)}$$

where $z = \cos\theta$, k is the center-of-mass momentum, and z_p ($z_p < 1$) is the location of the proton exchange singularity. The factor of $(z - 1)$ removes a bound on the radius of convergence of the extrapolation imposed
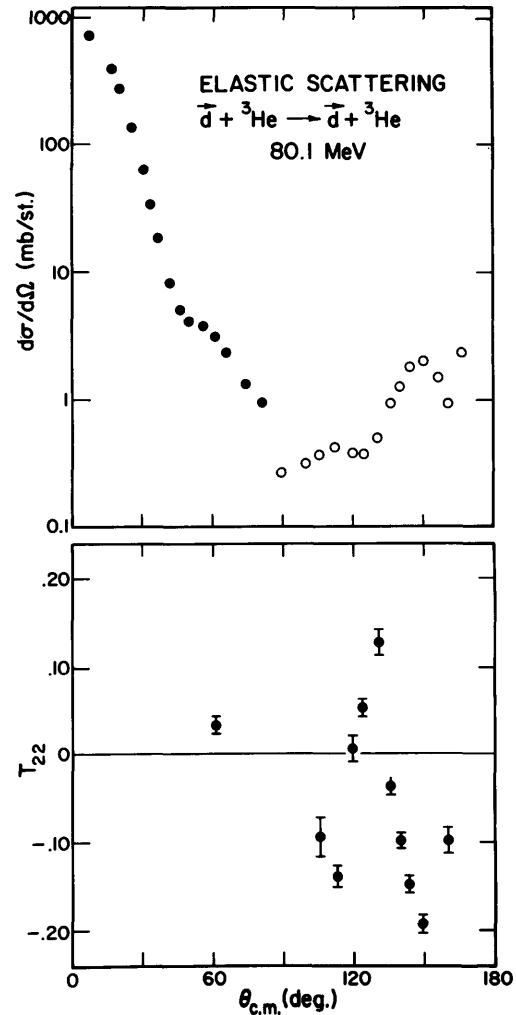

Figure 1. Angular distribution measurements of the differential cross section and T_{22} analyzing power for deuteron elastic scattering from ^{3}He at 80 MeV bombarding energy.

by interference with the Coulomb singularity. The measurements provide values of $F(z)$ in the physical region between $z = -1$ and 1. To obtain a value of the proton exchange residue, we must extrapolate $F(z)$ to z_p. The usual procedure reproduces $F(z)$ with a polynomial series of rank L and evaluates the series at z_p. The residue $F(z_p)$ should be proportional to the ratio, ρ_D, of the ^{3}He D-state and S-state coupling constants.

With the data presently available, $F(z)$ can be reproduced by a polynomial of order 6. The addition of the term of order 6 reduces the chi square of the fit by a factor of 2. Figure 2 shows extrapolations using
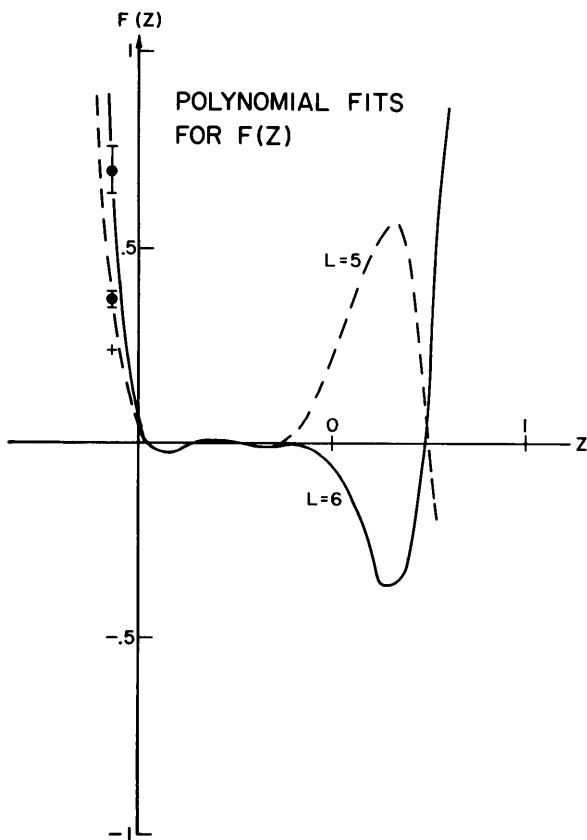
polynomials of order 5 and 6, with values of $F(z_p)$ equal to 0.37 and 0.69, respectively. Both of these values are larger than the prediction of Kim and Muslim[2] of $F(z_p) = 0.24$. At this time it is clear that the polynomial curves are larger than we would reasonably expect for those parts of the physical region where there are no measurements, so the discrepancies with the predicted residue are not significant.

The small observed values of T_{22} and especially the cross section resulted in values of $F(z)$ much smaller than the expected residue. This makes the extrapolation to the exchange pole uncertain. Since the cross section is a strong function of energy, this raises the question of whether there is a more optimal energy for the experiment. If we reduce the energy, the cross section rises, and measurements[3] at 10 MeV suggest that T_{22} has about the same magnitude. Thus lower energies would give a larger value of $F(z)$. A lower bound on the energy is provided by the Coulomb barrier. This means that a practical energy range for the experiment lies between 10 and 40 MeV, if the extrapolation function must fall within a factor of five of the expected residue. We are presently investigating the possibility of repeating the measurements at 30 MeV.

1) E.J. Stephenson, V.R. Cupps, J.R. Hall,
   W.W. Jacobs, W.P. Jones, M.D. Kaitchuck,
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2) Y.E. Kim and Muslim, Phys. Rev. Lett., 42, 1328
   (1979).

3) P.C. Colby, private communication.

Figure 2. Measurements of $F(z)$ as a function of $z = \cos\theta$. The curves are polynomial fits of maximum order 5 and 6. The cross marks the position of the residue expected from the calculations of Ref. 2.