LARGE-ANGLE DEUTERON ELASTIC SCATTERING

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Investigations of deuteron elastic scattering below 50 MeV have given diffractive cross section angular distributions and analyzing powers that oscillate about zero.[1,2] Recent measurements above 50 MeV show vector analyzing power angular distributions that rise at large angles to values near unity.[3-5] This feature is associated with a marked dampening of the diffractive oscillations in both cross section and analyzing power. The change in the average vector analyzing power from zero to nearly one signals a change in the dominant mechanism for deuteron elastic scattering. An understanding of this effect in simple semi-classical terms has motivated a detailed experimental investigation of large-angle dueteron elastic scattering.

The increase in size of the vector analyzing power at large angles is a result of scattering from the real part of the optical potential. As the bombarding energy increases, the spin-orbit potential makes a more significant alteration of the real central potential near the nuclear surface. The potentials appropriate to the three projections of the deuteron's spin along the orbital angular momentum axis are shown in Fig. 1a. The deflection function[6] (or scattering angle) for each spin projection is shown in Fig. 1b as a function of impact parameter. The largest negative deflection is for m=1 deuterons, thus back-angle scattering is dominated by this single projection of the spin. Beyond this maximum angle, the cross section

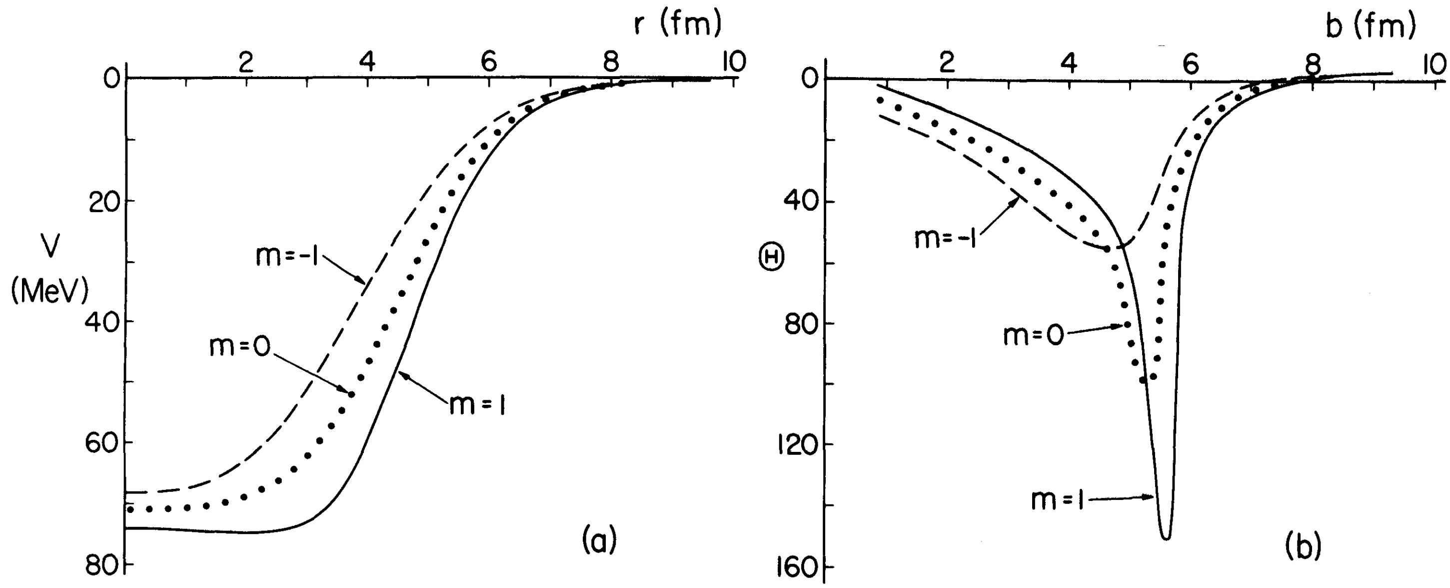

Figure 1. (a) Sum of real spin-orbit potentials for 80 MeV deuterons scattering from ^{58}Ni. The three curves (solid, dot, dash) correspond to the three projections of the deuteron spin (m=1,0,-1) along the orbital angular momentum axis. The potentials are from Ref. 8, and L=17. (b) Deflection function plotted against impact parameter for each of the three real central potentials.

falls smoothly, a phenomena discussed previously for α-particle scattering.[6]

The dominance of back-angle elastic scattering by a single spin projection is borne out in optical model calculations, shown in Fig. 2. The three

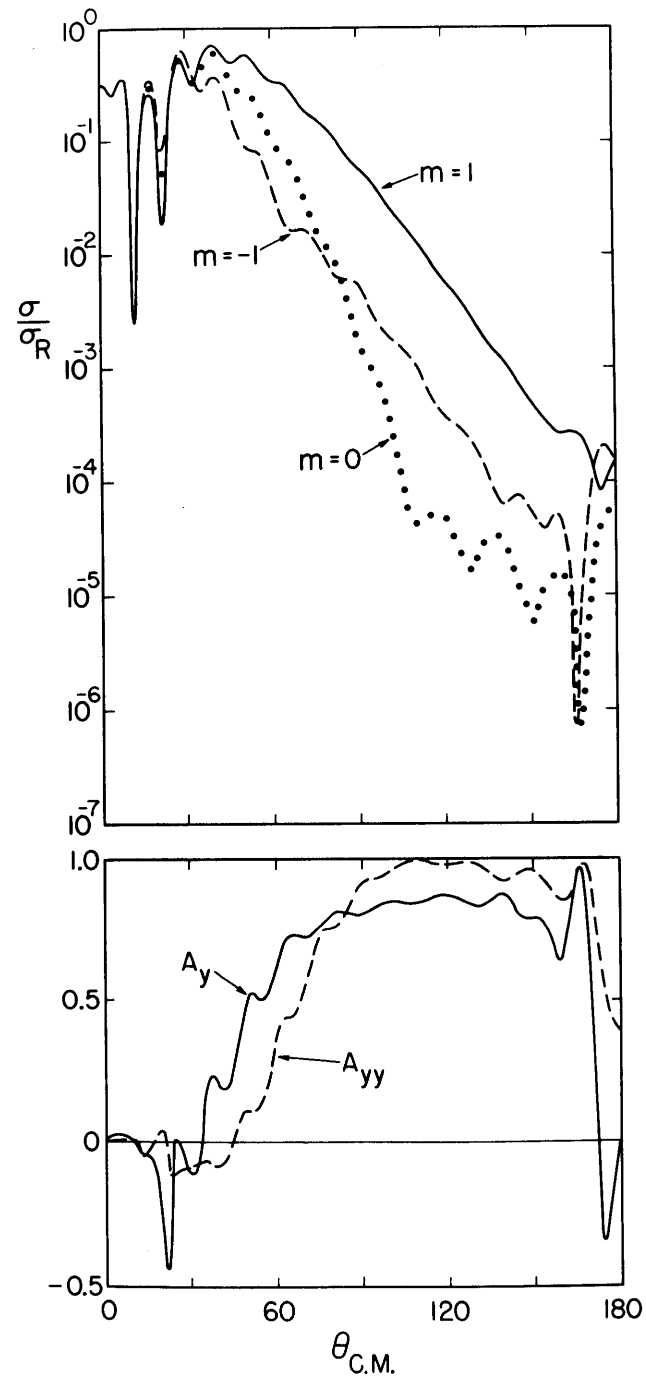

Figure 2. Partial cross sections for 80 MeV deuterons scattering from ^{58}Ni. The three curves are defined in Fig. 1. The lower graph shows the vector and tensor analyzing powers.

curves show that portion of the cross section arising from each spin projection. Beyond 60°, scattering of m=1 deuterons exceeds the other spin projections by about an order of magnitude. These m=1 deuterons may be associated with spin up deuterons in the beam, and their dominance at back angles leads to extreme values of the analyzing powers. This is best demonstrated in Cartesian notation[7] by the analyzing powers

$$A_y = \frac{\sigma_1 - \sigma_{-1}}{\sigma_1 + \sigma_0 + \sigma_{-1}}$$

$$A_{yy} = \frac{\sigma_1 + \sigma_{-1} - 2\sigma_0}{\sigma_1 + \sigma_0 + \sigma_{-1}} \quad ,$$

which are expressed in terms of the partial cross sections shown in Fig. 2. The dominance of m=1 deuterons results in back angle values of A_y and A_{yy} near unity.

Plans are in progress to extend elastic scattering measurements on ^{58}Ni at 80 MeV to 120°. Tests with the QDDM spectrograph gave useful spectra to 110°. A 150 mg/cm^2 ^{58}Ni target was used, viewed in transmission. Widely spaced measurements of the differential cross section and the analyzing powers A_y and A_{yy} were made from 50° to 90°, and are shown in Fig. 3. Information on the first excited (2^+ at 1.45 MeV) state was obtained simultaneously. The elastic cross section falls rapidly with angle, and the analyzing powers become large. Absolute calibration of the beam polarization is uncertain at present, and an error of 0.02 has been indicated to cover systematic relative errors from this uncertainty. The general features of the inelastic transition are the same as the elastic, indicating that spin-orbit effects dominate, even in the presence of angular momentum transfer. Measurements in smaller steps are planned, including A_{yy} at forward angles. Because of the large effects of the spin-orbit potential on the analyzing powers, a detailed investigation of

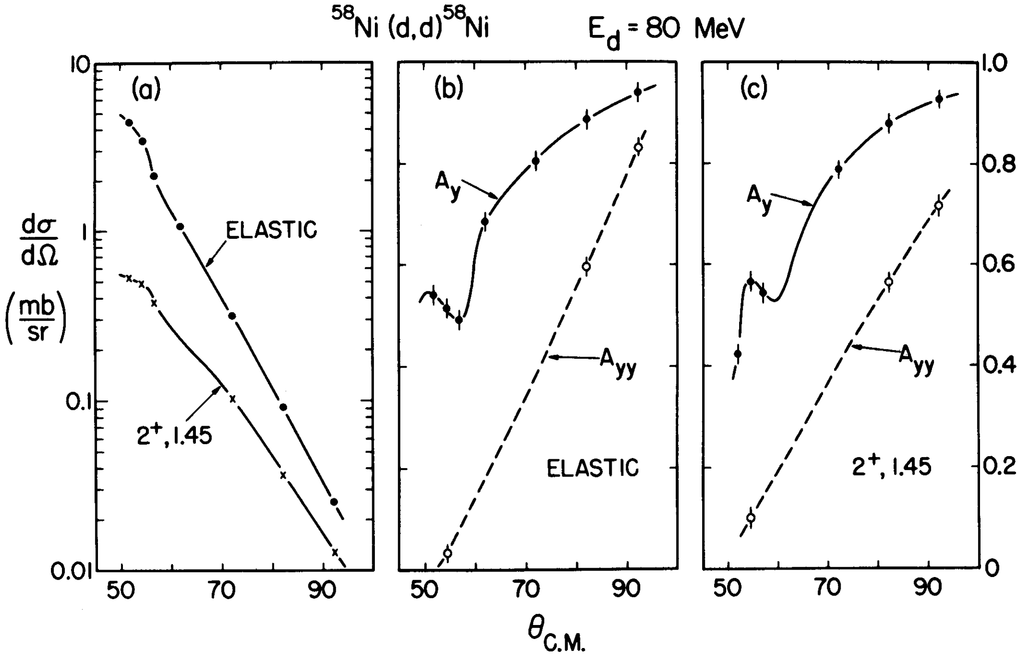

Figure 3. Measurements of the cross section, and vector and tensor analyzing powers for 80 MeV deuterons scattering from ^{58}Ni. Elastic and inelastic (2^+, 1.45 MeV) transitions are shown. The curves are a guide to the eye.

this potential should be possible.

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