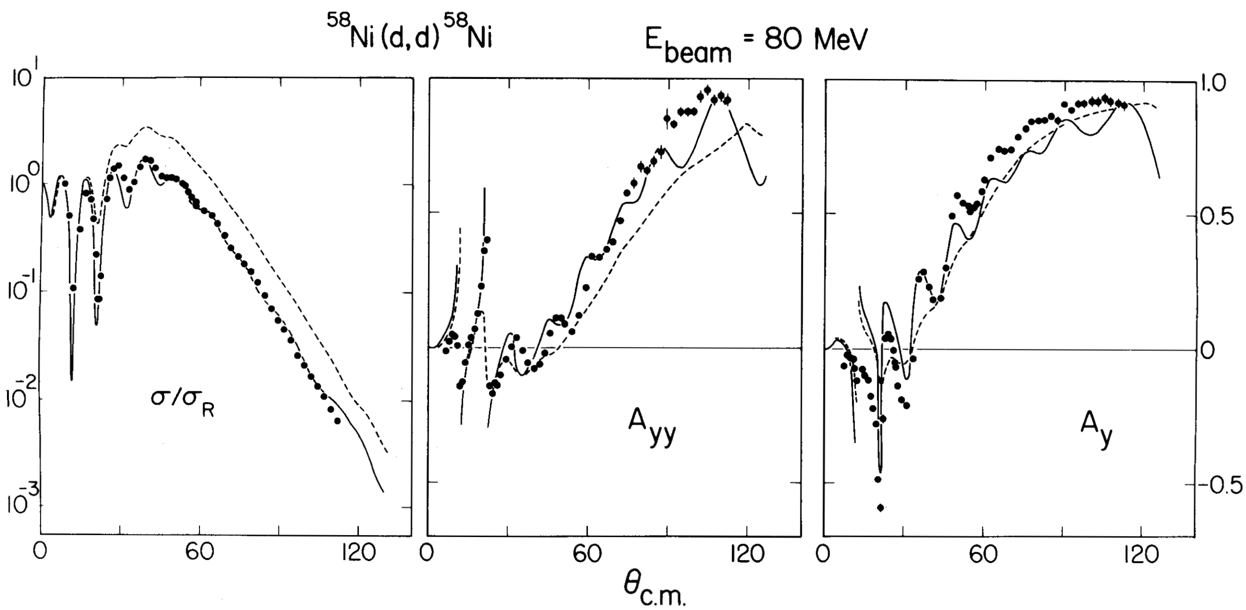

Figure 2. The measurements are the same as in Figure 1. The dashed curves are optical model calculations using a folding-model deuteron potential. The solid curves use the same potential but include coupling to deuteron breakup states.

The general shape of the vector analyzing power is given, but the differences between the calculation and the measurement are substantial at forward angles. This microscopic treatment of the deuteron-nucleus interaction is considerably more successful at this energy than at lower bombarding energies.[7)]

This also represents the first successful comparison between such a calculation and a tensor analyzing power. This result suggests that the derivation of a deuteron-nucleus potential through the folding model is sound, provided that the breakup channel (the new feature not already included in the nucleon-nucleus interaction) is coupled in explicitly. The high quality of the agreement also suggests that this is a nearly complete microscopic description.

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MEASUREMENTS OF THE TENSOR ANALYZING POWER, X_2, FOR $^{58}Ni(\vec{d},d)^{58}Ni$ AT 80 MeV.

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As part of a detailed study of elastic deuteron scattering from ^{58}Ni at E_d = 80 MeV, measurements of the tensor analyzing power $X_2 \propto 2A_{xx} + A_{yy}$ are in progress. Angular distributions of cross sections, $\sigma(\theta)$, vector analyzing powers, $A_y(\theta)$, and the tensor analyzing powers, $A_{yy}(\theta)$, have been measured in the angular range from about 6° to 112° and are discussed in another contribution to this report.[1]) These measurements can be made at IUCF with the vector-and tensor-polarized deuteron beams with vertical spin quantization axis and the QDDM magnetic spectrograph which defines a horizontal scattering plane. Other Cartesian tensor moments which may be measured in principle are A_{xx} and A_{xz}. The latter requires the use of a spin-precession solenoid and dipole magnets to produce a component of the deuteron spin along the momentum direction, and cannot presently be measured at IUCF. A_{xx} may be measured with a detector in the vertical scattering plane.

A particular linear combination of A_{xx} and A_{yy} of theoretical interest is the parameter $X_2 = (2A_{xx} + A_{yy})/\sqrt{3}$ which may be measured directly if the detection plane is inclined at 54.7° to the horizontal. X_2 is, to first order, independent of the spin-orbit component of the optical potential as shown by Johnson[2]). Measurement of this quantity in the presence of large spin-orbit effects such as those seen in the "rainbow" scattering region[3]) is of special interest. In particular, we may hope to see effects of the momentum-dependent tensor-potential term, T_P, which arises from Pauli exclusion-principle effects on deuteron propagation in nuclear matter[4]), as well as the now well-known radial tensor potential term, T_R, arising from the deuteron D-state.

In order to make such studies, an out-of-horizontal plane target chamber and detector system were constructed. Figure 1 is a photograph of the experimental facility. An angle plate was mounted under an existing target chamber for the γ-cave with an arm pivoting about the target location. A cryostat for a silicon plus hyper-pure germanium detector telescope[5]) may be mounted at three radial locations along the arm (20, 28 and 36 cm from the target).

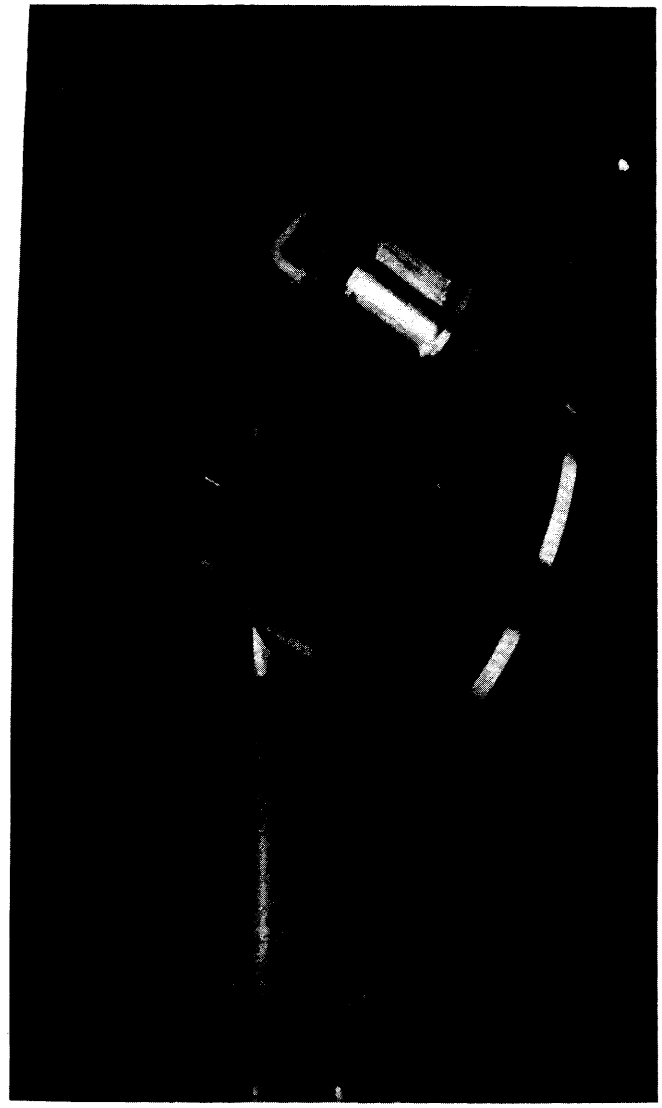

Figure 1. The X_2 target-chamber/detector-mount apparatus installed in the γ-cave, looking in the beam direction from above. A protective cover plate is in place concealing the Kapton window. A 54.7 degree angle from the horizontal is shown for the angle plate and the detector is situated at a 90° scattering angle.

Deuterons scattered from the target pass out of a 50 μm thick Kapton window through 18 to 33 cm of air and a 8 μm thick nickel detector window. The target chamber-detector mount may be rotated about the beam direction and locked in position at any angle in the range from 18° to 140°. An energy resolution of 180 keV and scattered deuterons with energies as low as about 50 MeV have been observed with this device.

The first measurements of X_2 have been made with this device over the angular range from 19° to 110°, but analysis has not proceeded to the point where the data can be presented in this report.

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REACTION MECHANISM IMPLICATIONS OF DEUTERON RAINBOW SCATTERING

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In proton inelastic scattering and proton-induced reactions, the vital information on nuclear structure is carried in the details of the diffraction patterns in the cross section and analyzing power. The same is true for deuteron-induced reactions, except that the diffractive oscillations are frequently much smaller in magnitude, and precise information is therefore harder to extract experimentally. The diffraction pattern is further attenuated at large scattering angles because of the appearance of rainbow scattering. There the values of the vector (A_y) and tensor (A_{yy}) analyzing powers approach unity in the deuteron elastic channel.

While information from the diffraction pattern is disappearing at large angles, the rainbow scattering picture suggests that the reaction mechanism itself has undergone radical change. Since with intermediate-energy deuterons, the spin effects in rainbow scattering are being observed for the first time, it is appropriate to consider the impact of rainbow scattering on the analyzing powers for deuteron-induced reactions. This region may be sensitive to both structure and reaction mechanism in a manner different from scattering at forward angles. It is likely that detailed agreement between theory and experiment will be hard to achieve, since these effects will be superimposed on top of larger effects due to the spin-orbit distortions in the entrance channel.

This contribution describes a series of observations and measurements concerning the implications of rainbow scattering for deuteron-induced reactions.

1. Theoretical Framework. Rainbow scattering takes place in the surface of the nucleus, and thus emphasizes the importance of large angular momentum in the scattering. By expanding the scattering matrix in terms of irreducible spin tensor operators, it is possible to specify in a simple fashion the character of deuteron elastic scattering in the limit of very large angular momentum. In that limit, it may be shown that the scattering matrix commutes with the operator