MEASUREMENTS OF X_2 AND OTHER RESULTS IN THE ANALYSIS OF d + ^{58}Ni ELASTIC SCATTERING

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During 1981, measurements have been completed of the tensor analyzing powers A_{yy} and $X_2 = (2A_{xx} + A_{yy})/\sqrt{3}$ in the elastic scattering of 80 MeV deuterons from ^{58}Ni. All of the elastic scattering measurements, including the cross section and vector analyzing power A_y, are shown in Fig. 1. The new measurements of A_{yy} are large near 21°, showing an effect of interference that is also prominent in A_y. The measurements of X_2 were made on a special scattering table set at 54.7° to the horizontal plane (described in Ref. 1). To first order, X_2 does not depend on spin-orbit forces,[2] and is expected to be a sensitive test of the presence of tensor potentials between the deuteron and the nucleus.[3] The measurements of X_2 show little structure, and are about half the size of measurements at 56 MeV.[4] At large angles they are much smaller than the predictions of Ref. 3.

While most of the general features of the data shown in Fig. 1 can be reproduced with global optical potential calculations,[5] significant improvements can be made if the potential parameters are adjusted. It was found that the use of a squared Woods-Saxon form for the radial dependence of the real central potential was significantly better than a Woods-Saxon form. This led to the use of an "arbitrary" shape composed of a series of Gaussian functions added to the traditional potential.[6] The spacing of the Gaussians was chosen to match the deuteron wavelength, and their width was chosen to minimize oscillations in their sum. Only the strengths were varied to improve agreement between the calculation and the data. The resulting calculation is a compromise that favors good reproduction of the cross section and vector analyzing power (the solid curve in Fig. 1). The cross section minima and large angle slope are well-reproduced, as is the pattern of the oscillations in A_y. The large A_{yy} values near 21° are reproduced, but the calculation overestimates the oscillatory pattern at larger angles. No tensor potentials were included in this fit, and the structures in X_2, which depend to first order on those terms, are not reproduced.

The "arbitrary" potential is depicted in Fig. 2 by the cross-hatched bands corresponding to one-standard-deviation errors in the potential. The width of the bands was computed from the diagonal elements of the error matrix of the fit. (Although correlation coefficients were not large, they may alter the error band in a complete calculation.) The solid curve is a "best-fit" potential using traditional radial shapes.[5] There are significant differences. The real central potential is more shallow in the surface and deeper in the interior. The imaginary and spin-orbit parts seem well-reproduced by the traditional shapes. The data determine the real parts of the

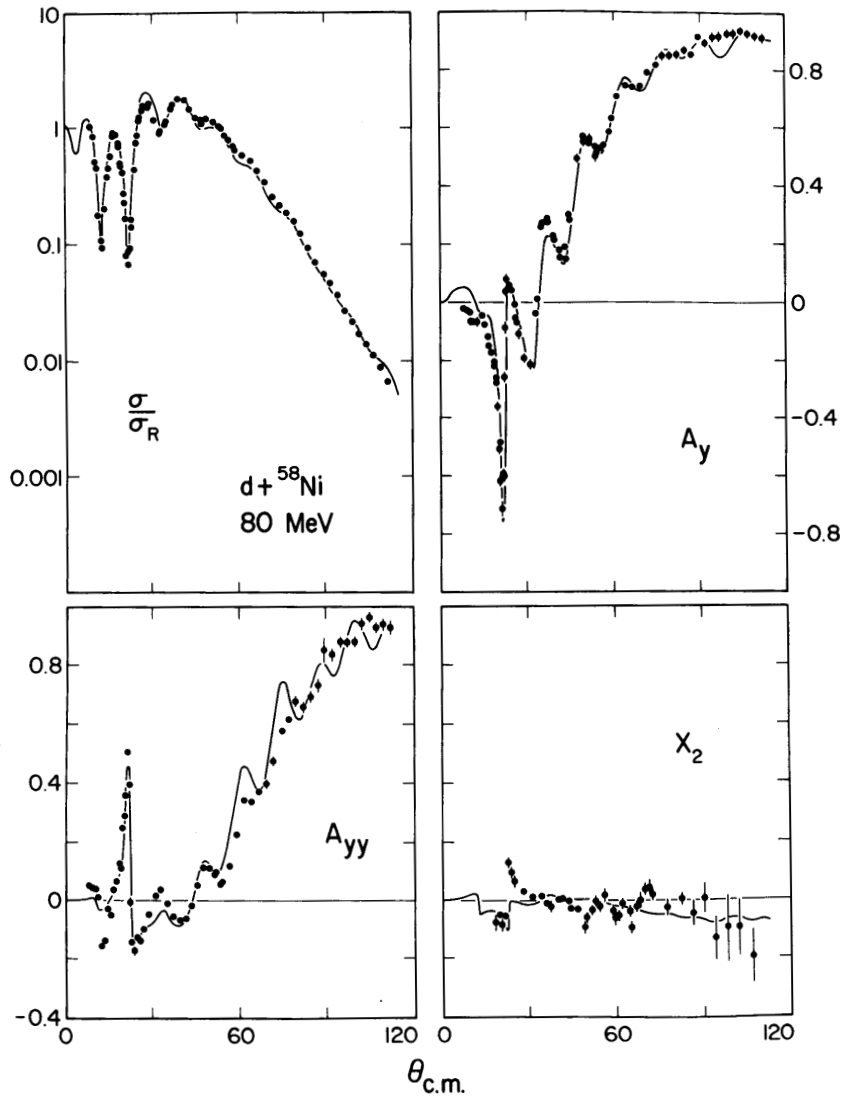

Figure 1. Measurements of the cross section (ratio to Rutherford), vector (A_y), and tensor (A_{yy} and X_2) analyzing powers for 80 MeV deuterons elastically scattered from ^{58}Ni. The optical model calculations employ the "arbitrary" potential displayed in Fig. 2.

potential to a much higher precision than the imaginary parts. This is an artifact of rainbow scattering, in which the real parts of the potential play a dominant role.

Most analyses[4] of the effects of tensor potentials in deuteron elastic scattering have found that the T_R potential is predominantly imaginary. Adding such a potential to our calculation (with half the strength) serves to reproduce some of the diffractive structure of the measurements of X_2 (see Fig. 3). Contrary to experience at lower energies, such a potential has a profound effect on other analyzing powers. The vector analyzing power has no values larger than 0.8 and the A_{yy} tensor analyzing power is noticeably reduced in magnitude. These differences occur primarily in the region beyond the rainbow angle, in a range of momentum transfer not seen in lower energy measurements.

It has been previously reported that microscopic

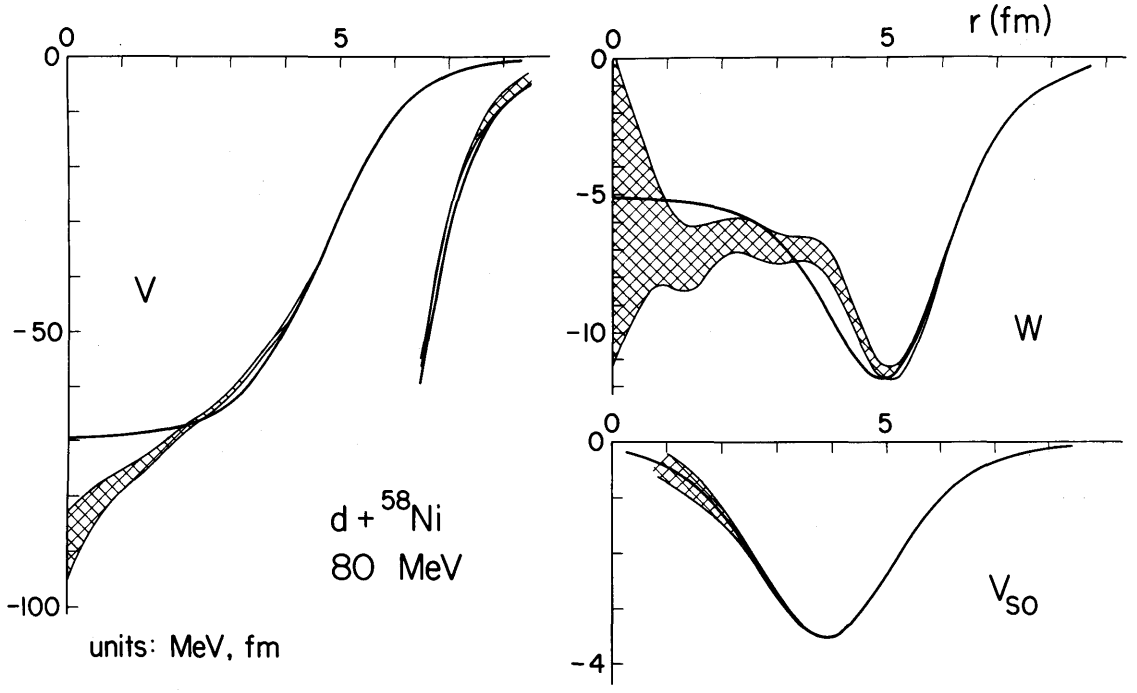

Figure 2. Comparison between the "best-fit" potential using traditional radial shapes (solid line), and the error band associated with an "arbitrary" potential. Beyond 6.5 fm, the real central potentials are multiplied by 10 to make the differences visible.

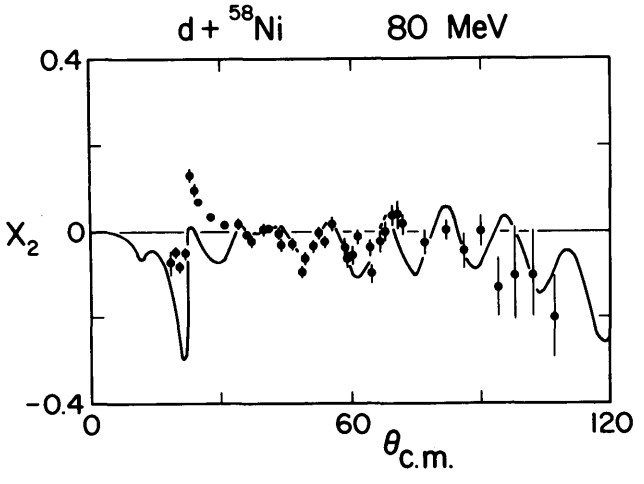

Figure 3. Measurements of X_2 and an optical model calculation including a T_R potential of half the strength of the one reported in Ref. 4.

calculations of deuteron elastic scattering that include coupling to break-up states[7] provide a surprisingly precise reproduction of the measurements.[1] The calculations for X_2 are shown in Fig. 4. They are in general agreement with the measurements and tend to support the microscopic calculation. Figure 4 also contains predictions for A_{xz}, which may be measured if the quantization axis of the polarized deuteron beam is placed in the scattering plane at 45° to the beam momentum. Unlike X_2, large differences are seen between the predictions of the microscopic model and the optical model, with or without tensor (in this case, the T_R potential from Ref. 3 is purely real). Measurements of A_{xz} that followed the solid curve would constitute evidence that the optical model is incapable of successfully reproducing deuteron elastic scattering data.

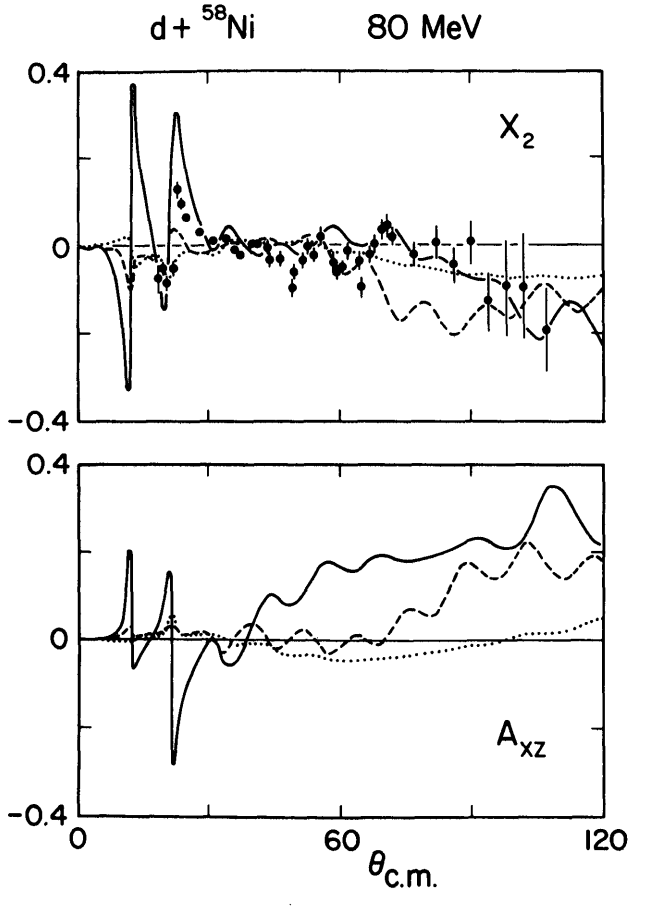

Figure 4. Measurements of X_2 and calculations of X_2 and A_{xz} using a microscopic model of Ref. 7 (solid curve) and an optical model with and without (dashed and dotted) the real T_R potential of Ref. 3.

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MEASUREMENT OF THE RELATIVE SIGN OF NEUTRON (M_n) AND PROTON (M_p) TRANSITION MATRIX ELEMENTS FOR THE 2^+_2 STATE IN ^{30}Si BY INELASTIC ALPHA-PARTICLE SCATTERING.

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One of the most exciting recent developments in the study of nuclear structure has been the appreciation of the isovector characteristics of nuclear excitation. A number of different experimental techniques have been developed to examine the separate roles played by neutrons and protons in the nuclear excitations. In inelastic scattering, the cross section for the transition to an excited state can be described in terms of separate matrix elements for proton and neutron excitations, M_p and M_n, respectively, or in terms of isoscalar and isovector matrix elements, $M_0=M_n+M_p$ and $M_1=M_n-M_p$. The cross