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Recoil Polarization of ^{12}C (15.11 Mev,1^+) Following the $^{13}C(p,d)^{12}C$ Reaction at E_p=41.3 MeV

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Angular correlation measurements have been made between the deuterons and the ^{12}C g.s. product nuclei in the reaction

$$^{13}C(p,d)^{12}C^*(15.11\ \text{MeV},1^+) \longrightarrow {}^{12}C(g.s.,0^+)+\gamma$$

at deuteron scattering angles of 40, 50, 60, and 75 degrees (lab.), and a proton bombarding energy of 41.3 MeV. These measurements yield information concerning the spin density matrix of the excited ^{12}C nucleus produced in the direct (p,d) reaction.

The experiment was performed using standard fast-slow coincidence techniques. The deuterons were detected and identified using a solid state ΔE-E particle telescope, while the recoil distributions were recorded in a 8x47 mm^2 Ortec position sensitive detector (PSD) set at the angle of the recoiling $^{12}C^*$ nucleus. The target consisted of a 50 $\mu g/cm^2$ self-supporting carbon foil enriched to greater than 99% ^{13}C.

The PSD could be positioned either parallel (horizontal) or perpendicular (vertical) to the reaction plane. Both measurements are required because the functions describing the decay are not linearly independant in a fixed plane. The angular distribution of the emitted γ-ray is reflected in the energy-position locus extracted from the PSD.

The center-of-mass correlation distributions may be written generally as[1]

$$W(\Theta,\phi) = \sum_{kq} \sqrt{\frac{4\pi}{2k+1}}\ t_{kq}A_kY^*_{kq}(\Theta,\phi)$$

where $k\leq 2J$ (J is the spin of the decaying particle), $-k\leq q\leq k$. The t_{kq} are the complex statistical tensors describing the polarization of the decaying particle in the center of mass frame of arbitrary orientation. (They may be directly expressed as linear combinations of the spin-density matrix.) The A_k are real terms determining the analyzing power of the decay ; they are completly determined for the decay under study (M1 gamma decay). If the quantization axis is chosen perpendicular to the reaction plane, then application of symmetry requirements with respect to reflection through the reaction plane plus parity conservation in the decay process reduces the number of t_{kq} involved to t_{00}, t_{20}, and t_{22} (for a 1^+ state).

Monte-Carlo simulations of the laboratory distribution functions associated with the individual t_{kq} have been performed on the VAX-11/750 at the Cyclotron Laboratory. Effects of finite geometry (beam spot size and detectors), beam divergence, and energy loss and multiple scattering of the ^{12}C nuclei in the target were included in the calculations. The fitting procedure fits the horizontal and vertical 2-D distributions simultaneously. Figure 1 shows the experimental results and the Monte-Carlo generated fit for the horizontal energy-position recoil distribution (Θ_d=75° lab.). The calculated distribution represents a linear combination of the functions associated with t_{00}, t_{20}, $Re(t_{22})$, and $Im(t_{22})$.

Finite range DWBA calculations using the code PTOLEMY[2] have been performed describing the recoil spin density matrix elements. Figure 2 displays a comparison of the DWBA results with the extracted differential cross-sections and density matrix elements, assuming a $1p_{3/2}$ neutron pickup. The computation used p+^{12}C optical potentials given by E. Fabrici et al.[3] and d+^{12}C potentials given by Lind et al[4]. The computation includes the deuteron s and d states, using the Reid soft core potential.

Examination of the results suggests that the "standard" DWBA formalism is quantitively inadequate for describing the recoil nucleus polarization. The DWBA calculations showed only a modest sensitivity to inclusion of spin-orbit and T_r tensor terms in the deuteron optical potential, suggesting that the recoil polarization process is dominated by matching conditions for the transferred angular momentum.

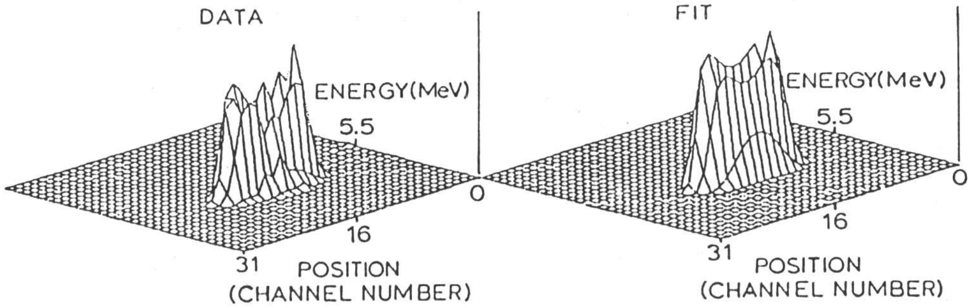

Fig. 1. Comparison of measured locus (horizontal, Θ_d=75°) with fit to Monte-Carlo generated functions.

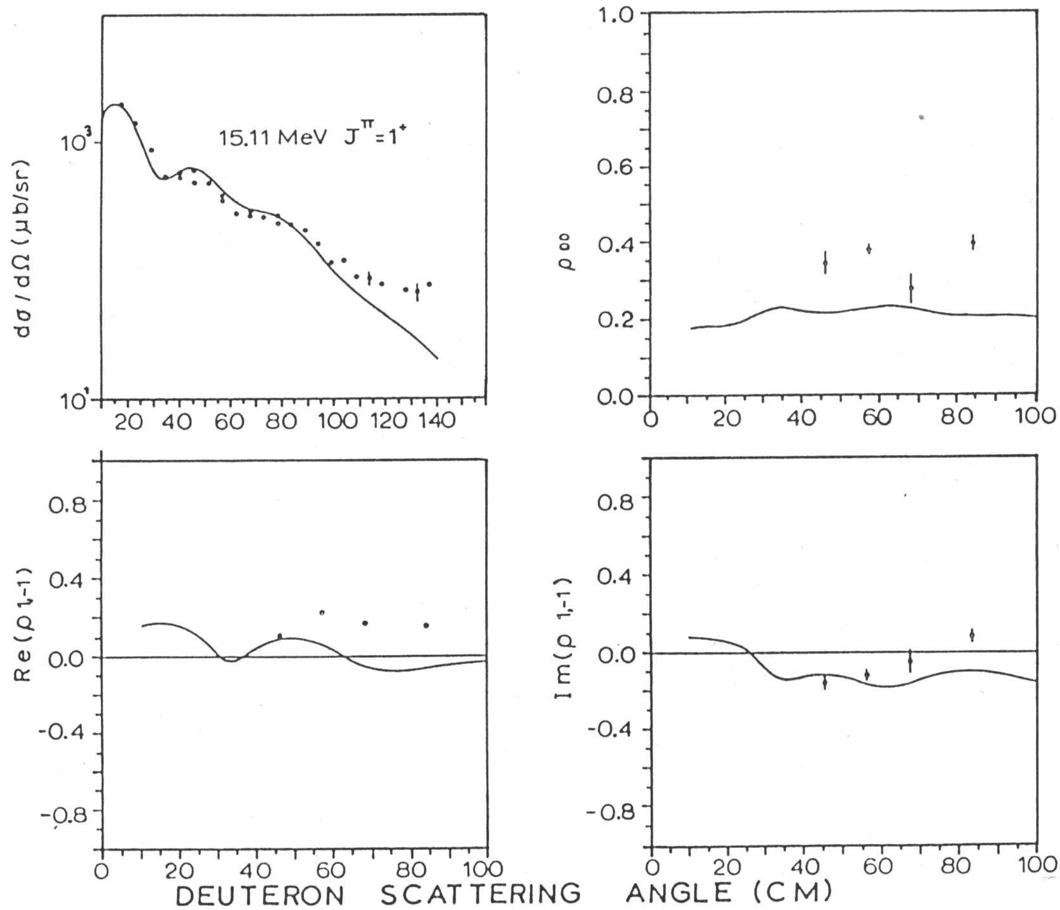

Fig. 2. Comparison of extracted observables with DWBA calculations.

References

1) M. Simonius, Lecture Notes in Physics ,Vol. 30, Springer, Berlin, 1974 p.38.
2) M.H. Macfarlane and S.C. Pieper, PTOLEMY computer code, ANL-76-11 Rev. 1.
3) E. Fabrici et al, Phys. Rev. C21 (1980) 3.
4) J.M. Lind, et al, Nuc. Phys. A276 (1977) 25.