EVIDENCE FOR DEUTERON CLUSTERING IN ^{7}Li FROM THE NONCOPLANAR $^{7}Li(p,pd)^{5}He$ REACTION AT Ep=200 MeV

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Even though a nucleus is well described by one clustering mode, other modes are not necessarily precluded since these modes do not constitute an orthonormal set of states; individual nucleons can belong to different cluster modes simultaneously.[1] For instance, ^{6}Li has both α+d and τ+t configurations of comparable amplitude.[2] This raises the question of whether ^{7}Li, long known[3] to have a spectroscopic factor near unity for α+t, might also exhibit significant ^{5}He+d clustering.

To explore this possibility, measurements were made of the $^{7}Li(p,pd)$ knockout reaction at 200 MeV. Data were taken for a coplanar geometry (Θ_p/Θ_d=64°/-47.4°) permitting quasi-elastic scattering and for three nearby noncoplanar geometries. Each of the four energy-sharing spectra showed a broad peak characteristic of s-state deuteron knockout. A distorted wave analysis indicates a d+^{5}He spectroscopic factor C_d of about unity, and a plane wave analysis comparing these to our $^{6}Li(p,pd)$ data[4] yields C_d=0.8.

A 22 mg/cm^2 ^{7}Li target, mounted in air and sealed between 2.1 mg/cm^2 protective foils of Cu-Ni alloy, was bombarded with 200 MeV unpolarized protons. The intrinsic Ge detector telescopes, and their associated electronics, were nearly identical to those used to study[4] the noncoplanar $^{6}Li(p,pd)$ reactions. There was negligible contamination of the spectra by sequential decay of intermediate excited states of $^{6,7}Li$ and ^{3}He.

Predicted cross sections were obtained from the distorted wave impulse approximation (DWIA). Published nuclear optical potential parameters[5-7] for the p+Li, p+α, and d+α systems were utilized. The two latter sets were crudely adapted to the p+^{5}He and d+^{5}He systems by multiplying their well depths by 5/4. We used the elastic p+d cross sections measured[8] at 198 MeV.

These calculations fitted the coplanar energy-sharing spectrum with a C_d of 1.4; an unphysical result since ^{7}Li has three nucleons outside the α-particle core. Numerous other parameter sets gave the C_d's as large as 2.2, but none smaller than 1.4.

The measured cross sections were integrated over a 25 MeV interval including the quasielastic peak, and are plotted vs. the noncoplanarity angle in Fig. 1. The DWIA (with C_d=1.4) substantially underpredicts the large-angle cross section, as it also does[4] for $^{6}Li(p,pd)$.

Reduction of the imaginary well depths was the only optical parameter variation which significantly reduced C_d. Eliminating the entrance-channel absorption reduced C_d to 1.1. This may be partially justified since the p+Li inelastic cross section may be largely breakup while, in the DWIA, the primary p+d interaction causes the quasi-elastic scattering.

Since the overprediction of C_d by the DWIA may also result from the diffuseness of the unbound ^{5}He

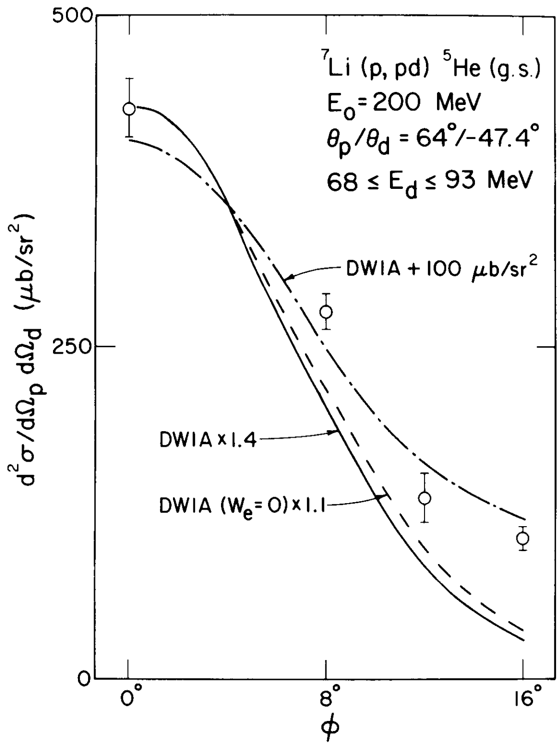

Figure 1. Cross sections for ^{7}Li(p,pd) at 200 MeV, integrated over a 25 MeV deuteron energy range, vs. deuteron noncoplanarity angle. DWIA predictions are shown with and without entrance channel absorption, and with an added isotropic "background".

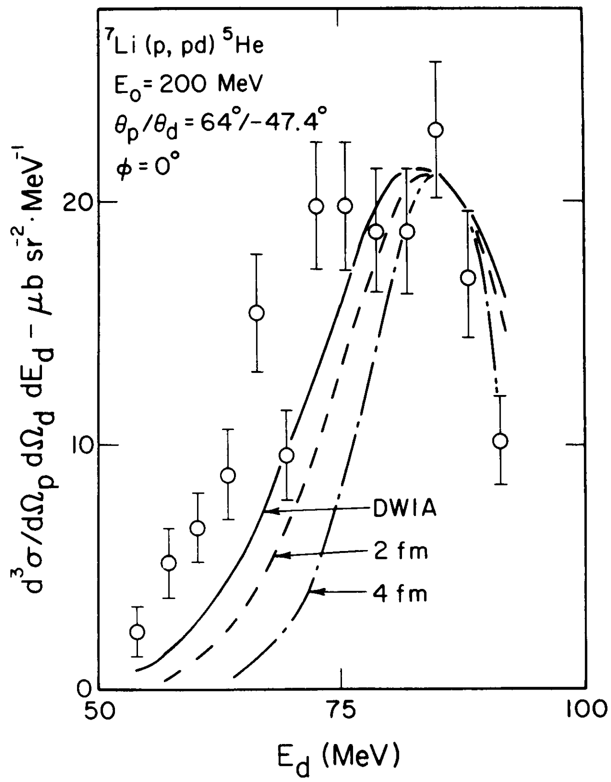

Figure 2. Coplanar energy-sharing predictions for the standard DWIA and with cluster wavefunctions enhanced in the tail region.

cluster, the tail of the cluster wave function was artificially enhanced by smoothly joining the Woods-Saxon interior function to an exponentially-decreasing exterior function. A 4 fm falloff radius for the latter function reduced C_d to 0.9, but the predicted quasi-elastic peak (Fig. 2) became too narrow to fit the noncoplanar data.

The large C_d and anomalous large-angle yield might result from other reaction mechanisms, not considered by the DWIA, whose yields are more nearly isotropic. A better fit to the data of Fig. 1 is obtained by adding a constant "background" of 100 μb/sr^2 to the DWIA prediction with C_d=1. But this procedure is questionable since, even at large φ, the energy-sharing spectra show the broad peaks characteristic of quasielastic scattering.

C_d was also estimated from the plane wave impulse approximation (PWIA).[9] Distortion and absorption effects for the ^{6,7}Li(p,pd) reactions should be similar, so the PWIA should better predict the ratio of the ratio of the reaction cross sections than their individual values. By equating the measured and PWIA-predicted ratios of these reaction cross sections and taking[4] C_d=0.76 for ^{6}Li, we find C_d=0.82 for ^{7}Li.

The FWHM of the momentum distribution for d+^{5}He clusters was estimated to be 140 MeV/c. Fig. 3 shows the result of taking the cross section to be proportional to the momentum probability (assumed Gaussian) and fitting the cross sections nearest the quasielastic peak, at each φ. The fit to the φ=16° (p=140 MeV/c) datum was ignored; studies of the ^{6}Li(p,pd) reaction[4] also show a discrepancy between measured and predicted cross sections for such large momenta.

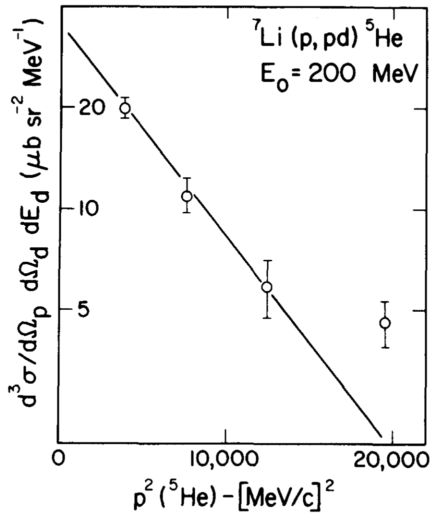

Figure 3. Measured cross sections vs. momentum-squared of the undetected cluster; both are taken at the quasi-elastic peak predicted by the DWIA.

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