INELASTIC PROTON SCATTERING TO M_1 STATES IN ^{12}C, ^{24}Mg AND ^{28}Si AT 62 MeV

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In order to make comparisons between (p,n) data at E = 62 MeV, (p,p') spectra were taken at the same energy in the angular range from 6^0 to 42^0 for ^{12}C, ^{24}Mg, and ^{28}Si. Since only T = 1 states are excited by the (p,n) reaction on these targets, interest is focused on the M_1 states in the analysis of the (p,p') spectra. Analysis is not complete as yet on the ^{24}Mg (p,p') and ^{28}Si (p,p') measurements. Papers including the ^{12}C (p,p') results are in draft form.

^{12}C (p,p') Results

Figure 1 shows a spectrograph spectrum of ^{12}C inelastic scattering at $\theta_{LAB} = 26^0$ in the region of excitation from 14.5 to 18 MeV. The 15.11 (1^+, T = 1) and 16.11 (2^+, T = 1) MeV states dominate the spectrum. A broad peak associated with excitation of the 16.58 MeV (2 , T = 1) state is clearly seen. A very broad peak (FWHM = 1.41 ± 0.15 MeV) centered at 15.4 ± 0.1 MeV is also indicated in this spectrum. This state has been seen in (α,α') scattering at 60 MeV and in (p,p') scattering at 155 MeV (but not at 45 MeV) by Buenerd et al. Comparison of a partial angular distribution for this state with the angular distribution for the 2^+,16.11 MeV state confirms their assignment of 2^+, T = 0 to the 15.4 MeV state. Similar spectrograph spectra were taken centered on the 12.71 MeV 1^+, T = 0 state at about 2^0 intervals from 8^0 to 42^0 for comparison with the 1^+, T = 1 state at 15.11 MeV.

Figure 2 shows the measured angular distribution for the 15.11 MeV state compared to the recently reported results at E_p = 65 MeV of Hosono et al.[2] and the earlier results at E_p = 61 MeV of Bertrand and Peele[3]. The solid line is a Distorted Wave Impulse Approximation calculation using the effective interaction of Walker and Picklesimer[4], Cohen and Kurath Wave Functions and Hosono[2] optical potential parameters. A similar

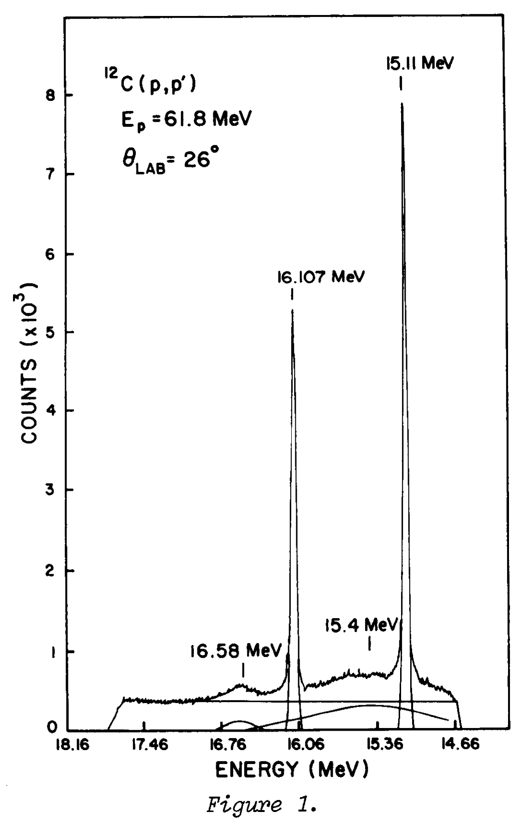

Figure 1.

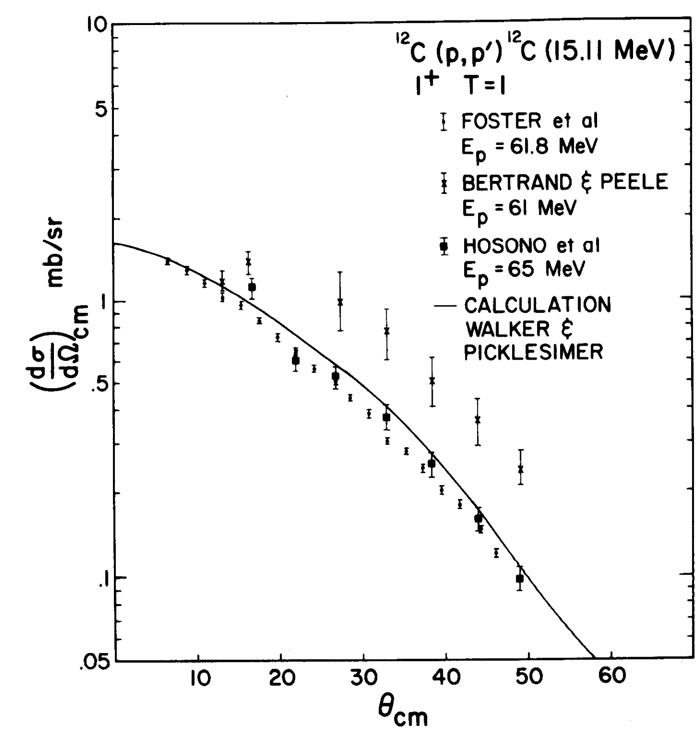

Figure 2.

plot for the 12.71 MeV state is seen in Figure 3. Agreement between the theoretical calculations which are parameter free and unnormalized is remarkable in that the distorted wave impulse approximation may not have been expected to be a reasonable approximation at an energy as low as 62 MeV.

Figure 4 is a similar angular distribution plot for the 16.1 MeV state. No theoretical calculation has been made by Walker and Picklesimer for this state as yet.

Angular distributions for ^{12}C (p,p') ^{12}C to the 15.11 MeV state and ^{12}C (p,n)^{12}N the ground state should be related by (1) $2 \frac{d\sigma}{d\Omega}(p,p') = \frac{d\sigma}{d\Omega}(p,n)$[5] if isospin is conserved. At E_p = 122 MeV, this relationship has been established to within 10% by comparison of ^{12}C (p,p') data of Comfort et al.[6] with ^{12}C(p,n) data of Goulding et al.[7] for which careful calibration of the neutron detector efficiency was done using ^7Li (p,n) $^7\beta e$ (g.s. + 0.43 MeV) in a method similar to that described by Schery et al.[8] Having established the validity of eq.(1) at 122 MeV, it was used to normalize the ^{12}C (p,n)^{12}N (g.s.) results to the ^{12}C (15.11) results.

Figure 5 shows ^{12}C (p,p') and ^{12}C (p,n) angular distributions for the comparable states at 15.11 (16.11) and 0.0 (1.0) MeV for the two reactions. The solid lines in this figure are DWBA calculations using the following optical model parameters[9]: V = 32.8 r_R = 1.2, a_R = 0.62, W_V = 7.54, W_D = 0, r_I = 1.40, a_I =0.67, V_{so} = 5.625, v_{so} = 0.9, a_{so} = 0.50. Normalizations required to bring the calculations to the observed values are N = 21 for the (p,p') to the 15.11 MeV state and N = 43 for the (p,n) to the ground state. This is consistant with $\frac{d\sigma}{d\Omega}(p,n) / \frac{d\sigma}{d\Omega}(p,p') = 2$ to within 2.5%. Normalization values of N = 220 and N = 430 are needed in the calculations to reproduce the experimental values for the ^{12}C (p,p') ^{12}C (16.11) and ^{12}C (p,n) ^{12}N (1.0) state. This also is consistant with a (p,n) / (p,p') cross section ratio of 2 to within 2.5% which also corroborates the validity of eq. (1). The absolute (p,n) cross sections were also compared with those measured by Madey et al.[9] which were taken

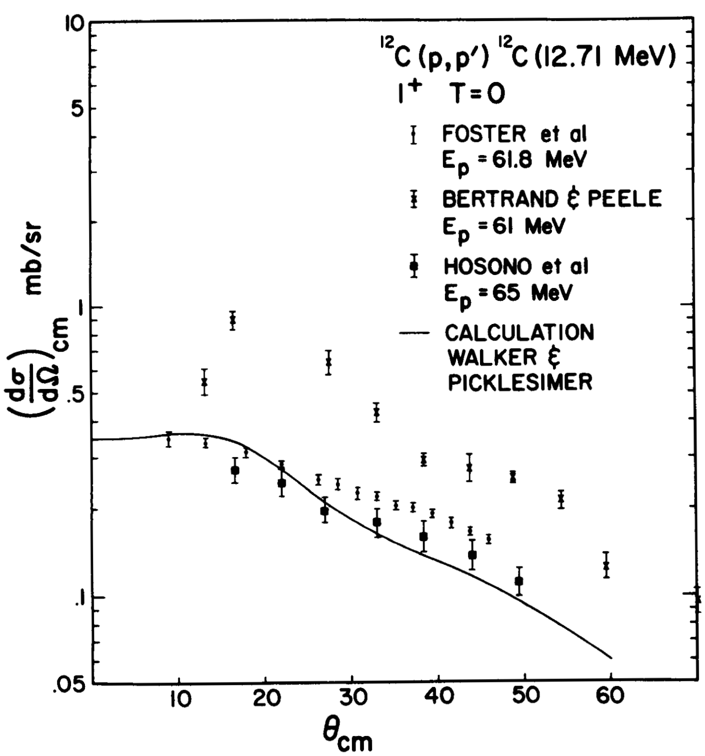

Figure 3.

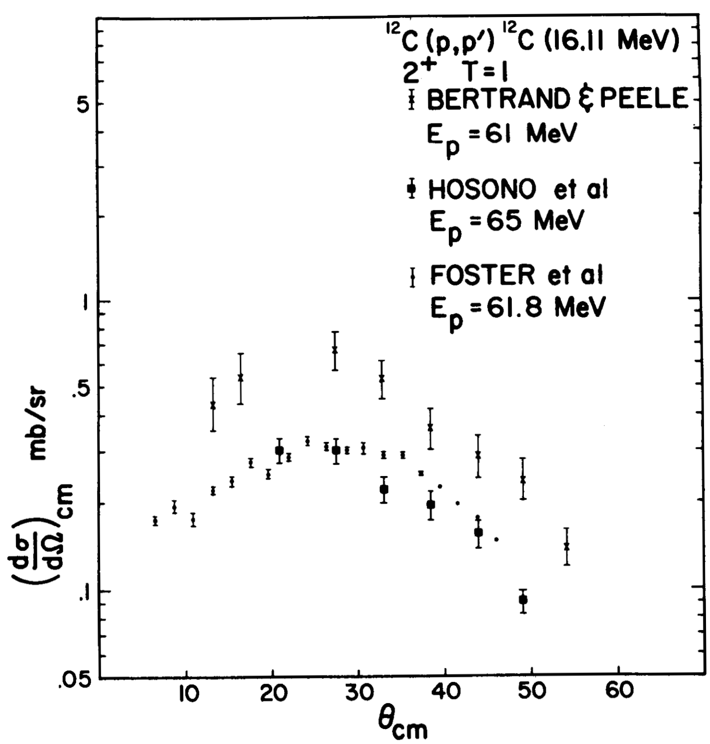

Figure 4.

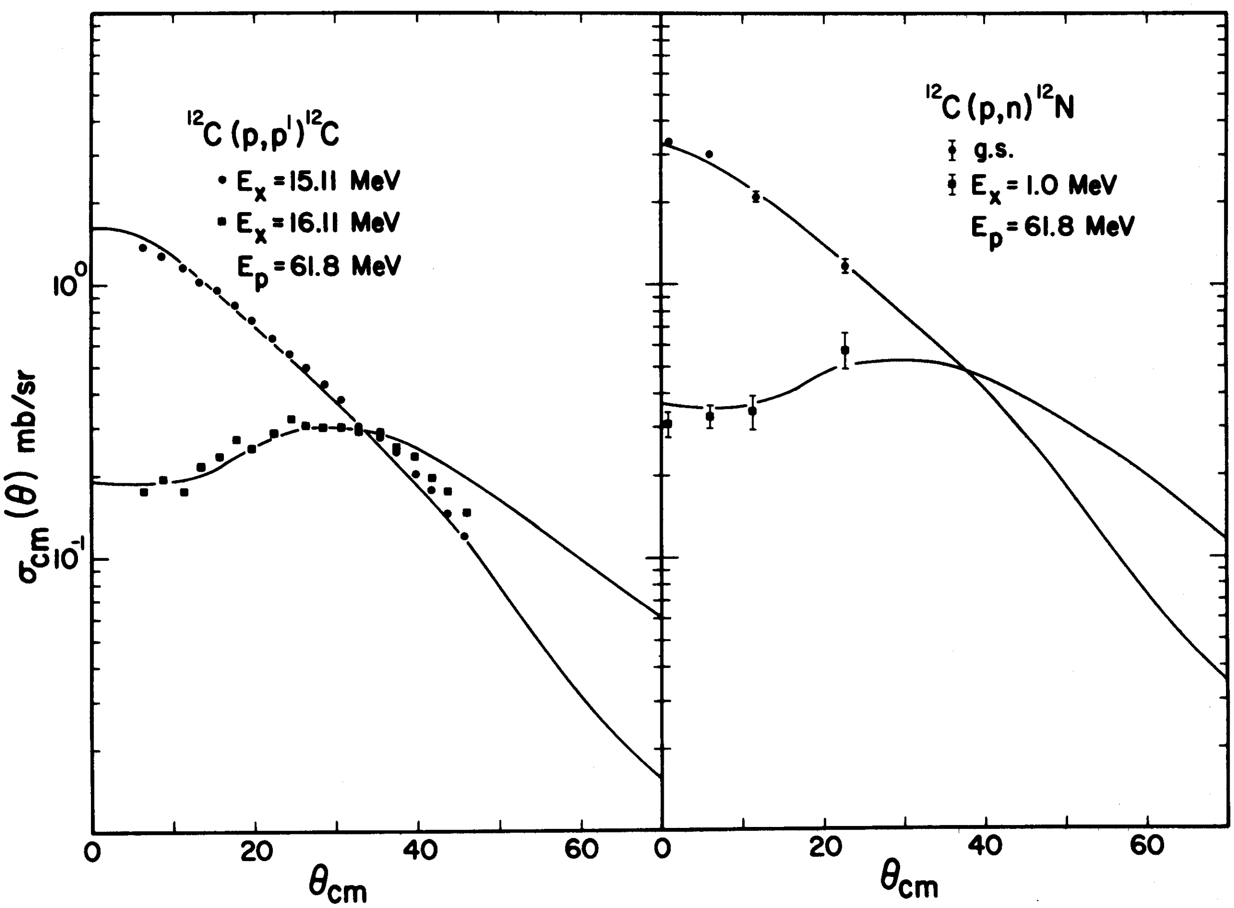

Figure 5.

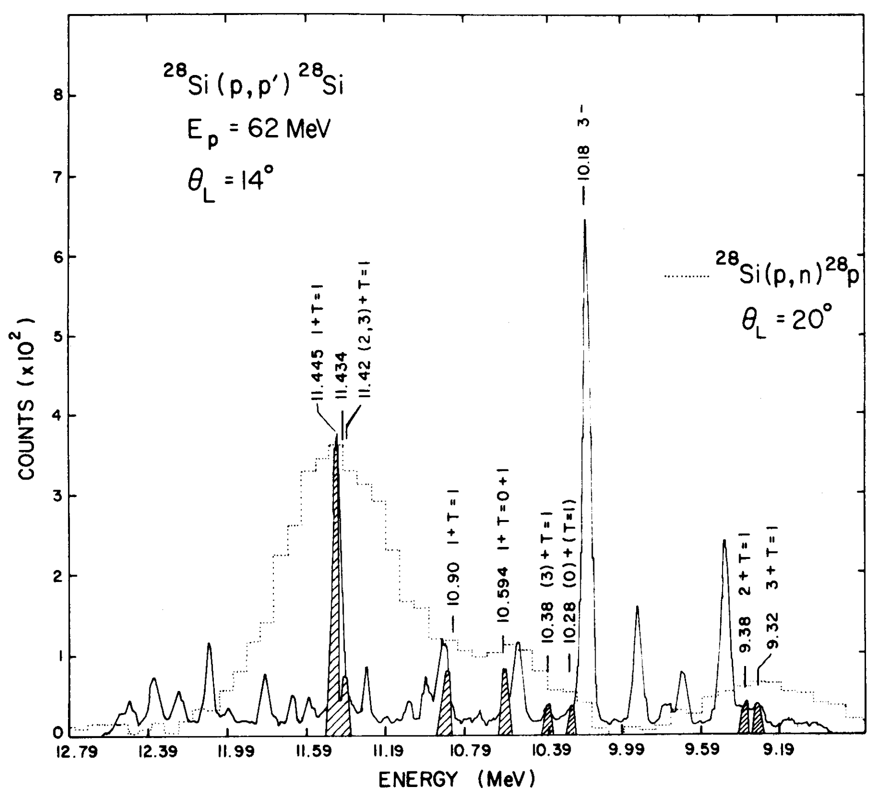

Figure 6.

at the same time but with the neutron detector efficiency calculated by the use of a computer code. Absolute values agree to 5%.

^{28}Si and ^{24}Mg

Figure 6 shows a ^{28}Si (p,p') ^{28}Si spectrograph spectrum at $\theta_{Lab} = 14^{o}$ and $E_p = 62$ MeV in the excitation energy range from about 9 to 12.8 MeV (solid lines) compared to a ^{28}Si (p,n) ^{28}P spectrum (dotted lines). The peak at 2.1 MeV excitation energy in the (p,n) spectrum has been matched in energy and normalized by height to its analog 11.45 MeV peak in the (p,p') spectrum. Shaded peaks in the (p,p') spectrum which has a resolution of 44 keV (FWHM), indicate T = 1 peaks reported in the literature. Energy resolution of the (p,n) data is 800 keV (FWHM). Such direct comparisons may be useful in determining distributions of T = 0 and T = 1 strength. However, as is clear from this spectrum, the direct comparison for ^{28}Si is limited by the resolution attained in both the (p,n) and (p,p') measurements. For instance, Figure 7 shows a comparison between the ^{28}Si (p,n)^{28}P (2.1 MeV) cross section angular distribution and two times the ^{28}Si (p,p') ^{28}Si (11.42 + 11.43 + 11.44 MeV) cross section distribution. The (p,p') cross section is high by about 30% due to the contribution of the unresolved 11.434 MeV T = 0 state in the (p,p') scattering. Similar comparisons are in process for ^{24}Mg (p,n) and (p,p') scattering at 62 MeV but are not yet complete.

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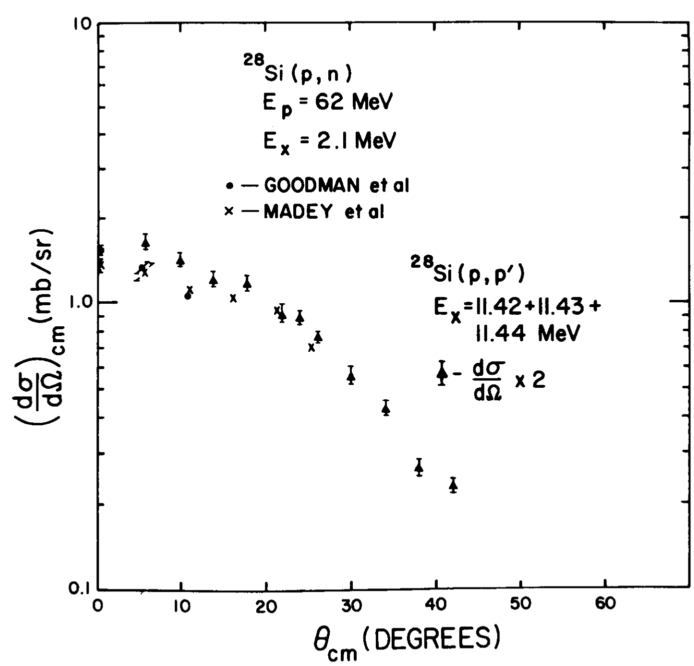

Figure 7.