SPECTROSCOPY OF A=12 AT HIGH EXCITATION

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A recent series of experiments at LAMPF has shown that a number of states in ^{12}C at excitation energies greater than 18 MeV are populated in various reactions with surprisingly large strength. For example, in $^{12}C(\pi,\pi')^{12}C^*$ experiments with T_π=180 MeV,[1] levels at 19.3, 20.6 and 21.6 MeV in excitation have much greater strength than might be anticipated on the basis of inelastic scattering experiments using conventional projectiles. Also, in the $^{13}C(p,d)^{12}C$ reaction at T_p=800 MeV[2] very strong levels are seen at 20.6 and 25.6 MeV of excitation while at lower energies ($T_p \leq 185$ MeV) the same reaction populates these states weakly or not at all.

It is apparent from these preliminary LAMPF results that there is something novel in the mechanisms of these two reactions. Before we can understand the nature of these new features, we must know the nature of these newly excited levels. We have therefore undertaken a program of conventional nuclear reaction measurements at the University of Colorado and the Indiana University Cyclotron Facility to do spectroscopy in the mass-12 system at excitation energies above 18 MeV. At the University of Colorado we have to date obtained spectra for the $^{11}B(h,d)^{12}C$ and $^{10}B(h,p)^{12}C$ reactions at E_h=45 MeV. Cross sections for the $^{14}N(p,t)^{12}N$, $^{14}N(p,h)^{12}C$, $^{14}N(d,\alpha)^{12}C$, $^{13}C(d,t)^{12}C$ and $^{13}C(d,h)^{12}B$ reactions have been measured at the Indiana University Cyclotron Facility at E_p=80 MeV and E_d=66 MeV.

Data analysis is only in the preliminary stages. Nevertheless some interesting features are already apparent. The three two-nucleon pickup reactions excite, among others, levels at 18.8, 19.6 and 20.6 MeV of excitation in ^{12}C (or their analogues). The pattern of excitation is shown in Table I. One can therefore conclude that there are positive parity levels at these excitations, that the 18.8 MeV level has T=1, the 19.6 level T=0 and the 20.6 level has both T=0 and 1, though it is predominantly T=0.

The (d,t) reaction excites both the 18.8 and 20.6

Table I. Summary of some (p,t), (p,h), (d,α) results leading to final states of ^{12}C. A check mark indicates appreciable yield in that reaction at the three pairs of angles indicated, selected to have roughly the same momentum transfer for reactions induced by both projectile types.

			T=1	T=1, T=0	T=0
θ_p	θ_d	E_x (MeV)	(p,t)	(p,h)	(d,α)
20°	30°	18.8	✓	✓	--
		19.6	--	✓	✓
		20.6	weak	✓	✓
40°	50°	18.8	✓	✓	--
		19.6	--	✓	✓
		20.6	✓	✓	✓
70°	70°	18.8	✓	--(?)	--
		19.6	weak	✓	✓
		20.6	✓	✓	✓

MeV levels, but not the 19.6 MeV state. The (d,t) to (d,h) population ratio indicates that both the T=0 and 1 components of the 20.6 MeV level are being excited via single neutron pickup. The spectrum shown in Fig. 1 illustrates these features.

The $^{10}B(h,p)^{12}C$ cross sections were measured using a HPGe stopping detector. The overall detector configuration allowed the acquisition of spectra extending up to ∿42 MeV of excitation in ^{12}C. Of the three levels mentioned above, only the 20.6 MeV level was observed clearly.

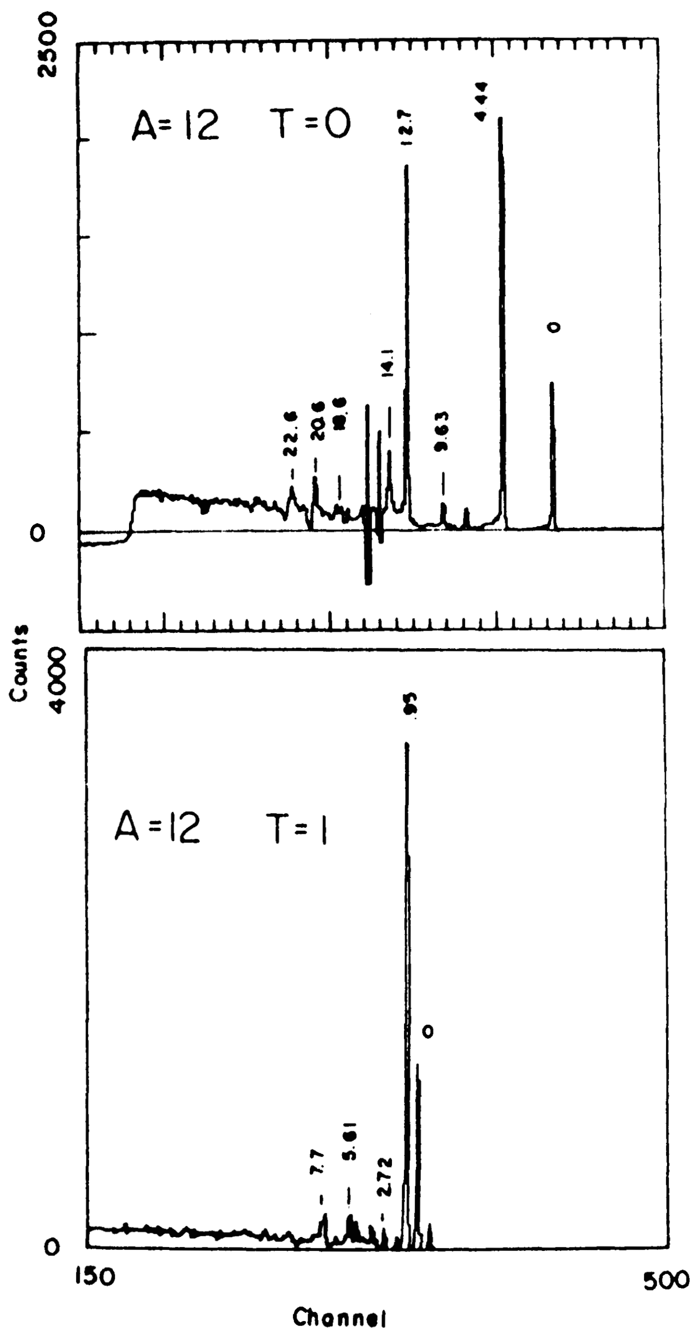
The $^{11}B(h,d)^{12}C$ reaction strongly excites levels at 18.3, 19.6 and 20.6 MeV. These results serve to make an interesting comparison with some recent $^{12}C(\pi^{\pm},\pi^{\pm}{}')$ measurements[3] which suggest spin mixing between levels at 19.25 and 19.65 MeV. In the (π,π') article the 19.25 MeV state is identified as a proton configuration while the 19.65 MeV state is said to be a neutron state. Our results show that the $^{11}B(h,d)$ reaction, which should, of course, populate proton states, excites a 19.6 MeV state but shows virtually no strength at 19.2 MeV. This observation is consistent with earlier measurements by Reynolds <u>et al.</u>[4] Thus, if the same levels are excited in the two reactions, the (h,d) and (π,π') results are inconsistent.

1) C.F. Moore et al., Phys. Lett. <u>80B</u>, 38 (1979).

2) T.S. Bauer et al., submitted to Phys. Rev. C; and G. Smith et al., to be published.

3) C.L. Morris et al., Phys. Lett. <u>86B</u>, 31 (1979); and C.L. Morris, Bull. Am. Phys. Soc. <u>24</u>, 824 (1979).

4) G.M. Reynolds et al., Phys. Rev. <u>C3</u>, 442 (1971).



<u>Figure 1</u>. The T=1 levels of the mass 12 system populated by the $^{13}C(d,^{3}He)^{12}B$ reaction at 40 degrees. The T=0 levels are obtained by subtracting approximately one-half of the ^{12}B spectrum from the data for the $^{13}C(d,t)^{12}C$ reaction, measured at the same time. The T=0 levels at 18.6, 20.6 and 22.6 MeV were previously unknown. The energy calculation is tentative.