Proc. Sixth Int. Symp. Polar. Phenom. in Nucl. Phys., Osaka, 1985
J. Phys. Soc. Jpn. 55 (1986) Suppl. p. 574-575

1.10

A Comparative Study of the $^{13}C(\vec{p},p')^{13}C$ and $^{13}C(p,n)^{13}N$ Reactions at E_p = 35 MeV

H. Ohnuma, K. Furukawa[a], S. Hayakawa[b], T. Hasegawa[c], N. Hoshino, K. Ieki, N. Kabasawa[a], K. Maeda[d], K. Miura[e], K. Nisimura[c], H. Orihara[f], T. Suehiro[e], T. Tohei[a] and M. Yasue[c]

Department of Physics, Tokyo Institute of Technology, Meguro, Tokyo 152, Japan
a)Department of Physics, Tohoku University, Sendai, Miyagi 980, Japan
b)Ashikaga Institute of Technology, Ashikaga, Tochigi 326, Japan
c)Institute for Nuclear Study, University of Tokyo, Tanashi, Tokyo 188, Japan
d)Faculty of General Education, Tohoku University, Sendai, Miyagi 980, Japan
e)Tohoku Institute of Technology, Sendai, Miyagi 982, Japan
f)Cyclotron and Radioisotope Center, Tohoku University, Sendai, Miyagi980, Japan

A recent discovery[1] of enhanced large-angle cross sections in the $^{16}O(p,n)^{16}F(0^-)$ reaction at E_p=35 MeV has aroused much interest because of the pure longitudinal nature of this transition, and been followed by other experimental[2] and theoretical[3] investigations. This $0^+ \rightarrow 0^-$ transition is thought to be an almost pure $\nu p_{1/2} \rightarrow \pi s_{1/2}$ single-particle transition. A similar single-particle like transition in ^{13}C, g.s. $(1/2^-) \rightarrow 3.09$ MeV$(1/2^+)$, has been extensively studied in (π,π')[4], (p,p')[5] and (e,e') reactions. This $1/2^- \rightarrow 1/2^+$ transition involves four amplitudes, ΔJ=0 and 1, and ΔT=0 and 1. Only the ΔJ=0, ΔT=1 component among those is related to the $0^+ \rightarrow 0^-$ transition. All the existing data on the $1/2^- \rightarrow 1/2^+$ inelastic scattering on ^{13}C show large deviations from the shell-model predictions.

We have studied both the $^{13}C(\vec{p},p')^{13}C$ and $^{13}C(p,n)^{13}N$ reactions at E_p=35 MeV to look into the problem of this $1/2^- \rightarrow 1/2^+$ transition. The $(\vec{p},p')$ experiment was done at the Institute for Nuclear Study, University of Tokyo, using a polarized proton beam from the AVF cyclotron and a magnetic spectrometer. The (p,n) data were taken using the TOF facilities at the Cyclotron and Radioisotope Center, Tohoku University.

The DWBA calculations are carried out using the code DWBA74[7]. A set of effective interactions of Bertsch et al. (M3Y)[8] is used along with the proton potential parameters of Fabrici et al.[9] and the neutron potential parameters of Carlson et al.[10] The transition amplitudes are obtained from the Cohen-Kurath[11] and the Millener-Kurath[12] wave functions.

The (p,n) angular distributions not only for the $1/2^+$ state (Fig. 1) but also for the other states are remarkably well reproduced by the DWBA calculation. The calculated (p.p') cross sections and analyzing powers for the states other than $1/2^+$ are also in good agreement with the data, provided "effective charges" are introduced[4,5] to some of the amplitudes.

On the contrary DWBA utterly fails to describe the (p,p') data for the $1/2^+$ state (Fig. 2). According to the calculation, both the (p,p') and (p,n) cross sections are dominated by the ΔJ=1 component and should give similar angular distributions. The (p,p') data for the $1/2^+$ state show, similarly to those at higher energies[5], a large deviation from the prediction. The present comparison of the (p,p') and (p,n) data and the DWBA analyses readily rule out the possibility of this discrepancy being due to higher-order reaction processes, improper choice of distorting potential parameters and/or effective interaction, or incorrect isovector amplitudes. Thus a strong suspicion falls on the isoscalar part of the transition amplitudes. However it seems that none of the single $J(LS)_{T=0}$ component is responsible for the discrepancy between the calculation and the data.

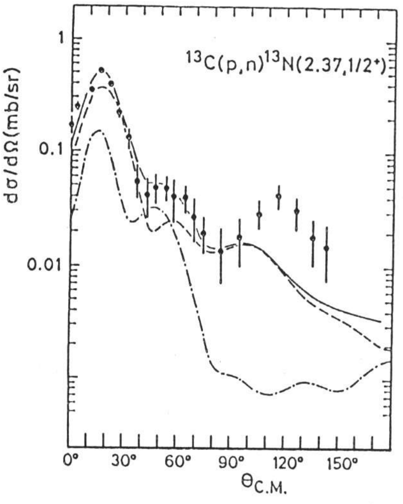

Fig. 1. The (p,n) angular distribution for the $1/2^+$ state. The solid, dashed and dash-dotted curves are total, J=1 and J=0 DWBA calculations, respectively.

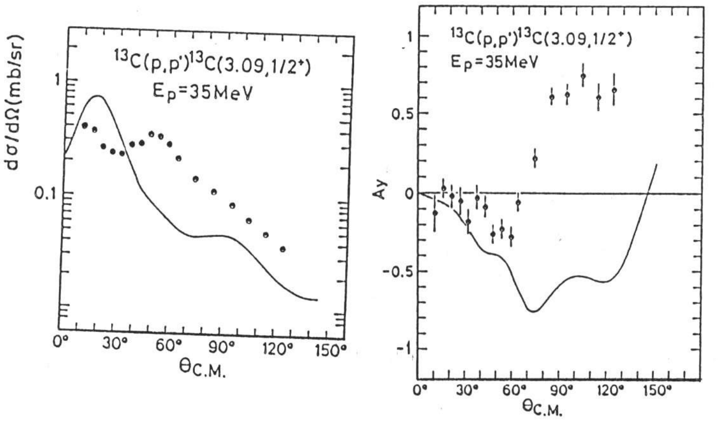

Fig. 2. The differential cross sections and analyzing powers for the $^{13}C(p,p')^{13}C(3.09, 1/2^+)$ reaction. The curves are DWBA calculations.

References

1) H. Orihara et al.: Phys. Rev. Lett. 49(1982)1318.
2) K. Hosono et al.: Phys. Rev. C30(1984)746; R. Madey et al.:IUCF Report 1983, p.35.
3) M. Yabe, K.-I. Kubo and H. Toki: preprint.
4) S. J. Seestrom-Morris et al.: Phys. Rev. C26(1982)594.
5) S. F. Collins et al.: Nucl. Phys. A380(1982)445; S. J. Seestrom-Morris et al.: Phys. Rev. C30(1984)270.
6) R. Hicks, unpublished.
7) R. Schaefer and J. Raynal: Saclay Report No. CEAR 4000(1970), unpublished.
8) G. Bertsch et al.: Nucl. Phys. A284(1977)399.
9) E. Fabrici et al.: Phys. Rev. C21(1980)830.
10) J. D. Carlson, C. D. Zafiratos and D. A. Lind: Nucl. Phys. A249(1975)29.
11) S. Cohen and D. Kurath: Nucl. Phys. 73(1965)1.
12) D. J. Millener and D. Kurath: Nucl. Phys. A255(1975)315.