TRANSFER REACTIONS

INNER PROTON SHELL STRUCTURE IN ^{58}Ni and ^{90}Zr FROM $(\vec{d},{}^3He)$ REACTIONS

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The aim of the present experiment is the measurement of the spin-orbit splitting of 1d protons in ^{58}Ni and 1f protons in ^{90}Zr. Both target nuclei are spherical spin-unsaturated nuclei for which the deficiencies of many-body theories in explaining the spin-orbit splitting[1] should be particularly apparent. The experiment on ^{90}Zr was further motivated by recent reports[2] of discrepancies between spectroscopic strengths as derived from (e,e'p) studies at NIKHEF and previous $(\vec{d},{}^3He)$ experiments[3] at 52 MeV.

In order to localize and identify the inner hole strengths we measured differential cross sections and vector analyzing powers of the $(\vec{d},{}^3He)$ reactions at 80 MeV at seven and four carefully selected forward angles for ^{58}Ni and ^{90}Zr, respectively. Using the QDDM spectrograph, an overall energy resolution of 50 keV was achieved and excitation energies up to 11 MeV in ^{57}Co and 8 MeV in ^{89}Y were investigated.

The reduction of the data obtained in an October 1984 run is in progress. Since the energy resolution was substantially better than in earlier transfer experiments[2,3] we can show that much of the previously observed continuous background results from unresolved groups. Hence in the present spectra, the problem of background subtraction is substantially reduced. Preliminary zero-range DWBA calculations show that most of the expected 1d and 1f hole strengths have been located; a sound j-assignment, however, must await further DWBA calculations yielding improved fits to the vector analyzing powers.

In the case of ^{90}Zr, zero-range DWBA calculations seem to corroborate the spectroscopic strengths of Ref. 3 resulting in a (preliminary) discrepancy with the (e,e'p) results.[2] A comparison of the spectra in Fig. 1 shows a very satisfactory similarity of the fine structure which supports the assumption of a direct one-step nature of the $(\vec{d},{}^3He)$ reaction in this case.

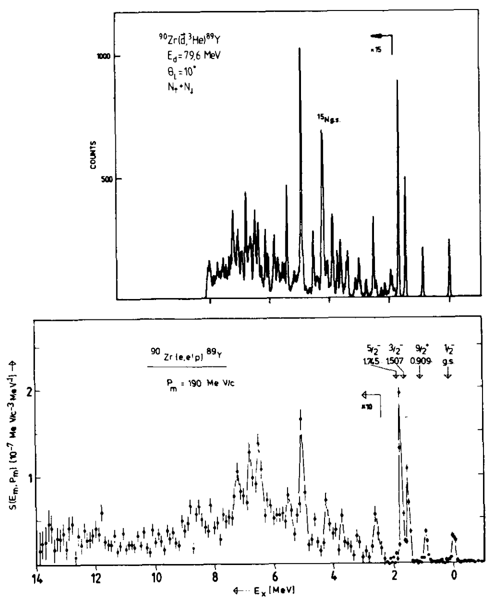

Figure 1. Comparison of missing energy spectra from a ^{90}Zr(e,e'p) experiment (Ref. 2; courtesy of L. Lapikas) and the present ^{90}Zr(d,^{3}He) experiment with identical energy scales. Both spectra were taken at kinematic conditions favoring ℓ = 3 transfer.

1) W.G. Love, Phys. Rev. C 20, 1638 (1979) and refs. therein.

2) L. Lapikas, Invited paper at the 10th PANIC Conference, Heidelberg (1984).

3) A. Stuirbrink, G.J. Wagner, K.T. Knopfle, Lin Ken Pao, G. Mairle, H. Riedesel, K. Schindler, V. Bechtold and L. Friedrich, Z. Phys. A297, 307 (1980).

$^{18}O(\vec{p},t)^{16}O$ at Tp = 90 MeV

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In the $^{17}O(\vec{p},t)^{15}O$ experiment[1] we also obtained some data for $^{18}O(\vec{p},t)$ from the 25% ^{18}O component of the target. As can be seen in Fig. 1 of the $^{17}O(\vec{p},t)$ report in the IUCF Annual Report of 1983 several ^{16}O excited states were resolved in the excitation range from about 5 to 17 MeV. A gap of about 2 MeV between 10 and 12 MeV excitation energy resulted at most angles from the two non-overlappinng QDDM momentum bites. One state in this 10-12 MeV region has been excited in earlier (p,t) work, the 4^+ state at 10.35 MeV.[2,3] However, in an analysis of the projectile energy dependence M. Pignanelli et al.,[3] observed a sharp decline of the integrated cross sections with increasing energy. At 38 MeV the 4+ state at 10.35 MeV had a cross section of 0.067 mb, and at 44 MeV it was no longer seen in their work. At 10 deg laboratory angle this state was, at most, extremely weak in our 90 MeV experiment. Similarly the "unnatural parity" 2^- state at 8.88 MeV was not seen in our experiment. Its integrated cross section was already down to 0.043 mb at 44 MeV in the former work.

Three relatively strong and three weaker triton groups from $^{18}O(\vec{p},t)$ were analyzed in the present work. The $0^+/3^+$ doublet at 6.05/6.13 MeV, the 3^- state at 13.3 MeV and a poorly resolved state at 16.35 MeV (see Fig. 1 in Ref. 1) are excited with maximal cross sections of about 0.1 mb/sr. The 2^+ state at 6.92 MeV, the 1^+ state at 7.12 MeV and the 2^+ state at 9.85 MeV are seen with only 10% of that strength.

The DWBA analysis of $^{18}O(\vec{p},t)$ became increasingly interesting as three kinds of problems were encountered with the evaluation of the $^{17}O(\vec{p},t)$ angular distributions.

Firstly, a strong sensitivity to the optical potentials was found. We dealt with this by using measured elastic scattering cross sections from $^{17}O(\vec{p},p)$[4] and from nat.$O(^3He,^3He)$[5] to deduce optical model parameters, listed in the Table.

Secondly, since the initial state in the $^{17}O(p,t)$ reaction has $J=5/2^+$, all but the transition to J=1/2- (L=3) have mixed L-values. Only for the well known configurations in ^{15}O it is therefore possible to perform reliable DWBA calculations. In $^{18}O(p,t)$, however, the L transfers are unique.

Thirdly, the DWBA codes used, FRUCK2 and CHUCK3, showed increasing divergence with decreasing momentum-