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1.78 Neutron Hole States in ^{89}Zr via the $(\vec{d},t)$ Reaction

H. Ito, M. Tosaki, N. Matsuoka, M. Fujiwara, H. Sakai
K. Hosono, T. Saito and T. Yamazaki

Research Center for Nuclear Physics, Osaka University
Ibaraki, Osaka 567, Japan

Using one-nucleon pick-up reactions, valence and deep hole states in residual nuclei have been investigated. Recent two experiments give different results concerning the distributions of $1f_{7/2}$ and $1f_{5/2}$ neutron hole strengths in ^{89}Zr. Duhamel et al.[1] performed an experiment of (^{3}He,α) reaction with 97.3 MeV ^{3}He particles and reported that about 50% of the $1f_{7/2}$ neutron hole strength existed in the excitation energy range of E_x = 3.5-7.7 MeV. Kasagi et al.[2] used the $(\vec{p},d)$ reaction at 90 MeV and reported that the strength in E_x = 3.4-7.0 MeV was due to the $1f_{5/2}$ neutron hole states and the $1f_{7/2}$ neutron hole strength was distributed in the range E_x > 7 MeV. The value of the spin-orbit splitting of the 1f neutron hole states obtained by Kasagi et al. is about 2 MeV larger compared with the value estimated by a theoretical calculation[3]. In both experiments, the energy resolution was not so good (about 200 keV) and Duhamel et al. used an unpolarized beam. In order to extract the $1f_{7/2}$ and $1f_{5/2}$ neutron hole strengths more accurately, it seems necessary to perform experiments with good energy resolution using polarized beams.

As a first step of such an experiment, we measured the triton spectrum from ^{90}Zr(d,t)^{89}Zr reaction up to 13 MeV excitation energy at θ_{lab} = 13°. The deuteron energy was 60 MeV, and the spectrum was taken using the spectrograph RAIDEN at RCNP. The target used was a self-supporting foil of 0.49 mg/cm^2 thick. The overall energy resolution was 30 keV (FWHM). The spectrum is shown in fig. 1. At the excitation energy region above 7 MeV, we see no sharp peaks other than those of isobaric analog states, but at E_x < 7 MeV, there are many discrete peaks.

Next we measured differential cross sections and vector analyzing powers for the transitions to low-lying states ($E_x \lesssim$ 2.1 MeV) of ^{89}Zr in the ^{90}Zr$(\vec{d},t)^{89}$Zr reaction at 56 MeV in the angular range between 6° and 30°. Some examples of the results are shown in fig. 2. From fig. 2 it is seen that the angular distribution of the differential cross section depends strongly on the transferred ℓ-value, and the angular distributions of analyzing powers for the ℓ=1 transitions are out of phase between the $j_>$ and $j_<$ transitions.

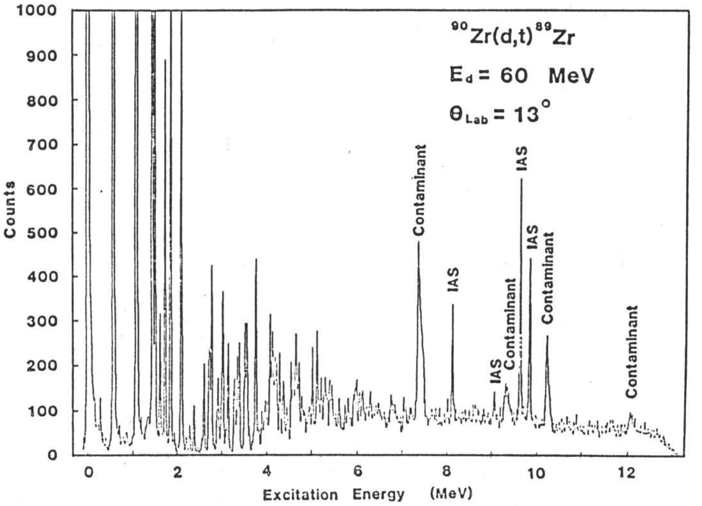

Fig. 1. Triton energy spectrum from the ^{90}Zr(d,t)^{89}Zr reaction at 60 MeV.

The experimental data were compared with the DWBA calculations using the code TWOFNR[4)], and the results are shown in fig. 2. The optical potential parameters were taken from refs. 5) and 6). The DWBA calculations reproduce the shapes of the experimental angular distributions of the differential cross sections and analyzing powers. The calculated angular distributions of analyzing powers are out of phase between $j_>$ and $j_<$ transitions as shown in fig. 2.

These results suggest that the $(\vec{d},t)$ reaction is a useful tool to determine the spin and parity of the neutron hole state. Further experiments of $(\vec{d},t)$ reaction to investigate hole state strengths in the higher excitation energy region of ^{89}Zr are now in progress.

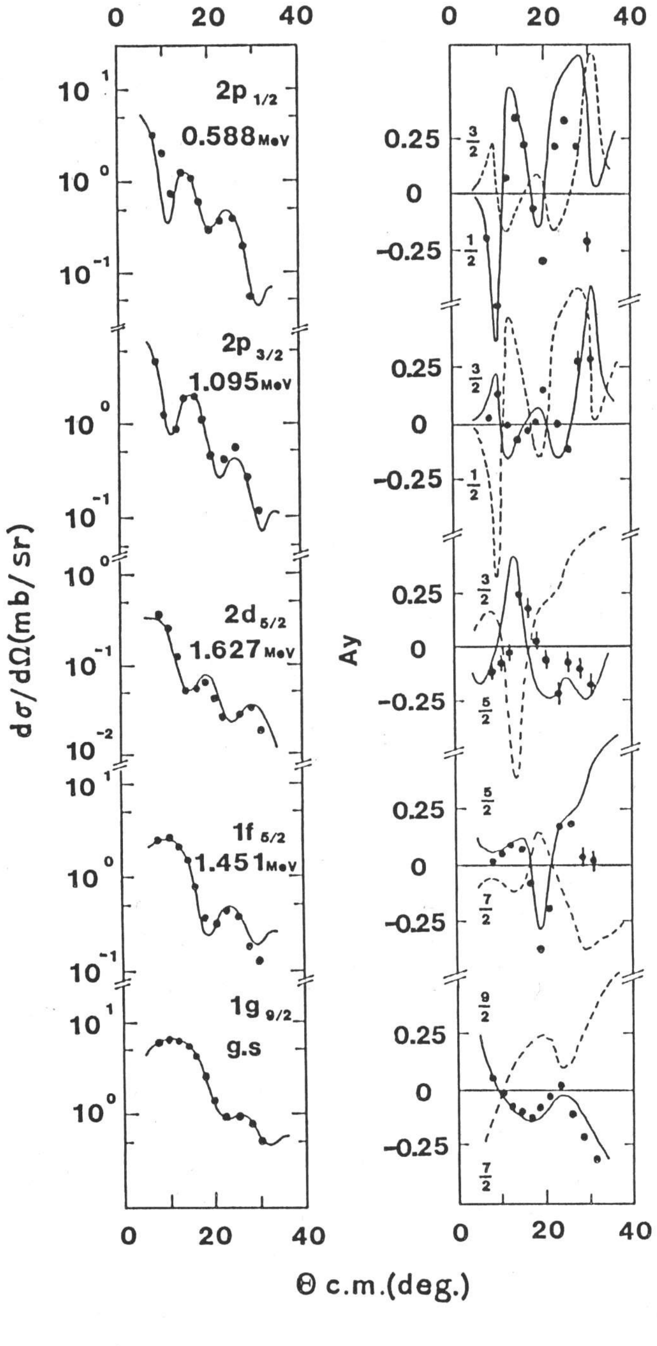

Fig. 2. Angular distributions of differential cross sections and vector analyzing powers from the $^{90}Zr(\vec{d},t)^{89}Zr$ reaction at 56 MeV. The solid and dashed curves are DWBA predictions.

References

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