Measurement of single-particle energies for Ca isotopes by using $(\vec{d}, ^3\text{He})$ reaction

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Recently, considerable progress has been made in the study of exotic nuclei, which consist of extremely unbalanced numbers of protons and neutrons. Related to the structure of such exotic nuclei, Otsuka and others have proposed a mechanism that causes a nuclear shell evolution due to the tensor force [1]. They have claimed that the effect appears even for stable nuclei and have compared their results with experimental values, for effective single-particle energies (ESPE) of the $d_{3/2}$ and $d_{5/2}$ states for Ca isotopes as an example. Actually, both of $1d_{3/2}$ and $1d_{5/2}$ states are significantly fragmented and the ESPE cited are mean values of many $1d_{3/2}$ and $1d_{5/2}$ levels weighted by S-factors determined by a $(d, ^3\text{He})$ experiment using an unpolarized deuteron beam. Because of lack of polarization measurement in this experiment, the j-values of most of d-states were not determined experimentally and guessed or simply assumed to be 5/2. Thus the result is not necessarily reliable enough.

In order to obtain reliable experimental data for single particle energies of $1d_{3/2}$ and $1d_{5/2}$ orbits, we performed this experiment and measured the angular distributions of the differential cross sections and the analyzing powers for $(\vec{d}, ^3\text{He})$ reactions on ^{44,48}Ca. The incident beam energy was 80 MeV. The energy resolution achieved was 60-85 keV.

For ^{48}Ca target, an experiment with a polarized deuteron beam has already been carried out at Indiana University Cyclotron Facility (IUCF) [3], and we confirmed that our data were consistent with their results. For the $^{44}\text{Ca}(\vec{d}, ^3\text{He})$ reaction, we assigned several levels, which were assumed to be $d_{5/2}$ in the old experiment, to be $d_{3/2}$. As a result, the sum of S-factors deduced for the $1d_{3/2}$ state amounts to about 75 % of the shell model limits and that $1d_{5/2}$ state turn out to be only one fourth of the limit. Thus we conclude that the most of $1d_{3/2}$ strength was found. But significant $d_{5/2}$ strength is missing so that the ESPE of the $d_{5/2}$ state deduced from these data is not reliable enough. In this experiment, we analyzed within a region of the excitation energies up to 5.19 MeV, but we found several broad peaks in the higher energy region. Further analysis including such region will be required for conclusive comparison of theory and experiment.

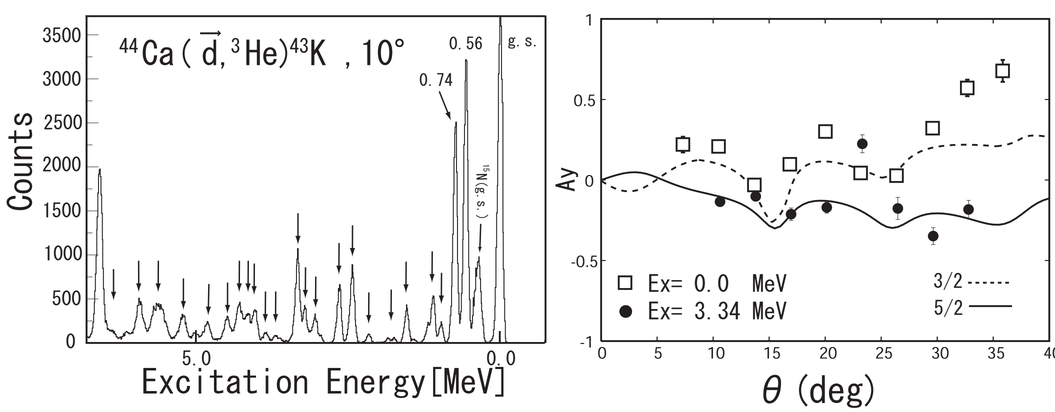

Figure 1: An observed spectrum (left) and angular distributions of analyzing power (right) for $^{44}\text{Ca}(\vec{d}, ^3\text{He})^{43}\text{K}$ reaction.

References

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