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# The ($\vec{p}$,$^3$He) Reactions on p-f Shell Nuclei at 65MeV

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Two nucleon transfer reaction in medium energy region is one of the interesting problems in the study on the reaction mechanism of transfer reactions and also it is a good tool to investigate two nucleon hole states in nuclei. With protons, (p,t) and (p,$^3$He) reactions are possible. Since the triton potentials in the analysis of (p,t) reactions are generally ambiguous in the medium energy region, the studies with (p,$^3$He) reaction are attractive, for which the optical potentials of $^3$He are less ambiguous. Nevertheless, the data of (p,$^3$He) reactions have been scarce because their yields are relatively small, the transition amplitudes are considerably complex and so on.

For these circumstances, we have started to investigate the ($\vec{p}$,$^3$He) reactions on medium weight nuclei at 65∿80MeV.

In the first experiment, $^{54}$Fe and $^{58}$Ni ($\vec{p}$,$^3$He) reactions have been measured in the excitation energy of 0∿10MeV with 65MeV protons from RCNP AVF cyclotron. The emitted $^3$He's are analyzed with the spectrograph "RAIDEN" and detected with the Kyushu SWPC system.

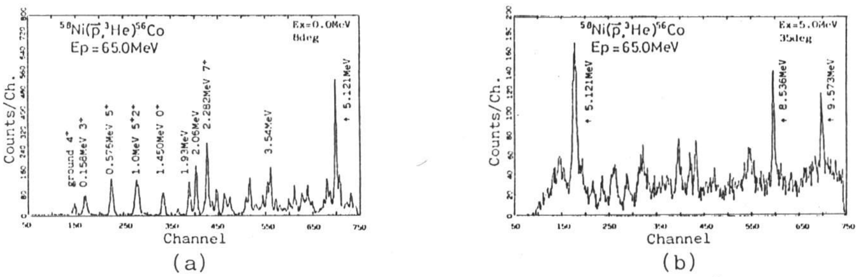
Typical momentum spectra of $^3$He's from $^{58}$Ni ($\vec{p}$,$^3$He) reaction at $\theta_L$= 8° and 35° are shown in Fig.1. The energy resolution was 30∿40keV. As is seen in the figure, strongly excited states exist in Ex=2.283 and 5.121MeV. In Ex=7∿10MeV, two clear excited states exist. The similar trends are observed in $^{54}$Fe ($\vec{p}$,$^3$He) reaction.

Fig.2 and 3 show the angular distributions of cross sections and analyzing powers leading to the 0.576MeV 5$^+$ ($p_{3/2}{}^{-1}$ $f_{7/2}{}^{-1}$ stretched) state and the 5.121MeV state in $^{56}$Co, respectively, together with the results of zero range DWBA analysis. For DWBA calculations, so-called "shallow" and "deep" $^3$He potentials have been used.[1] Fig.2 shows that the deep potential reproduces better the experiment as in the case of one nucleon transfer reactions. This situation does not change in the other transitions.

The 5.121MeV state in $^{56}$Co has been considered to be the $d_{3/2}{}^{-2}$ (stretched 3$^+$) state.[2] As is understood from Fig.3, however, the theory predicts this transition as the $s_{1/2}{}^{-1}$ $f_{7/2}{}^{-1}$ (stretched 4$^-$ state) one.

Other two transitions in Ex=7∿10MeV are assigned tentatively to correspond to the $s_{1/2}{}^{-1}$ $d_{3/2}{}^{-1}$ stretched 2$^+$ and $d_{5/2}{}^{-1}$ $f_{7/2}{}^{-1}$ stretched 6$^-$ states, respectively. The summary of the deeply bound two-hole stretched states observed in the present work is shown in Table I.

It is interesting that (p,$^3$He) reactions with polarized beam suggest the existence of the "deeply bound two-hole stretched states" which are excited with the pickup of a nucleon or two nucleons from the core of the nucleus.




(a) (b)

Fig. 1. Momentum Spectra of $^3$He from the $^{58}$Ni ($\vec{p}$,$^3$He) $^{56}$Co reaction in the excitation energy region of 0∿5MeV (at 8°) (a) and in 5∿9MeV (at 35°) (b).

Fig. 2.
Angular distributions of the cross section and analysing power for the 0.576MeV $5^+$ state in $^{56}Co$. The solid line shows the calculated result using the "deep" potential and the dotted line, using the "shallow" potential, in the DWBA analysis.

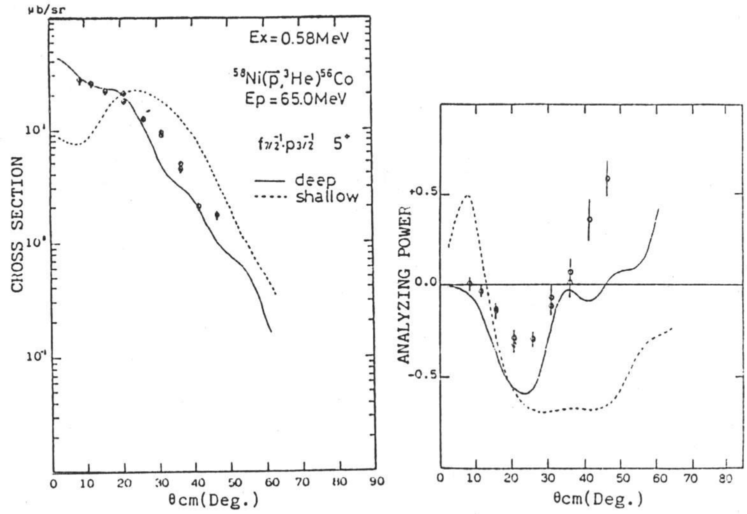



Fig. 3.
Angular distributions of the cross section and analysing power for the 5.121MeV state in $^{56}Co$. The solid line is calculated assuming the $s_{1/2}{}^{-1}$ $f_{7/2}{}^{-1}$ (stretched $4^-$) state and the dotted line, the $d_{3/2}{}^{-2}$ (stretched $3^+$) state.

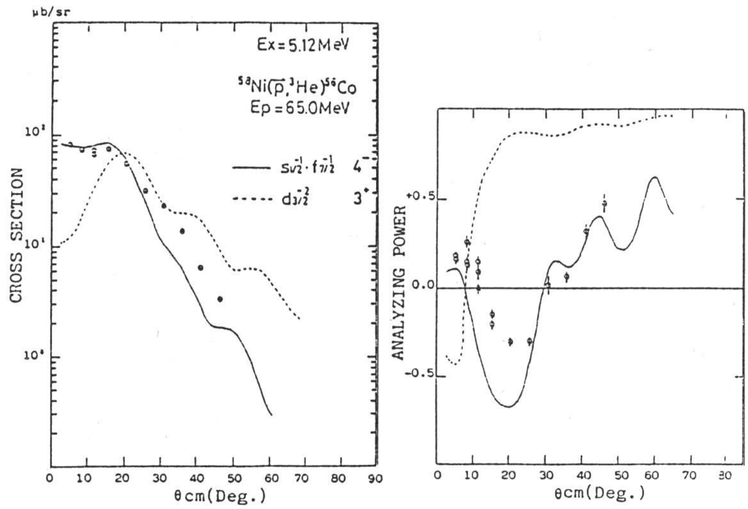



Table 1. Deeply bound two-hole stretched states observed in $^{54}Fe$, $^{58}Ni$ ($\vec{p}$,$^3He$) $^{52}Mn$,$^{56}Co$ reactions

| $^{54}Fe$ ($\vec{p}$,$^3He$) $^{56}Co$ Ex (MeV) | $^{58}Ni$ ($\vec{p}$,$^3He$) $^{56}Co$ Ex (MeV) | $J^\pi$ a) | configuration a) |
|---|---|---|---|
| 3.420 b) | 5.121 ± 0.01 | $4^-$ | $s_{1/2}{}^{-1}$ $f_{7/2}{}^{-1}$ |
| 7.552 ± 0.01 | 8.536 ± 0.01 | $(2^+)$ | ($s_{1/2}{}^{-1}$ $d_{3/2}{}^{-1}$) |
| 8.438 ± 0.01 | 9.573 ± 0.01 | $(6^-)$ | ($d_{5/2}{}^{-1}$ $f_{7/2}{}^{-1}$) |

a) Tentative assignment
b) Excitation energy from A. Guichard et al. P.R. C11 2027 (1975)

## References

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2) G. Bruge and R.F. Leonard, Phys. Rev.2, C2200 (1970)