Isospin Symmetry Structure of GT and $M1$ States in $A=54$ Nuclei

T. Adachi[a], A.D. Bacher[b], G.P.A. Berg[b,c], T. Black[b], C.C Foster[b], H. Fujimura[c], H. Fujita[a], Y. Fujita[a], K. Hatanaka[c], J. Jänecke[d], J. Kamiya[c], K. Katori[e], T. Kawabata[c], Y. Kitamuta[c], W. Lozowski[b], D.A. Robers[d], Y. Shimbara[a], Y. Shimizu[c], E.J. Stephenson[b], M. Uchida[f], H. Ueno[e], T. Yamanaka[c], M. Yoshifuku[a] and M. Yosoi[f]

[a] *Dept. Phys., Osaka University, Toyonaka,Osaka 560-0043*

[b] *Indiana University Cyclotron Facility, Bloomington, Indiana 47408, USA*

[c] *Research Center for Nuclear Physics (RCNP), Ibaraki, Osaka 567-0047, Japan*

[d] *Dept. Phys., University of Michigan, Ann Arbor, Michigan 48109 USA*

[e] *RIKEN, Wako Saitama 351-0198, Japan*

[f] *Dept. Phys., Kyoto University, Sakyo,Kyoto 606-8224*

Gamow-Teller (GT) states are characterized by the quantum numbers of $\Delta L=0$, $\Delta S=1$ and $\Delta T=1$. They are observed in charge exchange (CE) reactions. We did ^{54}Fe(^{3}He$,t$)^{54}Co reaction. The ^{54}Fe has $T_z=+1$, where T_z is the z component of isospin quantum number T. The T value of the ^{54}Fe ground state is $T_0=1$. Allowed T values of GT states in ^{54}Co are 0, 1 and 2, because T_z of ^{54}Co is 0.

The states which are analogous to GT states and observed in inelastic scatterings (IE) are called $M1$ states. Since the ^{54}Fe ground state has $T_0=1$, allowed T values of $M1$ states in ^{54}Fe are 1 and 2. By comparing GT states excited by the ^{54}Fe(^{3}He$,t$) reaction and $M1$ states excited by the ^{54}Fe(p,p') reaction, the analogous structure of 1^+ states in ^{54}Co and ^{54}Fe can be studied.

In hadron reactions at intermediate energies and at 0°, it is known that $\sigma\tau$ interaction is dominant [1] and GT and $M1$ states with $\Delta L=0$ nature are excited prominently. There is a good proportionality between cross sections and transition strengths of GT and $M1$ states [2], where the relevant isospin Clebsh-Gordan (CG) coefficients in IE and CE reactions are different. For analog GT and $M1$ states, the ratio of CG coefficients is 1:1 for the transitions to $T=1$ states, while it is 1:3 to $T=2$ states. If we normalize the strengths by $T=1$ states, $M1$ states with $T=2$ are enhanced. Therefore, isospin T of these states can be identified based on the difference of CG coefficients depending on T of states [3]. Since $T=0$ states are observed only in ^{54}Co spectrum, $T=0$ states can be identified by comparing two spectra.

In order to study the analogous structure and to identify T, the 'level-by-level' comparison of analogous $M1$ and GT states is needed. The 'level-by-level' comparison was difficult because of insufficient resolution in (p,n) reaction and difficulty of 0° experiment in (p,p') reaction. In the ^{54}Fe(^{3}He$,t$) reaction at an incident energy 140 MeV/u performed at RCNP, a good resolution of 35keV was achieved by using a new beam line WS course [4] and Grand Raiden spectrometer [5] and applying the *dispersion matching* [6,7]. The ^{54}Fe(p,p') experiment was performed at IUCF by using K600 spectrometer [8]. The *dispersion matching technique* allowed a good resolution of 35 keV.

The energy spectra from ^{54}Fe(^{3}He$,t$) and ^{54}Fe(p,p') reactions are shown in Figs. 1(a) and (b). From the comparison of Figs. 1(a) and (b), good correspondence of peaks can be seen in the region above $E_x=8.3$ MeV. Good correspondence of states suggests that isospin symmetry of $A=54$ was good even at this highly excited region although the final nuclei are different. The states which was observed only in ^{54}Co, are the $T=0$ states.Those $M1$ and GT states for which analog states are observed have isospin values either $T=1$ or $T=2$. Obtained ratios of yields for analog states are shown in Fig. 2. The ratio of 10.5 MeV states, which were suggested to be $T=2$ [9], was normalized to 3. The ratio of states are divided into two groups. The groups of states in the $8.3\sim10.0$ MeV region in ^{54}Fe(^{3}He$,t$) spectrum show the ratio of about unity. On the other hand, the states above 10.0 MeV show ratios between two or four. The predicted ratios from CG coefficients are 1 and 3 for $T=1$ and $T=2$ states, respectively. It is suggested that the states in the first group is of $T=1$ and those in the second group is of $T=2$. The $T=2$ states are distributed in higher excited energy region compared to $T=1$ states.

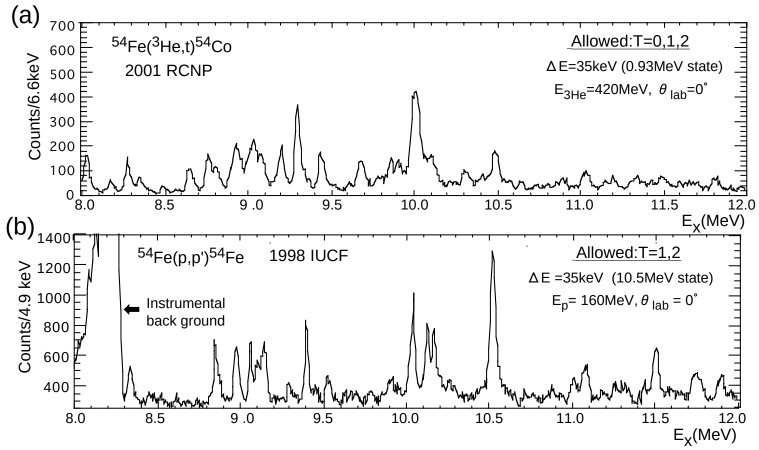

Figure 1: Energy spectrum for $E_x = 8 \sim 12$MeV : (a) ^{54}Fe(^{3}He$, t$) reaction obtained from RCNP. : (b) ^{54}Fe(p, p') reaction obtained from IUCF.

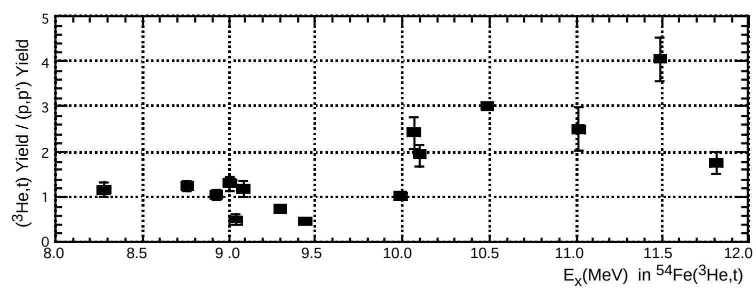

Figure 2: Experimentally obtained ratios between ^{54}Fe(^{3}He$, t$) yields and ^{54}Fe(p, p') yields for analog states. The ratio is shown as a function of excitation energy in the ^{54}Fe(^{3}He$, t$) spectrum.

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