Gamow-Teller Transition Strengths in fp-shell Nuclei

Y. Fujita[a], T. Adachi[a], H. Fujita[a], G.P.A. Berg[b], H. Fujimura[b], K. Hara[b], K. Hatanaka[b], J. Kamiya[b], T. Kawabata[b], Y. Kitamura[b], K. Nakanishi[b], Y. Shimbara[a], Y. Shimizu[b], M. Uchida[c], H.P. Yoshida[b], M. Yoshifuku[a] and M. Yosoi[c]

[a] *Department of Physics, Osaka University, Toyonaka, Osaka 560-0043*
[b] *Research Center for Nuclear Physics, Osaka University, Ibaraki, Osaka 567-0047*
[c] *Department of Physics, Kyoto University, Sakyo, Kyoto 606-8502*

Understanding the explosion mechanism of core collapse of supernovae and the associated element synthesis is one of the most important and challenging problems in nuclear astrophysics. Since the core consists of the elements in the iron region, and the core collapse proceeds through the inverse β-decay process, Gamow-Teller (GT) transitions in fp-shell nuclei play a decisive role in the collapse process.
The most direct information on the GT transition strengths, B(GT), is obtained from the studies of GT β decays, but they suffer from the Q window limitation. On the other hand, charge exchange (CE) reactions, like (p,n) or (n,p), especially those performed at $E_{\rm in} > 100$ MeV/nucleon, can be used to map the GT strengths over a wider excitation. This is based on an approximate proportionality between the reaction cross sections at the scattering angle $\theta = 0°$ and B(GT) values [1].
The insufficient resolution of these reactions was overcome by using $(^3\text{He}, t)$ reaction performed at RCNP, Osaka using a 140 MeV/nucleon ^{3}He beam [2]. The outgoing tritons were momentum analyzed by using Grand Raiden spectrometer. Owing to the *beam matching conditions* realized in combination with the new WS beam line, a resolution of 30-35 keV has been realized, and even bump like GT resonances in the $E_x = 8-11$ MeV region were resolved into states (for example, see Fig. 1).
With the achieved high resolution, it is now possible:
• to study the detailed distribution of the B(GT) strengths;
• to compare the distribution with those of the isobaric analogous transitions obtained from inelastic (IE) reactions, like (p,p') or (e,e') reactions;
• to identify the isospin values T of the highly excited states based on the different ratio of Clebsch-Gordan coefficients in CE and IE reactions for different T states;
• and thus to study the B(GT) strengths expected in the (n,p) type reaction, which is more important in the core collapse procedure, if isospin symmetry is assumed.

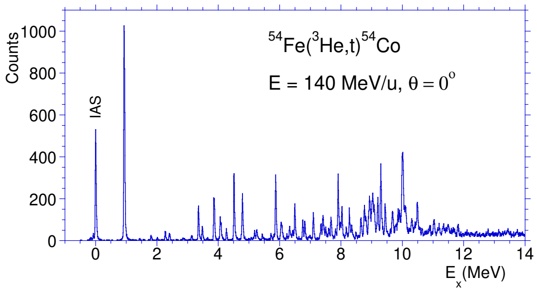

Figure 1: A high resolution ^{54}Fe$(^3\text{He}, t)$ reaction spectrum taken at 0°. Due to the dominance of the $\sigma\tau$ interaction at small q, GT states are dominant.

The analysis has been performed for the $T_0 = 1$ nuclei ^{58}Ni and ^{54}Fe, and a systematic study of B(GT) values for the fp shell nuclei is in progress.

References

[1] T.N. Taddeucci et al., Nucl. Phys. **A469** (1987) 125.
[2] Y. Fujita et al., Eur. Phys. J. A **13** (2002) 411; refs. therein.