Study of Gamow-Teller transitions in fp-shell nuclei using the ^{60,62,64}Ni(^{3}He, t)^{60,62,64}Cu reactions

L. Popescu[a 1], T. Adachi[b], G.P.A. Berg[c], P. von Brentano[d], D. de Frenne[a], K. Fujita[e], Y. Fujita[b], K. Hatanaka[e], E. Jacobs[a], A. Negret[a 1], K. Nakanishi[e], Y. Sakemi[e], Y. Shimbara[e], Y. Shimizu[e], Y. Tameshige[b], A. Tamii[e], M. Uchida[f] and M. Yosoi[f]

[a]*Dept. of Subat. and Rad. Phys., Gent University, B-9000 Gent, Belgium* [b]*Dept. Phys., Osaka University, Toyonaka, Osaka 560-0043*
[c]*KVI, Groningen University, NL-9747 AA Groningen, The Netherlands*
[d]*IKP Köln University, Köln, Germany*
[e]*RCNP, Osaka University, Ibaraki, Osaka 567-0047*
[f]*Dept. Phys., Kyoto University, Sakyo, Kyoto 606-8224*

In order to study the the Gamow-Teller (GT) transitions in fp-shell nuclei, charge-exchange (CE) reactions ^{60,62,64}Ni(^{3}He, t)^{60,62,64}Cu were performed at RCNP, Osaka. The targets were highly enriched ^{60,62,64}Ni foils with a thickness of 1.94 mg/cm^2, 1.15 mg/cm^2 and 0.47 mg/cm^2 respectively. A 420 MeV ^{3}He beam from the RCNP Ring Cyclotron was used. The outgoing tritons were momentum analyzed by the Grand Raiden spectrometer at 0°. By applying the *momentum dispersion-matching technique* [1] and using the high-resolution "WS" course [2] for the beam transportation and the "faint beam method" for the diagnosis of the matching conditions [3, 4], an energy resolution of 35 keV (FWHM) was achieved. In addition, a good angular resolutions was achieved, by applying the *angular dispersion-matching technique* and by realizing the "over-focus mode" in the spectrometer [5]. This excellent energy resolution (achievable only at RCNP for the moment) enabled the identification of individual levels up to high excitation energies. Many candidates of states excited by GT transitions were identified.

Figure 1 shows the ^{60,62,64}Cu spectra. Several identified states are indicated in the picture. The peak that appears around channel 40 is the ^{12}N g.s. originated from a ^{12}C contamination in the target. At high excitation energies the density of the levels is very high and a bump-like structure dominates the spectra.

Another goal of this study is to disentangle the $T_0 - 1$, T_0 and $T_0 + 1$ isospin components by combining the information from complementary (p, n)-type, (n, p)-type and inelastic scattering reactions. The (^{3}He, t) reaction excites all three components, inelastic scattering reactions the latter two, and the (n, p)-type reaction only the $T_0 + 1$ component. The reaction ^{64}Ni(d,^{2} He)^{64}Co was already studied last year at the AGOR cyclotron of the KVI, Groningen, at E_d=170 MeV, using the Big-Bite Spectrometer with the EuroSuperNova detector [6, 7]. An energy resolution of about 100 keV was achieved. At this moment we are also preparing 0° (p, p') experiments at the iThemba LABS, South Africa.

Once the B(GT) distributions for the different isospin components are obtained, the displacement and intensities of the $T_0 - 1$ and $T_0 + 1$ distributions with respect to the T_0 distribution can be studied for nuclei with different T_0. Such a systematic investigation on Ni or any other series of isotopes has never been possible before.

In the (^{3}He, t) reaction the GT strength is distributed to the three isospin components according to the relevant Clebsch-Gordan (CG) coefficients. The CG coefficients are almost proportional to 1, $(1/T_0)$ and $(1/T_0)^2$ for the $T_0 - 1$, T_0 and $T_0 + 1$ isospin components, respectively. Due to the high value $T_0 = 4$ for ^{64}Ni, only 2% of the the total strength goes

[1]Permanent address: IFIN-HH, Bucharest, Romania

to $T_0 + 1$. The study using the $(d,^2\text{He})$ reaction, which exclusively excites $T_0 + 1$, is thus mandatory to obtain the distribution of the $T_0 + 1$ component.

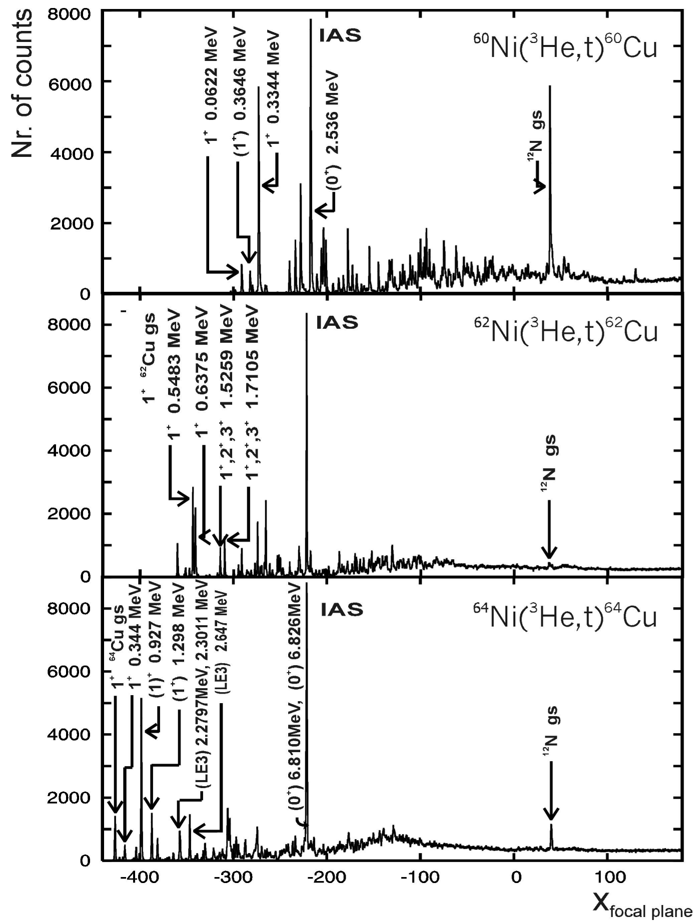

Figure 1: The 0° spectra of ^{60}Cu, ^{62}Cu and ^{64}Cu for scattering angles between 0° and 0.5°. The x axis represents the position in the focal plane. The peak which appears around the channel 40 is the ^{12}N ground state; it is due to the ^{12}C contamination of Ni targets. Some other 1^+ levels have been identified and indicated in the figure. The most intense peak in each spectrum was identified to be the isobaric analog state of the ground state of each target nucleus (IAS).

The ground states of both ^{64}Co and ^{64}Cu have $J^\pi = 1^+$. Therefore the $B(\text{GT})$ values for the transitions to the ground state of ^{64}Ni can be determined directly from the β-decay studies. These $B(\text{GT})$ values will provide a very important calibration standard for the GT strengths in $(d,^2\text{He})$ and $(^3\text{He},t)$ CE reactions on fp-shell nuclei.

References

[1] Y. Fujita *et al.*, Nucl. Instrum. Meth. Phys. Res. B **126** (1997) 274; and references therein.
[2] T. Wakasa *et al.*, Nucl. Instrum. Meth. Phys. Res. A **482** (2002) 79.
[3] H. Fujita *et al.*, Nucl. Instrum. Meth. Phys. Res. A **484** (2002) 17.
[4] Y. Fujita *et al.*, J. Mass Spectrom. Soc. Jpn. **48(5)** (2000) 306.
[5] H. Fujita *et al.*, Nucl. Instrum. Meth. Phys. Res. A **469** (2001) 55.
[6] L. Popescu *et al.*, KVI Annual Report (2003) p.17.
[7] L. Popescu *et al.*, The Proceedings of the Nuclear Physics Large and Small Conference, Mexico, April, 2004 (in print).