RCNP EXPERIMENT E252

PROPOSAL FOR EXPERIMENT AT RCNP

September 22, 2004

TITLE:
High Resolution Study of Gamow-Teller and Fermi Excitations in ^{56}Co via the (^{3}He,t) Reaction at 140 MeV/u

SPOKESPERSONs:

Full Name	Nolan T Botha
Institution	University of Cape Town
Title or Position	D1
Address	iThemba LABS, Somerset West 7129, South Africa
Phone number	+27 21 843 1133
FAX number	+27 21 843 3525
E-mail	nolan@tlabs.ac.za

Full Name	Hirohiko Fujita
Institution	School of Physics, University of the Witwatersrand / iThemba LABS
Title or Position	Researcher
Address	iThemba LABS, Somerset West 7129, South Africa
Phone number	+27 21 843 1133
FAX number	+27 21 843 3525
E-mail	hfujita@tlabs.ac.za

EXPERIMENTAL GROUP:

Full Name	Institution	Title or Position
Y. Fujita	RCNP, Osaka University	Associate Professor
G.P.A. Berg	KVI, Groningen	Senior Researcher
T. Adachi	Osaka University	D3
R.W. Fearick	University of Cape Town	Researcher
K. Fujita	RCNP, Osaka University	D2
J. Carter	University of the Witwatersrand, Johannesburg	Professor
K. Hatanaka	RCNP, Osaka University	Professor
K. Nakanishi	RCNP, Osaka University	D2
R. Neveling	iThemba LABS, Somerset West	Researcher
Y. Shimbara	RCNP, Osaka University	Researcher
Y. Shimizu	RCNP, Osaka University	D3
F.D. Smit	iThemba LABS, Somerset West	Senior Researcher
Y. Tameshige	RCNP, Osaka University	D1
A. Tamii	RCNP, Osaka University	Associate Professor
M. Yosoi	Kyoto University	Research Associate

RUNNING TIME: Beamline tuning for the dispersion matching 1.5 days
+ Data taking time 5.5 days

BEAM LINE: Ring : WS course

BEAM REQUIREMENTS:	Type of particle	^{3}He
	Beam energy	420 MeV
	Beam intensity	≤ 20 nA
	Other requirements	energy resolution ≤ 100 keV halo-free, small emittance

BUDGET: Experimental expenses : 100k yen for a new Faraday cup
Support for the stay of the researchers from foreign countries is appreciated.

RCNP EXPERIMENT E252

TITLE:
High Resolution Study of Gamow-Teller and Fermi Excitations in ^{56}Co via the (^{3}He,t) Reaction at 140 MeV/u

SPOKESPERSONs: N. T. Botha and H. Fujita

SUMMARY OF THE PROPOSAL

We propose a high resolution study of ^{56}Fe(^{3}He,t)^{56}Co reaction at 140 MeV/nucleon. One of the main issues is isospin mixing of 0^+ states in ^{56}Co. In Refs. [1, 2], isospin mixing between the IAS (0^+) at 3.599 MeV and neighboring 0^+ state at 3.527 MeV are discussed using the (^{3}He,t) and (p,n) reactions on ^{56}Fe. In order to resolve these 0^+ states, however, they used a lower incident energy beam ($E_{\rm He} = 24.6$ MeV, $E_p =$ 17 MeV), where contributions of 2-step reactions are not negligible. Another (p,n) reaction measurement at 160 MeV on ^{56}Fe is reported in Ref. [3], where due to the lack of energy resolution, these 0^+ states were observed as one peak at 3.5 MeV. They also suggested the existence of a strong GT (1^+) state in this region.

The high resolution (^{3}He,t) measurement facility at RCNP allows us to observe these states separately without suffering from contributions of 2-step reaction processes. Recently, with further development of the Grand Raiden spectrometer, the WS beamline and the accelerator complex; the AVF cyclotron and the Ring cyclotron, a resolution of less than 40 keV has been obtained rather stably. In order to distinguish 0^+ states from 1^+ states, an angular distribution of cross sections will be required. We plan to take data at 0°, 4° and 8°. For the measurement at 4°, we plan to make a new Faraday cup. Since absolute cross section at 0° may be ambiguous if dispersive mode is applied, we will take data with both achromatic and dispersive beam at 0°.

We also plan to study the GT strength distribution from the ^{56}Fe(^{3}He,t) spectrum. Due to the lack of a standard B(GT) value from β decay measurements, we plan to use

GT unit cross section of ^{58}Ni(^{3}He,t) reaction to estimate the absolute B(GT) value. By comparing the GT strength distribution in ^{56}Co with the analogous $M1$ (1^+) strengths in ^{56}Fe, which will be measured by ^{56}Fe(p,p') measurement at iThemba LABS, the isospin T values of the analog 1^+ states will be investigated. These informations are astrophysically very important. This is because in a supernova explosion process the iron-mass range core nuclei collapse by electron capture and emit neutrinos, which are dominated by GT$_+$ transitions [4].

The Grand Raiden spectrometer and the standard VDC focal plane detector system will be used for the analysis and detection of outgoing tritons. We request a good quality single-turn extracted 140 MeV/nucleon ^{3}He beam of up to 40 nA. Complete matching conditions and over-focus mode will be applied for high resolution measurement.

References

[1] T.G. Dzubay, R. Sherr, F.D. Becchetti, Jr, and D. Dehnhard, Nucl. Phys. **A142** (1970) 488.

[2] H. Orihara, K. Ogawa, T. Murakami, S. Nishihara, T. Nakagawa, and K. Maeda, Nucl. Phys. **A403** (1983) 317.

[3] J. Rapaport, T. Taddeucci, T.P. Welch, C. Gaarde, J. Larsen, D.J. Horen, E. Sugarbaker, P. Koncz, C.C. Foster, C.D. Goodman, C.A. Goulding, and T. Masterson, Nucl. Phys. **A410** (1983) 371.

[4] J. Toivanen, E. Kolbe, K. Langanke, G. Martínez-Pinedo, P. Vogel, Nucl. Phys. **A694** (2001) 395.