PROPOSAL FOR EXPERIMENT AT RCNP

TITLE: INTERACTION OF FAST ^{3}HE PROJECTILES WITH SOLID TARGETS

SPOKESPERSONS:

Ziemowid Sujkowski, The Andrzej Sołtan Institute for Nuclear Studies
05-400 Świerk, Poland

Yoshitaka Fujita, Department of Physics, Osaka University,
Toyonaka, Osaka 560, Japan

EXPERIMENTAL GROUPS:

The Andrzej Sołtan Institute for Nuclear Studies, 05-400 Świerk, Poland

Department of Physics, Osaka University
RCNP, Osaka University
Tokiwa Jr. College

RUNNING TIME:

Total running time not including beam preparation: 10 shifts

BEAM LINE:

WS course, Grand Raiden

BEAM REQUIREMENTS:

Type of particle:	^{3}He
Beam energy:	450 MeV
Beam intensity:	$>$ 20 pnA
Other requirements:	energy resolution $<$ 300 keV
	beam must be halo-free
	calibrated Faraday Cup

TARGETS:

thin C, Ni, Ag and Au (2-100 μg/cm^2)

WITH:

D. Chmielewska, Researcher, IPJ, Poland
T. Adachi, M1, Osaka University
G.P.A. Berg, Guest Professor, RCNP
S. Chojnacki, Researcher, IPJ, Poland
H. Fujita, D3, Osaka University
M. Fujiwara, Associate Professor, RCNP
K. Hara, D1, RCNP
Y. Haruyama, Kyoto Prefectual University
I. Katayama, Professor, KEK
H. Ogawa, Nara Women's University
J. Rzadkiewicz, Graduate Student, IPJ, Poland
M. Saito, Kyoto Prefectual University
T. Shimbara, D1, Osaka University
T. Shinada, D2, Osaka University
M. Tanaka, Professor, Tokiwa Jr. College
M. Yoshifuku, M1, Osaka University

SUMMARY OF THE PROPOSAL:

The present proposal consists of two strongly related parts. Part I can be considered as an addendum to proposal [E93]. The latter consisted mainly in measuring coincidences between the $^3He^+$ ions, i.e. the ^3He ions emerging from the target after having captured one electron, and the corresponding photons from the REC process. This experiment, though considered at the time as merely a feasibility test (compare the PAC decision of 1997), was fully successful [3,4]. The coincidence photon spectra from thin carbon targets of two thicknesses, 9.6 $\mu g/cm^2$ and 4.6$\mu g/cm^2$, were recorded at two angles $\Theta = 80°$ and 130° in practically background-free fashion (the background had been the main concern of the PAC). However, due to the shortage of time, an essential though simple part of the planned experiment has not been done: a measurement of the singles ratio of the He^+ to He^{++} ion intensities as a function of the target thickness, so as to permit a reliable extrapolation to zero target thickness of the three cross-sections underlying these ratios: the $\sigma_{\rm REC}$, $\sigma_{\rm NREC}$ and $\sigma_{\rm ion}$. In view of the very large value $\sigma_{\rm ion}$ being about 10^9 larger than $\sigma_{\rm REC} + \sigma_{\rm NREC}$, the measured $(Y_{\rm REC} + Y_{\rm NREC})/Y_{\rm ion} = R$ yield ratio value is strongly thickness dependent. This is the main source of experimental uncertainties in the results presented in [3].

It is proposed to measure the R value for carbon targets of thicknesses of about 5, 10, 20, 50, 100, ≈1000 μg/cm2. Estimating that about 2.5 hours of effective data taking are needed per target and about 2 shifts will be spent for setting up the experiment and for target changing this part of the proposal requires four shifts (not counting the beam making time).

The same type extrapolation experiment measuring the R ratio as a function of target thickness could bring highly valuable information if it is also done for higher Z-target values. This would permit to determine the $\sigma_{\rm NREC}$ and $\sigma_{\rm ion}$ values (and not only their ratios) for high Z and, hopefully, shed new light on the puzzle of refs. [2,5], i.e. on the discrepancies between experiment and theory in the R vs Z function. A serious difficulty in such extrapolation experiments is the lack of self-supporting very thin targets for practically any element except carbon. Having determined the precise cross-section values for carbon we propose to extend the measurement of yield ratios as functions of target thickness for such elements as e.g. Ni, Ag and Au using carbon backed targets. The backing will have 20$\mu g/cm^2$ thickness while the evaporated layer will range from a couple of $\mu g/cm^2$ to the saturation value ≈ 100$\mu g/cm^2$). This experiment will require 6 additional shifts. The total number of shifts requested is then 10.

Notation: REC - the Radiative Electron Capture
NREC - the Non-Radiative Electron Capture
$\sigma_{\rm REC}$, $\sigma_{\rm NREC}$ - the corresponding cross-sections
$\sigma_{\rm ion}$ - the cross-section for ionization of $^3He^{++}$ ions i.e. for stripping of the single electron from the ion.

References

[1] Z.Sujkowski et al., "Radiative electron capture by fast $^3He^{++}$ projectiles " Proposal to the PAC at RCNP, 1996 (enclosure 1)

[2] D.Chmielewska et al., Proceedings of the 8th International Conference on Nuclear Reaction Mechanisms, Varenna 1997, Ricerca Scientifica ed Educazione Permanente, p.703

[3] D. Chmielewska et al. Proceedings of the XXXVIII International Winter Meeting on Nuclear Physics, Bormio 2000, Ricerca Scientifica ed Educazione Permanente, suppl. 116, 90 (enclosure 2)

[4] Z. Sujkowski, Proceedings of the NEWS'99, Osaka Conference

[5] K. Dennis et al., Phys. Rev. A50,(1994),3992

[6] T.Stoehlker et al., Phys. Rev. A 51,(1995),2098