Direct measurements of astrophysical nuclear reaction rates on light neutron-rich nuclei at TRIAC and JAEA-RMS

H. Miyatake[1,4], H. Ishiyama[1], Y.X. Watanabe[1], Y. Hirayama[1], N. Imai[1], M-H. Tanaka[1], N. Yoshikawa[1], S.C. Jeong[1], Y. Fuchi[1], T. Nomura[1], I. Katayama[1], H. Kawakami[1], T. Ishikawa[2], S.K. Das[3], Y. Mizoi[3], T. Fukuda[3], T. Hashimoto[4], K. Nishio[4], S. Mitsuoka[4], H. Ikezoe[4], M. Matsuda[4], S. Ichikawa[4], P.K. Saha[4], A. Sato[5], T. Shimoda[5], T. Sasaqui[6]

[1] *Institute of Particle and Nuclear Studies, KEK, Tsukuba, Ibaraki, 305-0801 Japan*
[2] *Faculty of Science and Technology, Tokyo University of Science, Noda, Chiba, 278-8510 Japan*
[3] *Laboratory of Physics, Osaka Electro-Communication Univ., Neyagawa, Osaka, 572-8530 Japan*
[4] *Advanced Science Research Center, JAEA, Tokai, Ibaraki, 319-1195 Japan*
[5] *Department of Physics, Osaka Univ., Toyonaka, Osaka, 560-0043 Japan*
[6] *National Astronomical Observatory, Mitaka, Tokyo, 181-8588 Japan*

A systematic study of astrophysical reaction rates on light neutron-rich nuclei using low-energy radioactive nuclear beams (RNB) is in progress at the tandem facility of Japan Atomic Energy Agency (JAEA). There exist two kinds of RNB generators; One is to use a recoil-mass separator (JAEA-RMS) as an in-flight secondary-beam separator [1].The other is an ISOL-based RNB facility under a joint project of KEK and JAEA, named Tokai Radioactive Ion Accelerator Complex (TRIAC) [2].

Using low-energy (1-2 MeV / u) light neutron-rich RNB from the RMS, direct exclusive measurements of ^{8}Li(α, n)^{11}B and ^{12}B(α, n)^{15}N reaction rates have already been carried out to improve our understanding of the heavy-element synthesis in high-temperature and neutron-rich environments such as supernovae. The RNB was directly injected into a gas chamber, named multi-sampling and tracking proportional chamber (MSTPC) [3]. Neutron counter walls were also set to surround the MSTPC. Figure 1 shows newly observed excitation function of the ^{12}B(α, n)^{15}N reaction in the region of T = 2 - 5 $\times$ 10^{9} K. Some resonance structures can be found in the figure. Based on the experimental reaction rates, we will discuss the reaction path from lithium to nitrogen.

The first beam of TRIAC was ^{8}Li supplied on October 2005. The beam energy can be variable from 0.178 MeV/u up to 1.1 MeV/u with better energy resolution and higher intensity compared with the case from JAEA-RMS. Direct measurements of reaction rates of ^{8}Li(d, p), (d, t), (d, α), (d, n), (p, α) are in progress in the low-energy region corresponding to the T $\leq$ 3 $\times$ 10^{9} K that is important for element synthesis in the early universe. Cross sections of ^{8}Li(d, t) and (d, α) have already been measured at the energies of E$_{cm}$ = 0.48, 0.78, 0.96 and 1.2 MeV using a CD_2 target and large-area position-sensitive silicon detectors. A further experiments to increase data points will be carried out in this summer. Measured excitation functions and reaction rates of ^{8}Li(d, p), (d, t) and (d, α) will also be presented.

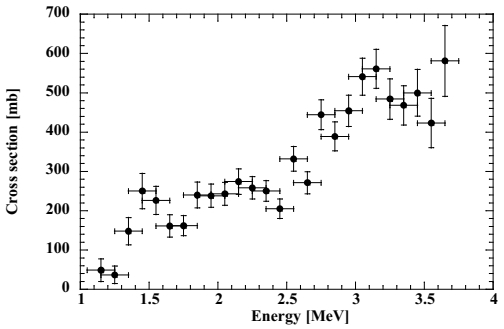

Figure 1: *Excitation function of the ^{12}B(α, n)^{15}N reaction.*

[1] H. Ishiyama et al., to be published in Nucl. Instrum. Methods A.;
[2] H. Miyatake et al., Nucl. Instrum. Methods B204(2993)746c.
[3] T. Hashimoto et al., Nucl. Instrum. Methods A556(2006)339.