^{26}Si + α resonant scattering measurement to study ^{26}Si(α, p)^{29}P reaction rate

M. J. Kim,[*1] K. Y. Chae,[*1] K. Okawa,[*2] S. Hayakawa,[*2] S. Adachi,[*3] S. M. Cha,[*4] T. Chillery,[*2] N. N. Duy,[*1] T. Furuno,[*3] G. M. Gu,[*1] S. Hanai,[*2] N. Imai,[*2] D. Kahl,[*5] T. Kawabata,[*3,*6] C. H. Kim,[*1] D. Kim,[*4] S. H. Kim,[*1] S. Kubono,[*6] M. S. Kwag,[*1] J. Li,[*2] N. R. Ma,[*2] S. Michimasa,[*2] K. Sakanashi,[*3] H. Shimizu,[*2] O. Sirbu,[*5] N. K. Uyen,[*1] H. Yamaguchi,[*2] R. Yokoyama,[*2] and Q. Zhang[*2]

An X-ray burst can be characterized by a sudden and intense release of X-ray radiation from a compact stellar object such as a neutron star. A total energy release of approximately $10^{39–40}$ ergs can be achieved per burst in just a few seconds. It is believed that the proton-rich nuclei up to the Sn-Sb-Te region can be synthesized during the burst. To better understand the X-ray bursts, studying the ^{26}Si(α, p)^{29}P reaction is essential since ^{26}Si is considered to be one of the waiting points in the nucleosynthesis.

A sensitivity study, which identifies the important nuclear reaction rates that affect the X-ray light curves or ash composition, suggests that the ^{26}Si(α, p)^{29}P is one of the impactful reactions to the light curve of the X-ray burst.[1)] Despite its importance, the study of ^{26}Si(α, p)^{29}P is less understood experimentally. Thus we have performed a ^{26}Si + α experiment to measure the ^{26}Si(α, p)^{29}P reaction directly and the resonant scattering to investigate resonances in ^{30}S, which can be populated in the ^{26}Si(α, p)^{29}P reaction as intermediate states. The result on the ^{26}Si + α resonant scattering is described in this report.

The ^{26}Si + α resonant scattering was measured at the Center for Nuclear Study Radioactive Ion Beam Separator (CRIB)[2)] of the University of Tokyo. The radioactive ^{26}Si beam was produced at E = 2.14 MeV/nucleon through the ^{3}He(^{24}Mg, n)^{26}Si reaction by impinging ^{24}Mg at E = 7.56 MeV/nucleon on a cryogenic ^{3}He gas target.[3)] The ^{26}Si beam was separated and purified by combining the magnetic analysis and velocity selection with a double achromatic system and a Wien filter. Two PPACs were located at the upstream of the reaction target for the event-by-event monitoring of beam position and time-of-flight. The typical ^{26}Si beam intensity was 2.8 × 10^{4} pps, and the beam purity was ∼16%. The ^{26}Si beam was impinged on the ^{4}He gas target with a pressure of 250 Torr. The reaction target was kept at room temperature. The thick target method is adopted for the experiment to scan a wide excitation energy range in ^{30}S.

The light charged particles were measured by silicon detector telescopes. Using four layers of silicon detectors ($\Delta E1$, $\Delta E2$, $E1$, and $E2$ layer), each species of charged particles could be easily identified. The $\Delta E1$ and $\Delta E2$ detectors are segmented into 16 strips providing the horizontal and vertical position information, respectively. The $E1$ and $E2$ detectors are pad type silicon detectors. The scattering angle was obtained based on the position information. To obtain the excitation function of ^{26}Si(α, α)^{26}Si reaction, the α energies were converted to the center-of-mass energy by considering the kinematics of the reaction and the energy loss of particles in the gas target. Figure 1 shows the excitation function obtained at $\theta_{C.M.}$ = 174°. Fitting the experimental excitation function with the theoretical R-matrix calculations, we will extract resonance parameters of levels in the ^{30}S, such as excitation energy, spin, parity, and α partial width, to constrain the ^{26}Si(α, p)^{29}P reaction rate.

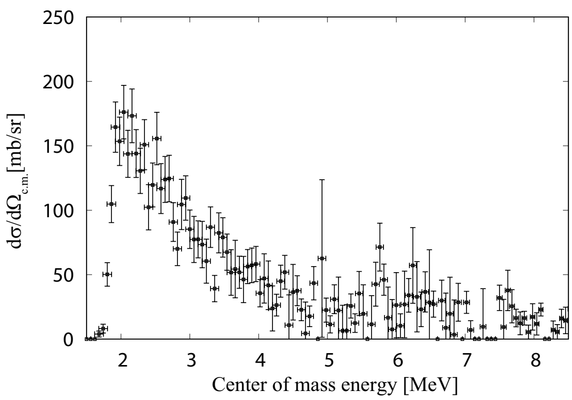

Fig. 1. Excitation function of ^{26}Si + α elastic scattering at $\theta_{c.m.} = 174°$

References
1) R. H. Cyburt *et al.*, Astrophys. J. **55**, 830 (2016).
2) Y. Yanagisawa *et al.*, Nucl. Instrum. Methods Phys. Res. A, **539**, 74 (2005).
3) H. Yamaguchi *et al.*, Nucl. Instrum. Methods Phys. Res. A **589**, 150 (2008).

*1 Department of Physics, Sungkyunkwan University
*2 Center for Nuclear Study, University of Tokyo
*3 Department of Physics, Osaka University
*4 Center for Exotic Nuclear Studies, Institute for Basic Science (IBS)
*5 Extreme Light Infrastructure Nuclear Physics (ELI-NP)
*6 RIKEN Nishina Center