GARIS-II commissioning #3 and #4

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We developed a new gas-filled recoil ion separator (GARIS-II) to study asymmetric actinide-target based fusion reactions[1)]. As the first step, we measured the solid angle of the separator offline using a standard α-source of ^{241}Am, and it was determined to be 18.2 msr[1)]. As the second step, we performed online testing to evaluate the separation capability of GARIS-II from background particles, and its transmission using ^{40}Ar-induced fusion reactions. These reaction products were collected onto a focal plane detection (FPD) system with high efficiency under extremely low background conditions[2)].

As the third step of commissioning #3, we performed online operating tests on GARIS-II using ^{22}Ne-induced fusion reactions of ^{197}Au, ^{205}Tl, ^{208}Pb, ^{209}Bi, ^{232}Th, and ^{238}U. The reaction products were separated in-flight from projectiles and other by-products using GARIS-II, and then they were guided into the FPD system after passing through the time-of-flight detector[3)]. The separator was filled with He gas at the pressure of 10, 33, 80, and 173 Pa. For further background rejection using GARIS-II, we tested He-H_2 mixture as the filled gas at the same gas pressure. Figure 1(A) shows the intensity distribution of ^{215}Ac, which is produced via the ^{197}Au(^{22}Ne,4n) reaction, at FPD in the case of filling at 33 Pa He gas and 33 Pa He-H_2 mixture (He:H_2=2:1). The optimum $B\rho$ was shifted up to 11% and the transmission was increased from 11.4% to 14.6%. The $B\rho$ shift implies that the average equilibrium charge state of recoil ions moving in a filled gas becomes small. The improvement of transmission is due to a decrease in the multiple scattering between the recoil ion and filled gas atom. Figure 1(B,C) shows a comparison of background (BG) level at each peak of intensity distribution between the He and the He-H_2 mixture. The BG level was significantly changed, and the beam-like particles were strongly suppressed.

As the fourth step of commissioning #4, we performed online tests on GARIS-II using ^{48}Ca-induced fusion reactions of ^{208}Pb . We measured an excitation function of ^{208}Pb(^{48}Ca,2n)^{254}No and the transmission of GARIS-II for ^{254}No. The maximum transmission was 73% assuming σ = 2.05 μb[4)] when the separator was filled with He gas at a pressure of 73 Pa, and the magnetic rigidity $B\rho$ was set to 2.064 Tm. The maximum transmission of GARIS-II is two times higher than that of GARIS, which is 36%. Further, it is better than design value of 61% for GARIS-II. Transmission data are summarized in Fig. 2.

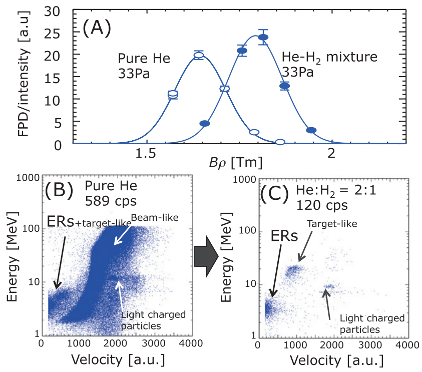

Fig. 1. (A) Intensity distribution of ^{215}Ac at FPD, (B, C) Two-dimensional views of energy measured by Si detector vs. recoil velocity measured using the timing counter.

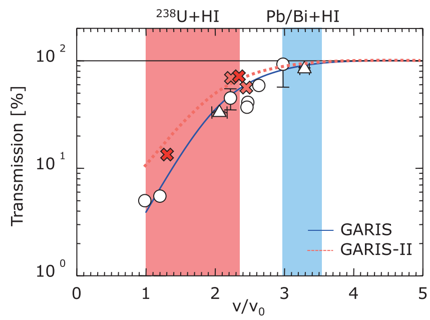

Fig. 2. Transmission curve. Velocity regions of interest for the reactions of both cold fusion and hot fusion are given by the blue and red stripes, respectively. ○, △: GARIS, ×: GARIS-II. Solid and dashed curves are estimated by considering multiple scattering with the filled gas for GARIS and GARIS-II, respectively.

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