

Measurement of the $^{248}\text{Cm} + ^{48}\text{Ca}$ fusion reaction products at RIKEN GARIS

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The reaction, $^{248}\text{Cm} + ^{48}\text{Ca} \rightarrow ^{296}\text{Lv}^*$ (Livermorium, $Z = 116$), has been studied at the RIKEN Linear Accelerator (RILAC) Facility using a gas-filled recoil ion separator GARIS. Although this reaction was intensively studied at the Flerov Laboratory of Nuclear Reaction (FLNR), Russia^{1,2}, and GSI, Helmholtzzentrum für Schwerionenforschung, Germany³, the number of observed events is still very small because of the small production cross sections. The first aim of the present study is to observe more events in the region of superheavy nuclei and possibly to obtain new spectroscopic information of those nuclei. The second aim is to examine the performance of the GARIS facility using the relevant reaction for a future project with the ^{50}Ti beam, instead of the ^{48}Ca beam, to search for new heaviest nuclei. Because of the limitation of target nuclear species, one needs to use beams heavier than ^{48}Ca for further investigation of superheavy nuclei.

A ^{48}Ca beam was accelerated by RILAC at 262 MeV, and it irradiated ^{248}Cm targets prepared by electro deposition of $^{248}\text{Cm}_3\text{O}_8$ on titanium foils. Eight targets were mounted on a wheel rotating at 1000 rpm. The diameter of the wheel is 10 cm. The average thickness of $^{248}\text{Cm}_3\text{O}_8$ was 0.290 mg/cm², which contained 0.265 mg/cm² ^{248}Cm , and that of titanium foils was 0.903 mg/cm². The energy of the beam at half depth of the target was estimated to be 250 MeV by using a range-energy table. Reaction products were separated from beam particles and from unwanted particles by GARIS and then implanted in a position-sensitive semiconductor detector (PSD), which covered 60 mm × 60 mm, set on the focal plane of GARIS. Four side detectors (SSDs) of the same size were set in a box arrangement to detect the decay products (alpha particles or spontaneous fission (SF) fragments) emitted at backward angles from the PSD. Time-of-flight counters consisting of micro-channel plates (MCPs) were set upstream of the PSD. The average beam intensity was 0.8 particle μA. In a beamtime of 10 days, 4.3×10^{18} ^{48}Ca ions irradiated the targets. The Bp value of the GARIS was set to 2.21 Tm.

We observed five correlated events during the experiment, all of which terminated by spontaneous fission (SF). Decay characteristics of those events agreed well with previous studies^{1,2,3}. Although it is difficult to identify the nuclides of the products only from the present experimental study, we could state that two of the events were attributed to the decays of ^{293}Lv (3 n evaporation channel) and three of them to the decays of ^{292}Lv (4 n evaporation channel) by referring to the assignments in the previous studies. The two events attributed to the ^{293}Lv decay consisted of three consecutive alpha decays followed by SF. The two events attributed to the ^{292}Lv decay consisted of two alpha decays followed by SF. One of the events we tentatively assigned to the decay of ^{292}Lv consisted of three alpha decays followed by SF. The tentative assignment is based on the decay characteristics of the decay energies and decay times of ^{292}Lv and ^{288}Fl (Flerovium, $Z = 114$) and the decay time of ^{284}Cn (Copernicium, $Z = 112$). Because an alpha decay of ^{284}Cn has not been observed, this possibly involves a new decay mode of ^{284}Cn and new isotope ^{280}Ds decays by SF. The production cross sections of ^{293}Lv and ^{292}Lv were deduced to be $2.1^{+2.9}_{-1.4}$ pb and $3.1^{+3.0}_{-1.7}$ pb, respectively, by assuming the transmission of GARIS to be 0.35. Observed events are summarized in Table I.

Further analysis is now in progress.

Table I Observed decay events, energies, and time intervals of the events.
 Bottom row indicates the possible assignments of nuclei

Chain 1	Chain 2	Chain 3	Chain 4	Chain 5
10.79 MeV 0.032 s	10.47 MeV 0.253 s	2.77 MeV ⁺ 0.0020 s	10.66 MeV 0.0041 s	7.76 MeV ⁺⁺ 0.032 s
9.89 MeV 0.548 s	9.89 MeV 3.97 s	9.99 MeV 0.243 s	0.83 MeV ⁺ 0.0090 s	9.72 MeV 0.666 s
232 MeV 0.065 s	2.46 MeV ⁺ 7.76 s	182 MeV 0.832 s	9.09 MeV 0.282 s	1.64 MeV ⁺ 7.56 s
	195 MeV 19.8 s		163 MeV 0.0096 s	221 MeV 4.63 s
^{292}Lv	^{293}Lv	^{292}Lv	$^{292}\text{Lv}^{+++}$	^{293}Lv

⁺ escape energies (partly measured using PSD)

⁺⁺ energies measured only using SSD. ⁺⁺⁺ tentative

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