2 - 21 Attempt to Study the α-decay of ^{216}U by ^{40}Ca+^{nat}Hf Reaction

Yang Huabin, Zhang Zhiyuan, Ma Long, Yu Lin, Jiang Jian, Gan Zaiguo,
Wang Jianguo, Tian Yulin, Huang Tianheng, Wang Yongsheng and Sun Mingdao

An attempt has been made recently to synthesize very neutron-deficient ^{216}U isotope in ^{40}Ca+^{nat}Hf reaction at the gas-filled recoil separator SHANS[1]. A beam of $^{40}Ca^{12+}$ at an energy of E_{lab}=194.6 MeV was delivered by the sector focusing cyclotron of the Heavy Ion Research Facility in Lanzhou (HIRFL). The average beam intensity was about 100 pnA. Self-support targets of natural hafnium foils with thickness of 420 μg/cm^2 was mounted in a fixed frame. Evaporation residues recoiled from the target were separated from the primary beam by the separator and then implanted into the Si-box detector (consist of three position sensitive silicon detectors and eight non-position sensitive silicon detectors)[2]. In order to distinguish the α-decay events from the implantation events, two multi-wire proportional counters (MWPCs) were mounted upstream from the Si-box detector. Behind the Si-box detector a fourfold segmented Clover detector was installed for γ-ray studies.

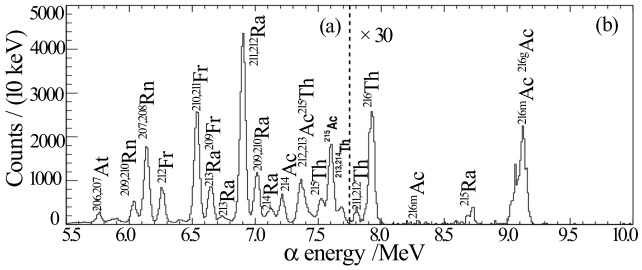

Fig. 1 α-decay spectrum of the ERs measured in one position sensitive silicon detector and vetoed with the MWPCs using the ^{40}Ca+^{nat}Hf reaction: (a) α energy from 5.5 to 7.75 MeV ; (b) α energy from 7.75 to 10 MeV and decay following recoil implants within 150 ms. Notice the scale was changed at 7.75 MeV.

Fig. 1 shows an α-spectrum of the evaporation residues produced in the reaction ^{40}Ca+^{nat}Hf at 194.6 MeV beam energy. For clarity, only the data measured in one position sensitive silicon detector is shown. Some neutron-deficient isotopes and their isomers in the region close to N=126 such as ^{214}Ra, ^{215}Ra, ^{216}Th, ^{216}Ac and ^{215}Ac was produced in this reaction. Their measured α-decay data is consistent with the reported values. We search for ^{216}U based on the energy-position-time correlation measurement. However, it was not observed in this experiment. Besides looking for new isotope ^{216}U, we also interested in the γ-ray studies as they can provide valuable information on nuclear structure. ER-γ-α coincidences and α-γ coincidences are useful tools to study transition in the nuclei[3]. Searching for α-γ coincidences in the energy region E_α=(6.0-9.5) MeV , we observed some γ (X)-rays following the α decay of ^{216}Ac, ^{214}Ac, ^{215}Th and ^{213}Ra (in Fig. 2). The measured γ energies are in agreement with literature values. The observed X-rays of Ra and Fr indicated that internal conversion happened during the γ transitions. The results of ER-γ-α coincidences in this work are also shown in a two-dimensional plot of the α energy versus γ energy (in Fig. 3). γ-rays of ^{215}Ac, ^{214}Th, ^{215}Th, ^{210}Ra, ^{211}Ra and ^{212}Ra were observed. We will continue the study of ^{216}U in another reaction ^{40}Ar+^{180}W in the next experiment.

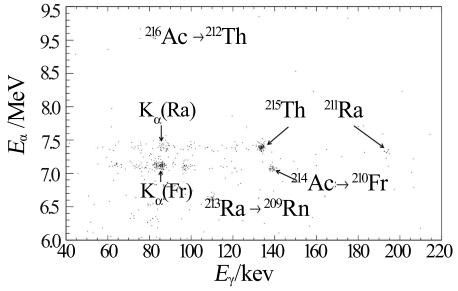

Fig. 2 Two-dimensional plot of α-γ coincidences for products from complete-fusion reaction^{40}Ca+^{nat}Hf at E_{lab}=194.6 MeV.

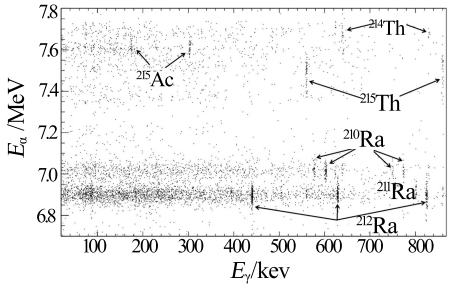

Fig. 3 Two-dimensional plot of ER-γ-α coincidences for products from complete-fusion reaction ^{40}Ca+^{nat}Hf at E_{lab}=194.6 MeV.

References

[1] Z. Y. Zhang, L. Ma , Z. G. Gan , et al., Nucl. Instr. And. Meth. B, 317(2013)315.

[2] Z. Y. Zhang, Z. G. Gan, L. Ma, et al., Phys. Rev. C, 89(2014)014308.

[3] P. Kuusinemi, F. P. Hebberger, D. Ackermann, et al., Eur. Phys. J. A, 30(2006) 551.