Experiments on the synthesis of element 107

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Results are presented of experiments on the synthesis of the 107th element. Bombardment of ^{209}Bi by ^{54}Cr has revealed new spontaneously fissioning emitters with half-lives $\sim$5 sec and $\sim$2 msec. Different control experiments using the crossing-reaction method give grounds for assuming that activity with $T_{1/2}$ $\sim$5 sec is due to the spontaneous fission of the isotope ^{257}105, which is formed as a result of the α decay of the isotope ^{261}107, which has a half-life of about 2 msec in a noticeable fraction of the events ($\sim$20%) and experiencing spontaenous fission.

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Most modern nuclear models predict the existence of a new region of increased stability of nuclei with $Z = 110$—114 protons and with $N = 184$ neutrons. Therefore, the synthesis and study of the radioactive properties of each new element of the periodic system are of fundamental significance for the confirmation of the validity of the hypothesis that superheavy elements exist.

The heaviest known element is 106. Its isotope with mass number 259 ($T_{1/2}$ $\approx$ 7 msec) was sythesized in 1974 by bombarding lead with accelerated ^{54}Cr ions.[1]

To synthesize the 107th element it was natural to choose the same method as for the 106th.[1] In this case the isotopes of the new element can be obtained in the reactions Tl+Fe, Pb+Mn, and Bi+Cr. According to our calculations, the largest cross section is expected for the reaction ^{209}Bi(^{54}Cr, $2n$)^{261}107.

As shown by the earlier studies,[1,2] one of the advantages of the synthesis method used by us is that when lead or bismuth is used as the target, we exclude practically the entire background due to the spontaneous fission of both the heavy elements and of the spontaneously fissioning isomers in the V—Cf region. To observe the 107th element we therefore used a highly sensitive and rapid procedure of detecting the spontaneous fissioning of the nuclei.

A 310-cm cyclotron was used to obtain a beam of ^{54}Cr^{+8} ions with energy 290 MeV and intensity up to 2×10^{12} ions/sec. We used in the experiments the same experimental setup as was used to study earlier the isotopes of the 104th element and to obtain for the first time the element 106.[1,2]

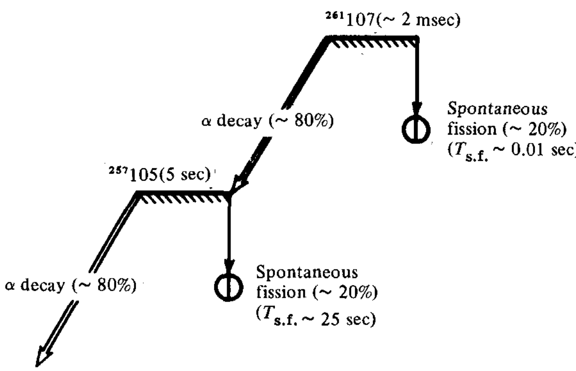
In the first experiments on the bombardment of ^{209}Bi by ^{54}Cr ions we observed a spontaneously fissioning emitter with an approximate half-life 5 sec.[3] The results of experiments with the crossing reactions ^{209}Bi+^{54}Cr, ^{208}Pb+^{55}Mn, and ^{205}Tl+^{58}Fe have indicated that the yield of the observed activity exhibits the same regularities that can be expected when the 107th element is produced.

From the point of view of the concepts of spontaneous fission, one could not exclude completely the possibility of so long a lifetime for the 107th element. According to the systematics of the α decay,[4] however, the half-life of the isotope $^{261}107$ should amount to ~ 1 msec. The reason for this discrepancy became clear when an activity having the same half-life (~ 5 sec) was observed in the reactions $^{209}Bi+^{50}Ti$ and $^{208}Pb+^{51}V$, which lead to formation of the 105th element.

In the succeeding experiments, the speed of the experimental procedure was greatly increased, and bombardment of ^{209}Bi by ^{54}Cr ions revealed a spontaneously fissioning emitter with $T_{1/2} \sim 2$ msec. The yield of this emitter correlated in all the experiments with the yield of the long-lived activity with $T_{1/2} \sim 5$ sec, which can be regarded as the result of spontaneous fission of the isotope $^{257}105$, produced after the α decay of $^{261}107$.

The results of various control experiments (observation of the spontaneous fission of the isotope $^{257}105$ with $T_{1/2} \approx 5$ sec; investigation of the probability of the spontaneous fission of the 103rd-element isotopes produced in the reaction $Tl+^{50}Ti$; the absence of the effect when ^{209}Bi is bombarded with ^{53}Cr ions, etc) all allow us to draw the sufficiently well founded, in our opinion, assumption that the observed isotope of the 107th element possesses the properties represented in the figure.

We registered altogether about 110 events due to decay of the nuclei of the 107th element.



Whereas the partial period of the α decay of the isotope $^{261}107$ agrees sufficiently well with the predicted value,[4] the partial period of the spontaneous fission is approximately larger by 10 orders of magnitude than the value expected from extrapolation of the experimental data. This difference in the value of $T_{s.f.}$ cannot be attributed to hindrance due to the odd number of protons.

This fact (together with the properties of the isotopes $^{259}106$[1] and $^{263}106$[5]) points to a regular increase of the lifetimes of the heavy nuclei relative to spontaneous fission, and indicates, in our opinion, a possible existence of a region of stability of the superheavy elements.

Since the isotope $^{261}107$ undergoes predominantly α decay, there are all grounds for assuming that the lifetimes of the heavier isotopes will increase, as is predicted by the systematics of the α decay. Thus, for example, the isotope $^{267}107$, which should be produced in the reaction ^{249}Bk (^{22}Ne, $4n$) can have according to our estimates a half-life larger than 1 sec. Such large lifetimes will make it possible to study the chemical properties of the atoms of the 107th element—eka rhenium.

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