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EXPERIMENTS ON THE SYNTHESIS OF THE ELEMENT WITH ATOMIC NUMBER 107

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Most of the modern nuclear models predict the existence of the region of enhanced stability for nuclei with proton number around 110-114 and neutron number N=184. The synthesis and investigation of the decay properties of each new element as heavy as possible is in principle important to confirm the validity of the hypothesis about the existence of superheavy elements.

Among the known elements, element 106 is the heaviest one. Its isotope with mass number 259 ($T_{1/2}$ ~ 7 ms) was first synthesized in 1974 by bombarding lead with ^{54}Cr ions [1].

For the synthesis of element 107, it was natural to use the same method as that applied to produce element 106 (ref. [1]). In this case isotopes of the new element are producible by reactions Tl+Fe, Pb+Mn and Bi+Cr. According to our estimates, a maximum cross section is expected to be for the reaction $^{209}Bi(^{54}Cr,2n)^{261}107$.

Our previous experimental data have shown [1,2] that one of the advantages of the method is that the use of lead and bismuth as target materials eliminates background due to spontaneous fission of heavy elements and spontaneously fissioning isomers in the region of U–Cf. Therefore, to detect element 107 we used a highly sensitive and express technique designed for the detection of spontaneous fission.

At the 310-cm cyclotron, a $^{54}Cr^{8+}$ ion beam with an energy of 290 MeV and intensity up to $2x10^{12}$ ions/s has been produced. The experimental set-up was the same as that used previously to study the isotopes of element 104 and to produce element 106 for the first time[1,2].

In initial runs, as a result of bombardments of ^{209}Bi with ^{54}Cr ions a spontaneously fissioning activity with a half-life of about 5 s has been detected[3]. The results of cross bombardments, $^{209}Bi + ^{54}Cr$, $^{208}Pb + ^{55}Mn$ and $^{205}Tl + ^{58}Fe$, indicated that the yield of the activity observed obeyed the regularities that may be expected for complete fusion reactions.

In terms of the concepts of spontaneous fission, the possibility of such a long lifetime for element 107 cannot be excluded entirely. However, in accordance with the systematics of α-decay half-lives[4], the α-decay half-life of the isotope $^{261}107$ is expected to be about 1 ms. The reason for this discrepancy became clear after the observation of an activity with the same half-life (about 5 s) in the reactions $^{209}Bi + ^{50}Ti$ and $^{208}Pb + ^{51}V$ leading to the formation of element 105.

In subsequent experiments, the experimental technique used was still more rapid, and in the bombardment of ^{209}Bi with ^{54}Cr ions a spontaneously fissioning activity with $T_{1/2} \sim 2$ ms was detected. The yield of this activity in all experiments was correlated with the yield of the long-lived activity with $T_{1/2} \sim 5$ s, which can be identified as a product of spontaneous fission of the isotope $^{257}105$ formed after the α-decay of $^{261}107$.

The results of different control experiments (e.g., the observation of spontaneous fission of the isotope $^{257}105$ with $T_{1/2} \approx 5$ s, the investigation of the spontaneous fission probability for the element 103 isotopes formed in the reaction $Tl + ^{50}Ti$, the absence of the short-lived activity with $T_{1/2} \approx 2$ ms in the bombardment of ^{209}Bi with ^{50}Ti, the absence of any effect in the bombardment of ^{209}Bi with ^{53}Cr, etc.) enable one to make, from our point of view, a fairly well-grounded assumption that the element 107 isotope observed has the properties presented in fig. 1.

A total of about 110 events due to the decay of the element 107 nuclei have been detected.

While the partial α-decay half-life of the isotope $^{261}107$ agrees with the predicted value fairly well[4], the partial spontaneous fission half-life about 10 orders of magnitude exceeds the value extrapolated from the experimental data. This difference cannot be interpreted as being due to the hindrance factor resulting from the odd number of protons.

This fact, together with the properties of the isotopes $^{259}106$ (ref.[1]) and $^{263}106$ (ref.[5]) suggests the regular increase in the spontaneous fission half-lives of heavy nuclei and this, in our opinion, indicates the possible existence of the region of stability of superheavy elements.

Since the isotope $^{261}107$ undergoes mainly α-decay, there are grounds to assume that the lifetimes of the heavier isotopes will increase, as predicted by the α-decay systematics. For instance, the isotope $^{267}107$,

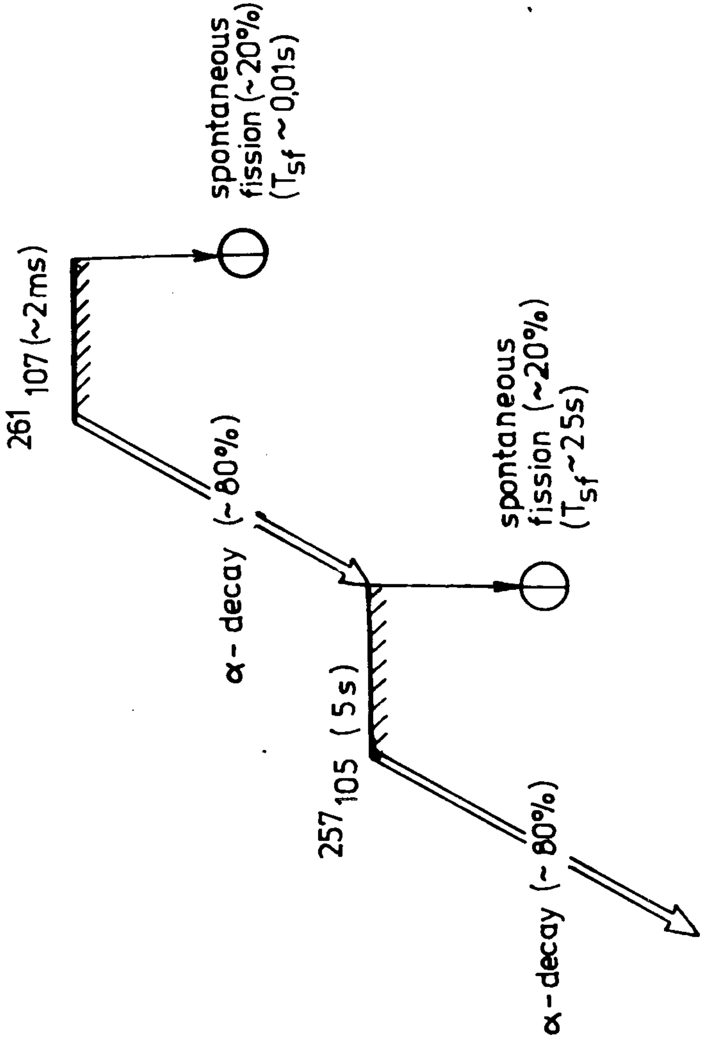

Fig.1

which is expected to be formed in the reaction $^{249}Bk(^{22}Ne, 4n)$, may have a half-life longer than 1 s. Such a long lifetime permits the investigation of the chemical properties of the atoms of element 107, ekarhenium.

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