EXPERIMENTS ON THE CREATION OF EINSTEINIUM 
AND FERMIUM IN A CYCLOTRON

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In this article we present the results of some experiments on the creation of  
einsteinium and fermium by cyclotron irradiation of a uranium target with quintu- 
ply charged nitrogen ions (N V) and sextuply charged oxygen ions (O VI).

The half-lives and α-particle energies were measured with the aid of photo- 
graphic plates, an ionization chamber with a spherical electrode, and a twenty-
channel pulse-amplitude analyzer. The separation of the transplutonic ele-
ments was performed by a chromatographic method.

The first communication on the creation of einsteinium in a cyclotron appeared in 1954 in an article by  
A. Ghiorso and others [1]. Einsteinium isotopes of mass numbers 246 and 247 were separated from a uranium  
target that had been irradiated by nitrogen ions. The einsteinium isotope E^246 decays by means of K-capture  
into Cf^246 with a half-life of a few minutes, and E^247 in addition to K-capture suffers α-decay with a half-
life close to 7 minutes and an α-energy of 7.35 Mev.

Somewhat later, Swedish investigators [2] isolated from uranium irradiated with oxygen ions the  
isotope fermium with an assumed mass number of 250, a half-life for α decay approximately 30 minutes  
and an α-particle energy of 7.7 Mev.

In the present paper we present some results of a few experiments (performed in 1955) on the creation  
of einsteinium and fermium isotopes by bombardment of uranium targets by nitrogen and oxygen nuclei.  
The Academy of Sciences of the USSR cyclotron with magnetic pole-pieces of diameter 150 cm, was used to ac-
celerate quintuply charged nitrogen ions and sextuply charged oxygen ions.

The nitrogen ions were obtained from a slit source [3], made especially for the present investigation.  
The nitrogen ion energy at the final radius was 105 Mev, and the ion current was 5·10^-9 amps.  

The sextuply charged ions of oxygen were obtained as a result of "stripping" doubly charged ions of oxygen  
on the molecules of the remaining gas in the cyclotron chamber. The maximum energy of the accelerated  
sextuply charged oxygen ions at the final radius was 120 Mev, and the current of ions with energies greater than  
100 Mev was 3·10^-8 amps.

In the experiment α-radioactive transplutonic elements were studied. The half-lives and energies of the  
α-particles were determined with the aid of an ionization chamber with a spherical electrode and a twenty-
channel pulse-amplitude analyzer.

In those cases when the number of disintegrations was insufficient for recording with the cloud chamber,  
the measurement of the α-energies and half-lives was performed by the method of thick photographic plates.  
In this work photographic plates of type "T" were used without a protecting gelatin layer, and with a resolving  
power of 0.4 Mev for α-energies of 5 to 8 Mev.*

Obtaining Einsteinium

When a uranium target is bombarded by ~100 Mev nitrogen ions, in addition to the reaction of complete

* The type "T" photographic plates were especially constructed and prepared in the laboratory of K. S. Bogomolov  
at the Scientific Institute of Motion Picture Photography.
capture of the nitrogen nucleus with subsequent emission of 4-7 neutrons, reactions of partial penetration of the nitrogen nucleus are also possible; these come about as the result of splitting off an \( \alpha \)-particle or a proton from the bombarding nucleus. Therefore, in the interaction of nitrogen ions with uranium nuclei, simultaneously with the creation of einsteinium isotopes, the creation of californium and berkelium isotopes also takes place. The result of these reactions is the possible creation of the isotopes \( \text{E}^{246-248} \), \( \text{Cf}^{244-248} \), \( \text{Bk}^{243-245} \).

To obtain einsteinium, a plate of uranium metal of thickness 0.1 mm and dimensions 5 x 15 mm was subjected to irradiation by accelerated nitrogen ions for 15-30 minutes. In 10-15 minutes after the irradiation, the uranium target was placed in the ionization chamber. The relatively great thickness of the active layer of the target and the intense \( \beta \)-radiation caused by the decay of the fission fragments that had been created to a large degree impaired the resolving power of the ionization chamber. Nevertheless, with the help of a collimator, groups with energies of 7.0-7.5 Mev were separated from the \( \alpha \)-spectra of the products. The results of the measurements on the half-life of the elements emitting this group of \( \alpha \)-particles are presented in Figure 1.

Analysis of the curve indicates the presence of two half-lives equal to about 7 and 40 minutes. The 7-minute half-life would seem to be due to the isotope \( \text{E}^{247} \), and the 40-minute one, to the isotope \( \text{Cf}^{244} \), whose half-life, according to the data in the literature, is 45 minutes, and whose \( \alpha \)-particle energy is 7.15 Mev.

In order to further identify the products of the reaction, the separation of the transplutonic elements from the uranium base and the fission fragments was undertaken. The separation was carried out by the precipitation of fluorides with 200 micrograms of lanthanum used as the carrier. The decomposition of lanthanum fluoride was accomplished by nitrous acid in the presence of boric acid, after which lanthanum hydroxide was precipitated and dissolved in hydrochloric acid. The salt solution was applied to a platinum disc, and then the target was dried and baked. The thickness of the target layer prepared in this way was about 10 micrograms per square centimeter.

The \( \alpha \)-particle spectrum of the transplutonic elements after their separation from the uranium and the fission fragments, obtained with the aid of an ionization chamber, is presented on Figure 2.

Further analysis of the products of the reaction was carried out by the chromatographic method. The separation of the transplutonic elements was carried out in a column, diameter 2 mm, height 17 cm at 85°C on a cationite (type Douex-50) with a 0.4 M solution of ammonium lactate at \( \text{pH} = 4.3 \). The time spent in separating the transplutonic elements did not exceed one hour in any of the experiments. The transplutonic elements were not separated from the carrier, since preliminary experiments on the disintegration of americium and curium for identical conditions showed that the presence of 200 micrograms of lanthanum do not interfere with the disintegration and has no influence on the positions of the chromatographic maxima.

Figure 1. The decay of isotopes with \( \alpha \)-energies of 7.0-7.5 Mev.

Figure 2. The \( \alpha \)-spectrum of the transplutonic elements.