THE SYNTHESIS OF ELEMENT 105

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In 1968 experiments were conducted at the Laboratory of Nuclear Reactions of the Joint Institute of Nuclear Research in order to produce a new chemical element with atomic number 105 [1].

In the case of the irradiation of Am^{243} with accelerated Ne^{22} ions with a very small cross section, the formation of short-lived emitters of α-particles with an energy of 9.4-9.7 MeV was observed. However, on the basis of an analysis of the decay schemes of the known α-radioactive nuclei with an odd number of nucleons, it may be assumed that the bulk of the α-decay of the isotopes with Z = 105 corresponds to the excited levels of the daughter nuclei (Z = 103), and the most intense α-lines belonging to the isotopes 105^{260} and 105^{261} should be sought in the softer part of the α-spectrum ($E_\alpha \leq 9.1$ MeV). Unfortunately, the energy interval 8.8-9.0 MeV includes the α-particles of isotopes (Z < 92) formed as a result of nuclear reactions on trace impurities of lead in the americium target [2]. Therefore, despite extensive work on the purification of the target from lead, the analysis of this part of the spectrum was greatly hindered in [1].

Nonetheless, the synthesis of element 105 can also be approached from the other side.

It is known that with increasing parameter of fissionability Z^2/A, the stability of nuclei with respect to spontaneous fission decreases sharply. Analyzing the latest experimental data on the properties of nuclei with Z equal to 100, 102, and 104, we can obtain an idea of the lifetime of isotopes of element 105 relative to spontaneous fission. Thus, for example, the half-life τ_{sf} for the isotope 105^{261}, according to our estimates, is 10^{-1}-10^2 sec (the prohibition due to the odd number of protons is equal to approximately 10^2-10^5), whereas the expected half-life of the α-decay of the same nucleus may lie within the range 10^{-1}-10 sec. These estimates are unquestionably extremely approximate; however, they permit us to assume that the isotopes of the new element formed in the reactions $Am^{243}(Ne^{22}, xn)105^{265-x}$ can experience spontaneous fission together with α-decay.

The method of observation based on the recording of spontaneous fission fragments possesses considerably higher sensitivity in comparison with methods of recording α-radiation. In the recording of spontaneous fission, the background conditions are considerably better, since of most of the side products of nuclear reactions, only a limited number of isotopes experience spontaneous fission.

Taking all the aforementioned into consideration, in October 1969 we conducted experiments in search of the spontaneous fission of isotopes of element 105. This work presents the results obtained.

EXPERIMENTAL METHOD

The experiments were conducted on the apparatus, the scheme of which is shown in Fig. 1. The beam of accelerated ions was focused with two pairs of quadrupole lenses and was incident on the entrance of a chamber separated from the vacuum volume of the accelerator with aluminum foil 15 μ thick. Behind the entrance window of the chamber was placed a target, made in the form of a layer ~1 mg/cm^2 thick with an area of ~4.5 cm^2, applied on an aluminum substrate 7 μ thick. The target was placed in a copper cassette mesh, cooled with water (transparency of the mesh 73%). For additional cooling of the target the entire volume of the chamber was filled with helium (pressure up to 40 torr). In the experiments we used targets of U^{235} (isotopic composition: U^{235} – 89.8%, U^{234} – 1.3%); Pu^{239} (99.6%); Am^{243} (Am^{243} – 97%, Am^{241} – 3%), and ions

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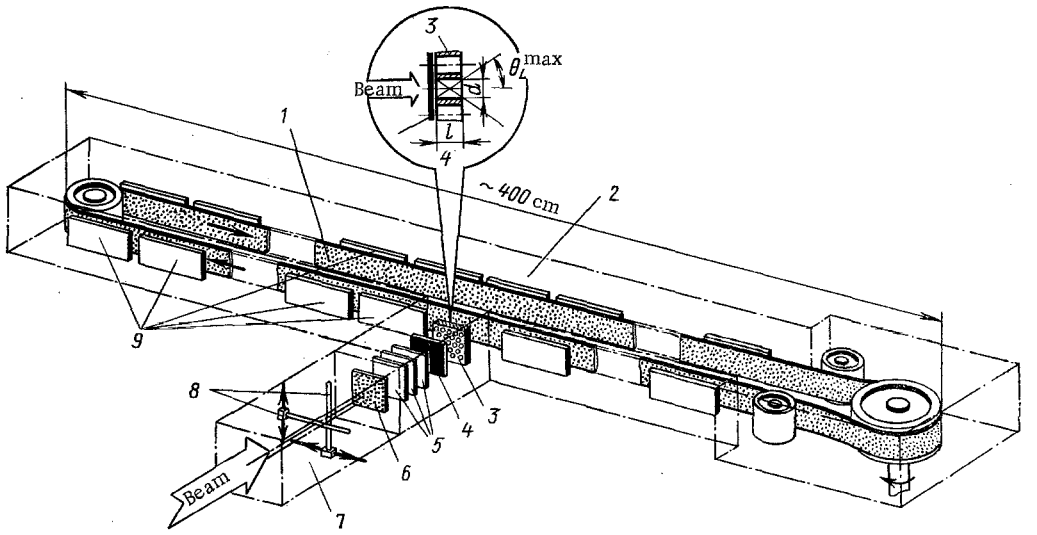

Fig. 1. Scheme of experimental apparatus for recording short-lived spontaneous fissioning nuclei. 1) Ribbon-collector of recoil nuclei; 2) helium ($p \approx 40$ mm Hg); 3) collimator; 4) target; 5) absorbers; 6) vacuum foil; 7) vacuum volume; 8) monitoring of beam distribution; 9) detectors of fission fragments.

of O^{16}, O^{18}, Ne^{20}, and Ne^{22} with maximum energies 135, 120, 192, and 175 MeV, respectively. The energy of the particles was varied with the aid of aluminum absorbers, placed in a special cassette between the entrance foil and target. The energy dispersion of the ions in the interval of energies from 5 MeV/nucleon up to the maximum should not exceed 2 MeV. The angular discrepancy of the beam was ~1°. A special device monitoring the distribution of flux density of ions incident on the target was set up at the entrance of the chamber. The intensity of the ion flux passing through the target was an average of $5 \cdot 10^{12}$ particles/sec.

In the experiments with Ne^{20} and Ne^{22}, the exact value of the integral flux of particles was required; it was determined according to the γ-activity of Se^{75} ($\tau_{1/2} = 120.4$ days; E_γ was equal to 121, 136, 265, 280, and 401 keV [3]), formed in the interaction of neon ions with the nickel ribbon-collector. A special experiment was conducted (Fig. 2) to measure the dependence of the yield of Se^{75} on the energy of the ions; the beam was monitored according to the yield of the radioactive isotope Na^{24}.

The recoil nuclei formed in the reaction were incident on a collector representing an "infinite" nickel ribbon 8 m long, 25 mm wide, and 0.05 mm thick, moving at a constant speed. Along the ribbon were arranged 105 detectors of fission fragments, prepared from phosphate glass in the form of plates with dimensions 60 × 35 mm. The efficiency of the recording of fission fragments was 95% [4]. The sensitivity of the method was such that the appearance of one track on the detectors during the experiment (30-50 h) corresponded to a cross section of formation of a spontaneously fissioning emitter of $\sim 2 \cdot 10^{-36}$ cm^2. In view of the fact that an intense neutron flux arises when the target is irradiated, materials with a minimum content of uranium and thorium of $\sim 10^{-8}$ g/g were used in the apparatus. In control experiments it was established that the background corresponds to a cross section of $< 5 \cdot 10^{-36}$ cm^2.

Thus, this apparatus can be used to reliably record fragments of the spontaneous fission of isotopes of element 105, formed in the reactions $Am^{243}(Ne^{22}, 4\text{-}5n)105^{261, 260}$, if the probability of spontaneous fission for these nuclei with respect to α-decay is ≥ 0.01 and the half-life $\tau_{1/2} \geq 0.05$ sec.

In an investigation of the principles of the formation of spontaneously fissioning isotopes in nuclear reactions, as will be shown below, it is necessary to determine the dependence of the cross section of forced fission of U^{235} and Am^{243} on the energy of the Ne^{22} ions. The experimental device for these measurements is shown schematically in Fig. 2.

RESULTS

In the first experiment a target of Am^{243} was irradiated with Ne^{22} ions with an energy of 114 MeV for 70 h. The rate of movement of the ribbon was selected equal to 78 cm/sec, which permitted observation of

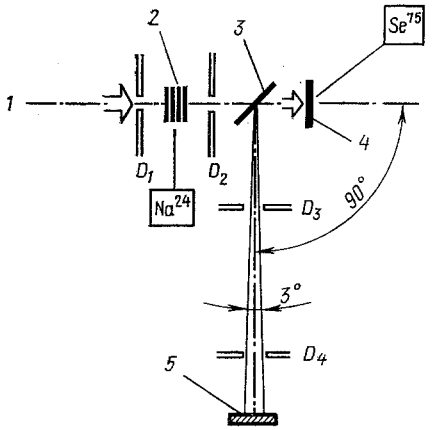

Fig. 2. Experimental device for measuring the cross sections of forced fission by heavy nuclei. 1) Ion beam; 2) aluminum absorbers; 3) target; 4) nickel collector; 5) detector of fragments; D_i) collimators.

fission fragments in the time range 0.05-10 sec. The results of the experiment are presented in Fig. 3. The short-lived emitter of spontaneous fission fragments with $\tau_{1/2} = 0.014$ sec is the well-known isomer Am^{242m}, which is formed in the reaction $Am^{243}(Ne^{22}, Ne^{23})Am^{242m}$. In addition, we recorded 58 cases of decay of a more long-lived isotope ($\tau_{1/2} \approx 2$ sec). The yield of new spontaneously fissioning nuclei corresponds to a cross section of $\sim 2 \cdot 10^{-34}$ cm^2.

To identify the atomic number of the new isotope, experiencing spontaneous fission with $\tau_{1/2} \approx 2$ sec, we conducted experiments, the need for which was due to the following circumstances.

At present many spontaneously fissioning isomers are known in the region of U to Cm with half-lives of 10^{-8}-10^{-2} sec [5]. In our case such nuclei can be formed with relatively great probability in reactions of multinucleon exchange [6] (see, for example, the yield of Am^{242m} in Fig. 3). It must be determined whether the observed new emitter of spontaneous fission fragments is a representative of this region of nuclei. As will be shown below, this question can be answered from a consideration of the angular distribution of recoil nuclei.

The possibility also remains that the spontaneous fission with $\tau_{1/2} \approx 2$ sec is experienced by an unknown isotope with atomic number 102, 103, or 104, formed in a reaction with escape of a charged particle. In this case a different method of analysis is possible, based on the study of the radioactive properties of the isotopes of these elements and the mechanism of the nuclear reactions leading to their formation.

Finally, if the spontaneous fission with $\tau_{1/2} \approx 2$ sec belongs to one of the isotopes of element 105, then the latter can be obtained in the case of irradiation of Am^{243} with Ne^{22} ions only in a reaction of total fusion with the formation of an excited compound nucleus 105^{265}, followed by evaporation of neutrons. A peculiarity of this reaction is the characteristic dependence of the yield of the isotope on the energy of excitation of the compound nucleus. Therefore a measurement of the function of excitation of the spontaneously fissioning product with $\tau_{1/2} \approx 2$ sec can serve as a supplementary and independent method of its identification.

Investigation of the Principles of Formation of the Spontaneously Fissioning Isotope with $\tau_{1/2} \approx 2$ sec

Angular Distributions of Recoil Nuclei. In reactions with the formation of a compound nucleus, followed by evaporation of neutrons, the angular distribution of recoil nuclei has a sharp maximum at small angles [7, 8]. In processes of multinucleon exchange (quasielastic scattering), the recoil nuclei have a substantial transverse component of the momentum, which leads to a substantial increase in the angular dispersion and a shift of the maximum of the angular distribution in the direction of far larger angles [9]. These circumstances can be used in the identification of the new isotope experiencing spontaneous fission $\tau_{1/2} \approx 2$ sec.

Using the apparatus presented in Fig. 1, we can measure the integral angular distributions, varying the degree of collimation of the recoil nuclei escaping from the target. Figure 4 shows the integral angular distributions of recoil nuclei for reactions with the formation of a compound nucleus (solid curve) and reactions of multinucleon exchange (shaded region); k is the degree of collimation of the recoil nuclei; $W_k/W_{0.5}$ represents the relative yields of the reaction products for various values of k. The curves were constructed on the basis of experimental data obtained in the irradiation of Au^{197}, Pb^{208}, U^{235}, U^{238}, Pu^{239}, Pu^{242} with ions of O^{18} and Ne^{22} [10, 11].

We performed analogous measurements for the reaction of $Am^{243} + Ne^{22}$ [12]. Between the target enclosed in the copper mesh with thickness $\delta_0 = 1$ mm and diameter of openings $d = 2$ mm ($k_0 = \delta_0/d = 0.5$) and the collector of recoil nuclei we placed a supplementary collimator with thickness $\delta = 4$ mm ($k_1 = (\delta_0 + \delta)/d = 2.5$) and measured the yield of spontaneously fissioning products for $k_0 = 0.5$ and $k_1 = 2.5$. For the isomer Am^{242m} ($\tau_{s.f} = 0.014$ sec), the ratio of the yields $W_{k1}/W_{k0} = 0.18 \pm 0.02$, which is in good agreement with the expected value of this quantity for the reaction of transfer of a nucleon $Am^{243}(Ne^{22}, Ne^{23})Am^{242m}$

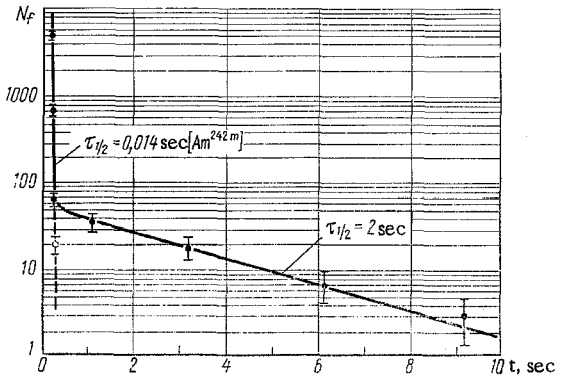

Fig. 3

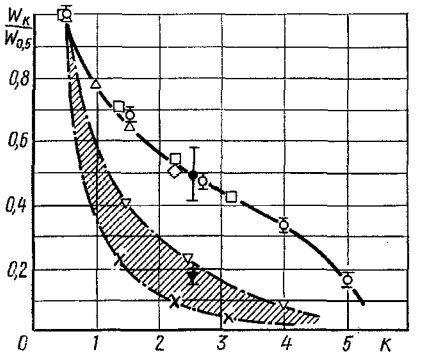

Fig. 4

Fig. 3. Time distribution of spontaneous fission fragments of nuclei formed in the reaction of $Am^{243} + Ne^{22}$, at an energy of the ions of 114 MeV.

Fig. 4. Integral angular distributions of recoil nuclei formed in the reactions: of total fusion: □) $Au^{197}(Ne^{22}, 4\text{-}5n)Ac^{213, 214}$; ◇) $U^{238}(O^{16}, 6n)Fm^{248}$; △) $U^{238}(Ne^{22}, 4n)102^{256}$; ○) $U^{235}(Ne^{22}, 5n)102^{252}$; of multinucleon transmissions: ×) $Pb^{208}(Ne^{22}, O^{18})Po^{212m}$; ▽) $Pu^{242}(Ne^{22}, F^{22})Am^{242mf}$. Blacks points: experimental data for products of the reaction $Am^{243} + Ne^{22}$ (▼) for the isomer Am^{242}; ●) for the spontaneously fissioning isotope with $\tau_{1/2} \approx 2$ sec].

(see Fig. 4). For the isotope with $\tau_{1/2} \sim 2$ sec we obtained a value $W_{k_1}/W_{k_0} = 0.47 \pm 0.10$. From these results it is evident that the observed emitter of spontaneous fission fragments with $\tau_{1/2} \approx 2$ sec is not a product of reactions of multinucleon transfer; therefore it cannot be assigned to the region of spontaneously fissioning isomers.

Analysis of Reactions with Emission of Charged Particles. It is known that together with reactions proceeding through a compound nucleus, direct processes of the type of (Ne^{22}, pxn), (Ne^{22}, αxn), (Ne^{22}, αpxn), are also possible, resulting in the formation of isotopes of elements 104, 103, and 102. These two types of reactions cannot be sufficiently reliably separated by the collimation method, based on the differences of the integral angular distributions of the recoil nuclei. Therefore we shall consider in greater detail the properties of isotopes with $Z < 105$ and the probability of their formation in the irradiation of Am^{243} by Ne^{22} ions.

From the experimental data that we obtained [11, 12] and the results of [13] on the investigation of the reactions

$$U^{238}(Ne^{20}, pn)Md^{256}; \quad U^{238}(Ne^{22}, p3n)Md^{256}; \quad U^{238}(Ne^{22}, 4n)102^{256}; \quad Am^{241}(O^{16}, p4n)102^{252}; \quad Pu^{239}(O^{18}, 5n)102^{252}$$

it is evident that the ratio of the cross sections σ(HI, pxn)/σ(HI, 4-5n) < 0.02 at all values of $x \geq 1$, if the energy of the bombarding particles corresponds to the maximum of the excitation functions of the reactions (HI, 4-5n). It should also be mentioned that in the irradiation of Am^{243} with Ne^{22} ions, no formation of kurchatovium with the known half-life $\tau_{1/2} = 0.1$ sec was observed [11]. This permitted an estimation of the cross sections of the reactions $Am^{243}[Ne^{22}, p(3\text{-}4)n]104^{259, 260}$; these were less than $5 \cdot 10^{-35}$ cm^2.

We investigated the probability of processes with emission of α-particles, and this was also investigated in [14], with the following reactions as examples:

$$Am^{243}(O^{18}, \alpha n)Md^{256};$$
$$Pu^{239}(Ne^{20}, \alpha 3n)102^{252};$$
$$U^{238}(Ne^{22}, \alpha 4n)Fm^{252}\ [14].$$

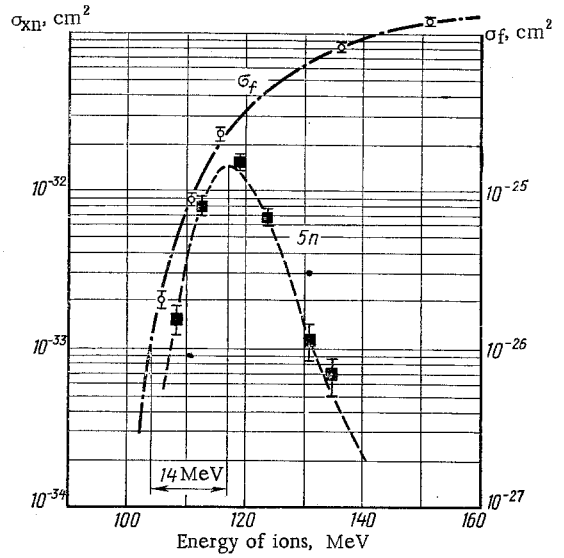

Fig. 5

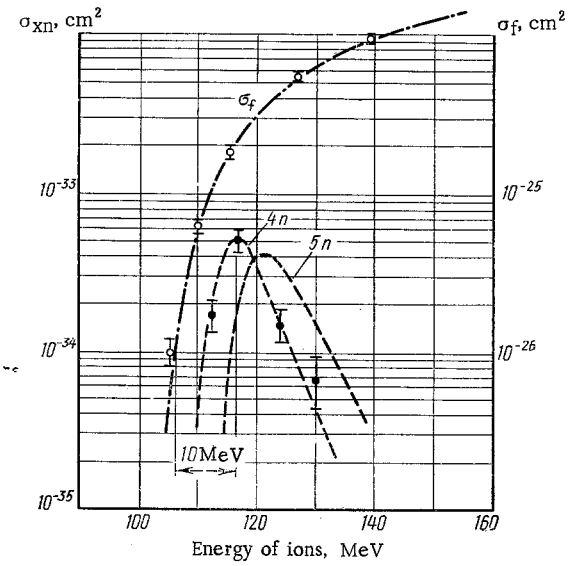

Fig. 6

Fig. 5. Dependence of the cross section of formation of the isotope 102^{252} on the energy of Ne^{22} ions. ——) Calculated excitation function of the reaction $U^{235}(Ne^{22}, 5n)102^{252}$; ■) experimental values; –·–·– [right-hand scale]) calculated dependence of the fission cross section of U^{235} for the energy of Ne^{22} ions; ○) experimental values.

Fig. 6. Dependence of the cross section of the formation of the spontaneously fissioning isotope with $\tau_{1/2} \approx 2$ sec on the energy of Ne^{22} ions: ——) calculated functions of excitation of the reactions $Am^{243}(Ne^{22}, 4n)105^{261}$ and $Am^{243}(Ne^{22}, 5n)105^{260}$; ●) experimental values; –·–·– [right-hand scale]) calculated dependence of the cross section of fission of Am^{243} on the energy of Ne^{22} ions; ○) experimental values.

From a comparison of these results with the data on the cross section of the corresponding reactions (HI, 5n), we can draw the following conclusions. The ratio σ(HI, α4n)/σ(HI, 5n), at the maxima of the excitation functions, is equal to ~10; the value of σ(HI, α3n)/σ(HI, 5n) that we measured is close to one, while for the reactions (HI, αn), such a ratio is already less than 10^{-3}.

Thus, reactions of the type of (Ne^{22}, αxn) proceed with a relatively high probability at x equal to 3-5. They lead to the formation of isotopes of element 103, the spontaneous fission of which has not been investigated. In view of this, we conducted direct experiments to determine the partial half-lives for the spontaneous fission of the isotopes 103^{256} and 103^{257}. In the irradiation of Am^{243} by ions of O^{18} with an energy of 95 MeV, the spontaneous fission of the two isotopes formed in the reactions $Am^{243}(O^{18}, 4\text{-}5n)103^{257, 256}$ could be simultaneously investigated. The cross sections of these reactions are known and comprise $\sim 3 \cdot 10^{-32}$ cm^2 [15]. In the case of irradiation for 15 h, not one spontaneous fission fragment was recorded; therefore it may be concluded that $\sigma_{s.f} < 10^{-35}$ cm^2. Taking into consideration the known values of the lifetime of these isotopes with respect to α-decay ($\tau_{1/2} \approx 35$ sec for both isotopes), we can indicate the lower limit of the half-life with respect to spontaneous fission for the isotopes 103^{256} and 103^{257}: $\tau_{s.f} > 10^5$ sec. The reactions Am^{243}[Ne^{22}, α(2-3)n] will lead to the formation of heavier isotopes of element 103 with mass numbers 258 and 259, the properties of which are unknown. However, it is difficult to believe that the odd–odd isotope 103^{258} will experience spontaneous fission with a half-life of ~2 sec. It is also rather improbable that when two neutrons are added to the nucleus of 103^{257}, the period of spontaneous fission will change by more than 10^5-fold; moreover, as was indicated above, the probability of the reaction $Am^{243}(Ne^{22}, \alpha 2n)103^{259}$ is very low.

Thus, the new emitter of spontaneous fission fragments with $\tau_{1/2}$ ~2 sec that we observed cannot be an isotope of element 103.

At an energy of Ne^{22} ions equal to 115 MeV, the cross sections of the reactions (Ne^{22}, αpxn) are extremely small. Moreover, at all x > 2, well-studied isotopes of element 102 are formed, not one of which can be the cause of the observed spontaneous fission.

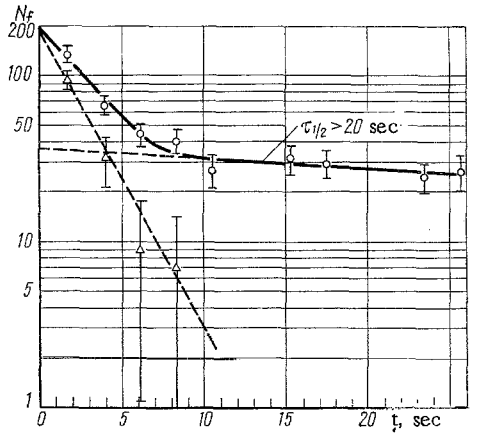

Fig. 7

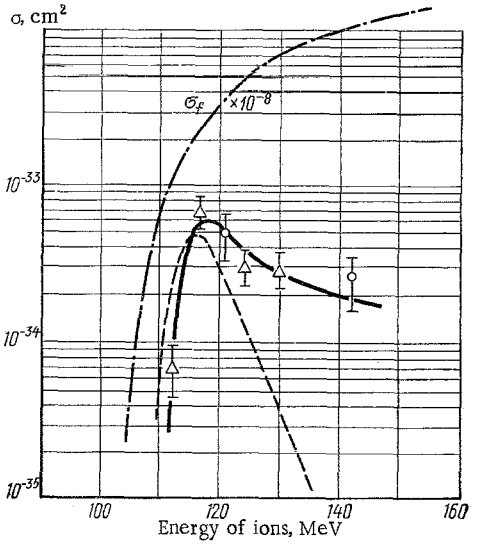

Fig. 8

Fig. 7. Distribution with time of fragments of spontaneous fission of nuclei formed in the reaction of $Am^{243} + Ne^{22}$. The summary data of experiments conducted at various energies of Ne^{22} ions are presented.

Fig. 8. Energy dependence of the yield of the isotope with $\tau_{1/2} > 20$ sec (determined according to spontaneous fission) on the energy of Ne^{22} ions: ———) function of excitation of the reaction $Am^{243}(Ne^{22}, 4n)105^{261}$; –·–·–·–) cross section of forced fission of Am^{243} by Ne^{22} ions; △) experimental values of the yield of the spontaneously fissioning isotope ($\tau_{1/2} > 20$ sec); ○) data for the isotope 102^{252}, formed in the reaction $Pu^{239}(Ne^{20}, \alpha 3n)102^{252}$.

Considering the data obtained altogether, we arrive at the conclusion that the product experiencing spontaneous fission with a half-life of ~2 sec observed in the reaction of $Am^{243} + Ne^{22}$ is an isotope of element 105.

Measurement of the Excitation Function. In the reaction of total fusion, according to the statistical model, the dependence of the probability of formation of an isotope with a given mass number on the energy of excitation of the compound nucleus takes the characteristic form, close to a gaussian distribution [16]. The charge, mass, and energy of excitation of the compound nucleus are well known; therefore the position of the maximum and the width of the curve of excitation are evidence of the number of evaporated neutrons, and, consequently, of the mass number of the final product as well. Such a situation exists for nonfissioning nuclei. In our case, as a result of the high coulombic barrier of the reaction and the great fissionability of the compound nucleus ($\Gamma_n/\Gamma_f \ll 1$), the excitation functions may be substantially distorted.

The cross section of the reaction with evaporation of x neutrons takes the form

$$\sigma_{xn} = \sigma_c(E)\, P_x(E) \left(\frac{\overline{\Gamma_n}}{\Gamma_f}\right)_E^x,$$

where $\sigma_c(E)$ is the cross section of formation of the compound nucleus; $P_x(E)$ is the probability of evaporation of x neutrons by a nucleus with initial excitation energy E; $\bar{\Gamma}_n/\Gamma_f$ is the ratio of the neutron and fission widths, averaged along the neutron cascade.

For heavy nuclei ($\Gamma_n/\Gamma_f \approx 0.01$), the cross section of formation of the compound nucleus practically coincides with the cross section of fission: $\sigma_c(E) \approx \sigma_f(E)$ [17]. The value of $P_x(E)$ can be obtained by calculation if the temperature of the nucleus and the energies of the bond of the neutrons are known. The ratio Γ_n/Γ_f in the region of heavy nuclei, as was shown in [17], depends slightly on the energy of excitation and can be determined with a satisfactory degree of accuracy on the basis of the known experimental data.

To compare the experimental and calculated functions $\sigma_{xn}(E)$ we measured the excitation function of the reaction $U^{235}(Ne^{22}; 5n)102^{252}$. The properties of the isotope 102^{252} are well known: according to [11, 18], it has a half-life of 2.4 ± 0.2 sec and in approximately one-third of the cases of disintegration experiences spontaneous fission. The measured excitation function is presented in Fig. 5. The same figure shows the energy dependence of the cross section of the fission of U^{235} by Ne^{22} ions. The function $\sigma_f(E)$ is in good agreement with the results of the calculations [19] and with the experimental data [20]. The experimental results obtained for the reaction $U^{235}(Ne^{22}, 5n)102^{252}$ are also in good agreement with the calculated excitation function (dotted curve). The maximum of the excitation function lies at an energy of the ions of 117 MeV and is displaced by 14 MeV relative to the coulombic barrier of the reaction.* For the branch of spontaneous fission the cross section at the maximum is $(1.5 \pm 0.3) \cdot 10^{-32}$ cm^2. The width of the curve at half the height is equal to 11 MeV.

In the following experiments [21] we measured the energy dependence of the cross section of the reaction leading to the formation of a new spontaneously fissioning isotope with $\tau_{1/2}$ ~2 sec. The rate of movement of the tape was selected equal to 28 cm/sec, which permitted recording of fission fragments in the time interval 0.15-28 sec. The experimental data are presented in Fig. 6. The dotted lines show the calculated curves corresponding to the evaporation of four and five neutrons from the excited compound nucleus 105^{265}. The same figure shows the dependence of the fission cross section of Am^{243} on the energy of ions of Ne^{22}. The maximum of the excitation function for the isotope with $\tau_{1/2}$ ~2 sec lies at an energy of the ions of 117 MeV and is displaced by 11 MeV relative to the coulombic barrier of the reaction. The width of the curve at half the height is 8 MeV.

The nature of the excitation function (see Fig. 6) is evidence that the observed new emitter of spontaneous fission fragments is formed as a result of a reaction proceeding through the formation of a compound nucleus, followed by evaporation of neutrons; consequently, it has the atomic number 105. In the reactions $Am^{243}(Ne^{22}, xn)105^{265-x}$, the isotopes with mass 260 and 261 will be formed with the greatest probability (evaporation of five or four neutrons from the compound nucleus). To determine the mass number of the isotope ($\tau_{1/2}$ ~2 sec) it is necessary to know the exact values of the bond energies of the evaporating neutrons, since the positions of the maxima of the excitation functions for the reactions (Ne^{22}; 4, 5n) differ by approximately 5 MeV. The absence of exact values of the masses of the nuclei with Z = 105 inevitably leads to some indeterminacy in the identification of the mass number of the isotope. And yet, if we take the calculated values of the masses of the nuclei [22, 23], on the basis of an analysis of the experimental data (the position of the maximum of the excitation function relative to the coulombic barrier of the reaction, the width of the curve of excitation), we can assume that spontaneous fission with $\tau_{1/2} \approx 2$ sec belongs to the isotope with mass 261.

The yield of the isotope at the maximum of the excitation function corresponds to a cross section of $(5.0 \pm 1.5) \cdot 10^{-34}$ cm^{-1}, whereas the expected cross section of the reaction $Am^{243}(Ne^{22}, 4n)105^{261}$, according to our estimates, is $\sim 2 \cdot 10^{-33}$ cm^2. Consequently, it may be assumed that the main type of disintegration of this isotope is α-decay ($\tau_{1/2} \approx 2$ sec), and the partial half-life for spontaneous fission is several times as great.†

In the measurement of the excitation function, more than 300 fragments were recorded; their time distribution is presented in Fig. 7. The half-life of the isotope of element 105 is equal to 1.8 ± 0.6 sec.

From Fig. 7 it is evident that together with τ ~2 sec, the formation of an isotope experiencing spontaneous fission with $\tau_{1/2} > 20$ sec is observed. The dependence of the cross section of formation of the isotope with $\tau_{1/2} > 20$ sec on the energy of ions of Ne^{22} (Fig. 8) differs from the function of excitation of the reaction proceeding with the formation of a compound nucleus. Therefore it is natural to assume that spontaneous fission with $\tau_{1/2} > 20$ sec is experienced by an isotope with Z < 105. Since the reactions (Ne^{22}, pxn) and (Ne^{22}, αpxn) are relatively improbable, while the properties of the isotopes 103^{256} and 103^{257} are known, it may be assumed that $\tau_{1/2} > 20$ sec belongs to the isotope 103^{258}, which is formed in the reaction $Am^{243}(Ne^{22}, \alpha 3n)103^{258}$. The nature of the excitation function of the reaction $Pu^{239}(Ne^{20}, \alpha 3n)102^{252}$ that we measured is additional confirmation of this hypothesis.

*The value of the coulombic barrier of the reaction corresponds to the energy of ions of Ne^{22} at which the fission cross section is equal to 0.01 barn.

†The results obtained subsequently on the α-decay of the isotope of element 105 are an experimental confirmation of this hypothesis [24, 25]. (Note during editing.)

The observed half-life $\tau_{1/2} > 20$ sec should most likely be assigned to the α-decay of the isotope 103^{258}; this does not contradict the systematics of the radioactive properties of nuclei with Z = 103 [26]. And yet, the isotope 103^{258}, together with α-decay, can experience electron capture in a definite fraction of cases ($Q_\beta = -2.4$ MeV [26]), being converted to the isotope 102^{258}, which undergoes spontaneous fission.

If the half-life of the isotope 103^{258} is less than 20 sec, then the measured half-life $\tau_{1/2} > 20$ sec is associated with the spontaneous fission of the isotope 102^{258}.

From the experimental data obtained in this work we can draw the following conclusions:

1. In the irradiation of Am^{243} with ions of Ne^{22}, a spontaneously fissioning isotope with half-life $\tau_{1/2} = 1.8 \pm 0.6$ sec is formed.

2. From the data on the angular distribution of the recoil nuclei and an analysis of the results of the control experiments it is evident that the spontaneously fissioning isotope with $\tau_{1/2} \approx 2$ sec has an atomic number of 105.

3. The nature of the excitation function gives evidence that the observed emitter of spontaneous fission fragments ($\tau_{1/2} = 2$ sec) is formed through a compound nucleus, followed by evaporation of neutrons. This is an independent confirmation of the fact that an element with Z = 105 was synthesized in the reaction of $Am^{243} + Ne^{22}$. The most probable mass number of the isotope of the new element is 261.

4. The yield of the spontaneously fissioning isotope of element 105 corresponds to a cross section of $5 \cdot 10^{-34}$ cm^2. It may be assumed that this isotope experiences predominantly α-decay.

5. It was shown that for the isotopes of element 103 with mass numbers 256 and 257, the half-life for spontaneous fission $\tau_{s.f} > 10^5$ sec.

6. Spontaneous fission with $\tau_{1/2} > 20$ sec, in all probability, can be explained by the formation of the isotope 103^{258} in the reaction $Am^{243}(Ne^{22}, \alpha 3n)103^{258}$. This isotope can experience not only α-disintegration, but also electron capture, which leads to the formation of the spontaneously fissioning nucleus 102^{258}.

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