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(Excerpt translation from Bulletin No. 6 of
the LIYaF Data Centre, September 1977)

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Measurements (Fig. 1) show that the energy distributions of various light nuclei are adequately approximated by normal distributions and can therefore be characterized by two parameters - the most probable energy $\bar{E}$ and the full width at the half-maximum of the distribution F.

The energy spectrum is usually measured in experiments within the limits $E_{min} - E_{max}$. Below this, the light nucleus yield obtained within these limits is denoted by $Y\Delta$. Knowing the spectrum parameters $\bar{E}$ and F, it is possible by extrapolation to determine the total Gaussian area from the value $Y\Delta$ and thus obtain the extrapolated yield of particular particles (Y). The Y values are usually normalized to the ternary fission α -particle yield.

Sometimes, when the values $\bar{E}$ and F are not known (for example, when the total isotopic yield for a particular light element is measured [15]), authors extrapolate to the low-energy region on the basis of the experimental spectrum available.

Tables 1-5 provide data on the measurement of the energy spectra and yields of light nuclei from the thermal neutron fission of ^{233}U, ^{235}U, ^{239}Pu and ^{242}Am^{m} and the spontaneous fission of ^{252}Cf. These data were obtained by the ΔE-E method or a magnetic mass spectrometry method with time-of-flight and energy determination and were taken from Refs [4-15]. The light nucleus yields are normalized by a factor equal to 10^4 times the number of α-particles from ternary fission.

Let us first examine the data on thermal-neutron-induced ternary fission (Tables 1-4), from which it can be seen that the energy spectrum parameters obtained by different methods are in satisfactory agreement. The same can be said of the light nucleus yields, although here there is some divergence. For example, Table 2 shows that the C, N and O yields obtained in Ref. [6] exceed corresponding yields found in Ref. [8].

For the above reasons, the results of Ref. [6] are considered to be too high since they do not take into account the possible recoil nucleus background. The same discrepancy is observed in the C nucleus yield results obtained in Refs [10, 11] (see Table 3). Clearly, it is for the same reason that a significant fluorine nucleus yield was found in Ref. [10], whereas no fluorine nuclei were discovered in Ref. [11].

Energy spectrum and yield parameter measurements (the yields are given per fission event) are presented graphically in Figs [2-6], as a function of the light nucleus mass number (Figs 2 and 4) and of the parameter characterizing the fissile nucleus, Z^2/A (Figs 3 and 5). Figure 6 shows the yields of the light elements formed as a function of Z^2/A of the fissile nucleus. It can be seen from the graphs that the data for the thermal neutron ternary fission of ^{233}U, ^{235}U, ^{239}Pu and $^{242}Am^m$ are fairly similar in character and that they are strongly dependent on Z and A of the light nucleus and slightly dependent on Z^2/A parameter of the fissile nucleus.

For practical application, the energy spectrum parameters and yield values obtained by the magnetic mass spectrometry method with time-of-flight and energy determination can be recommended in view of the advantages of the method indicated above and also the fact that results for the four thermal-neutron-induced fissile nuclei (^{233}U, ^{235}U, ^{239}Pu, $^{242}Am^m$) were obtained by this method.

The data on ternary fission of ^{252}Cf are somewhat scantier. They were obtained by the ΔE-E method (Table 5). The energy spectrum parameters were measured by Cosper et al. in Ref. [12] (data on the ^1H spectrum were also obtained in Ref. [14]), only for the H and He isotopes. In addition, some results are available for the total Li, Be and C isotope spectrum parameters (from Refs [12] and [15]). The values $\bar{E}$ and F for H and He isotopes in Ref. [12] are indicated in Figs 2 and 3. Comparing them with corresponding results obtained for thermal neutron fission, we can conclude that the data given in Ref. [12] seem to be entirely satisfactory.

The values $\bar{E}$ and F for ^1H from Ref. [14] are preferred, since they are more accurate and do not clash with the data in Ref. [12].

Table 5 contains the yield measurement results from Ref. [13]. The authors did not extrapolate the yields and indicate the yield only in the measured energy region. Using the energy spectrum parameters obtained in Ref. [12], we extrapolated the YΔ values from Ref. [13] for ^{1}H, ^{2}H, ^{3}H, ^{6}He and ^{8}He (for ^{1}H the spectrum parameters were taken from Ref. [14]). The Y values obtained through this extrapolation are given in the Table. They agree with the data in Ref. [12] for all nuclei except ^{6}He. A comparison of light nucleus yields from the spontaneous fission of ^{252}Cf with the yields from thermal-neutron-induced fission (see Figs 4 and 5) clearly shows that the value for ^{6}He obtained in Ref. [12] is preferable. Further, Whetstone and Thomas from the same group - Ref. [16] - obtained in earlier work a yield value ($Y(^{6}He) = 240 \pm 50$) which, although having less statistical accuracy, was closer to the value obtained in Ref. [12].

The H and He isotope yield data recommended for use are those obtained in Ref. [12], while for ^{1}H the more accurate result from Ref. [14] is recommended.

Overall yields for Li and Be isotopes were obtained in Refs [12, 15], but the results of these papers vary significantly. It is our assumption that in Ref. [12] the overall energy spectrum parameters were incorrectly determined and that the yield extrapolation result could therefore be wrong. In particular, the authors of Ref. [13] express doubts regarding the most probable energy values for the overall Li and Be spectra determined in Ref. [12]. Moreover, Fig. 6 shows that the data in Ref. [15] on Li, Be, B and C yields reflect better the nature of the rise in light element yields as the fissile nucleus parameter Z^2/A increases, and are more reliable.

In order to evaluate the accuracy of the results for the extrapolated total Li, Be and C isotope yields, it is necessary to know their energy spectrum parameters.

On the basis of the similarity between data on light nucleus energy spectra and yields from thermal neutron fission and corresponding experimental results available for ^{252}Cf (see Figs 2, 3), it can be assumed that the ^{252}Cf ternary fission process does not differ from thermal-neutron ternary fission and that, accordingly, the $\bar{E}$ and F parameters for light nuclei with $Z > 2$ created by the spontaneous fission of ^{252}Cf should not differ greatly from the parameters obtained in thermal neutron fission.

Those $\bar{E}$ and F pairs (see Tables 6, 6A, 7 and 8) which should give the maximum and minimum extrapolated yield values for light isotopes generated by the spontaneous fission of ^{252}Cf (no data are available on $\bar{E}$ and F for the ^{16}C spectrum so the ^{15}C spectrum parameters were used) were selected from the set of data available for the spectrum parameters for each of the light isotopes Li, Be and C.

In addition, we must know the isotope yield ratio for each of the elements of interest to us (Li, Be and C). Figure 4 shows that these ratios remain virtually unchanged for each of the fissile nuclei (see also Fig. 5). The isotope yield ratios from ^{240}Pu fission data (see Table 6) were used for the evaluations carried out.

Thus, using the selected $\bar{E}$ and F values, the isotope yield ratios and the results for the total Li, Be and C yields between E_{min} and E_{max} that were obtained in Refs [12, 13], we evaluated the possible range of yields of light nuclei with $Z > 2$ from the spontaneous fission of ^{252}Cf (see Tables 6, 6A, 7 and 8). In Fig. 4, this range is indicated by the hatching. The extrapolated ^{9}Li, ^{10}Be and ^{14}C isotope yields obtained from the data in Ref. 15 and from the yield ratios taken by us for light isotopes created in ^{240}Pu fission are also indicated here. We can see that the results of Ref. [15] agree reasonably well with those of Refs [12, 13] within the limits of existing uncertainties.

The following might also serve as evidence of the accuracy of the evaluations. There are two empirical regularities satisfied for each of the fissile nuclei that can be noted in Fig. 4: (a) ^{6}He, ^{10}Be and ^{14}C yields are exponentially dependent on the A values which correspond to them; (b) the ^{9}Li yield is close in size to that of ^{9}Be. The evaluations obtained for the ^{10}Be and ^{14}C yields for ^{252}Cf fully satisfy regularity (a). The ^{9}Li yield, however, seems to be a little too high and, in order to satisfy (b), we can assume that the range of values obtained for the Li isotope yields should be lowered to some extent.

In order to see the degree of agreement between the B isotope yield results of Refs [13] and [15], we must try to obtain the extrapolated value of the total B isotope yield from the value $Y\Delta$ from Ref. [13]. But, the yield of B isotopes is low and their energy spectrum parameters are unknown. For a rough evaluation we can assume that, with the parameters $\bar{E} = F$, the overall energy spectrum for B isotopes is Gaussian, which corresponds to the energy distributions of ternary fission light particles (except ^4He) (see Fig. 3). The data in Ref. [13] agree with those in Ref. [15] for the value $\bar{E} = F = 19$ MeV. A value of this kind for the most probable energy and width of the overall B isotope energy spectrum is very probable (see Figs 2 and 3 and also the B energy spectrum in Ref. [15]). The other value for $Y\Delta$, obtained at a lower E_{min}, gives too high an extrapolated yield for B, a fact which the authors of Ref. [13] also assumed.

The yields of light nuclei with $Z > 2$ from the spontaneous fission of ^{252}Cf obtained on the basis of the evaluations mentioned above are shown in Fig. 5 (see black circles on the graph).

The ternary fission of nuclei other than those shown in Tables 1-5 have been studied to a much lesser extent. Table 9 gives the energy spectrum parameters of α-particles generated in the fission of a few nuclei. The results were obtained by the photoemulsion method [17-19].

In conclusion, it should be pointed out that to compare the ternary fission process for different nuclei, it is important to know the probability of the formation of light nuclei in ternary fission as opposed to binary fission. Tables 1-5 show the ratio of their yield to that of the α particles. Data are therefore required on the fission yields of α-particles, and this topic is dealt with in the next section.

α-PARTICLE YIELD FROM TERNARY FISSION

The ratio of the yield of ternary as opposed to binary fission for various fissile nuclei has been measured frequently, but the results for the same nucleus have sometimes diverged by a figure greater than the measurement error.

Authors generally indicate only the statistical measurement errors despite the fact that there are a number of other sources of additional error: for example, (a) no separation of particles according to mass and charge; (b) different methods used for different fissile nuclei; (c) the shape of the α-particle energy spectrum is not well known; (d) uncertainties in allowing for the background in the soft region of the α-particle spectrum.

The α-particle yield from the thermal-neutron-induced fission of ^{233}U, ^{235}U, ^{239}Pu and the spontaneous fission of ^{252}Cf has been measured most frequently. We have selected from the literature available those papers which we consider best satisfy the requirements of accuracy [20-24]. The data are given in Table 10.

The measurement accuracy of the α-particle yield from binary fission depends largely on the method used to extrapolate the α-particle energy spectrum to the energy region below the registration threshold. It is normally assumed that the energy distribution of α-particles from ternary fission is Gaussian. This extrapolation method was used in Ref. [22], for example (Table 10). However, the α-particle spectrum from the spontaneous fission of ^{252}Cf measured in Ref. [25] is asymmetric. Similar α-particle spectra were also obtained in Ref. [20], where the results for the total α-particle yield were obtained by extrapolation (see Table 10).

Table 10 also shows the α-particle yields obtained in Ref. [21] by means of a ΔE-E semiconductor telescope. Possible systematic and non-systematic errors were studied. The data in Table 10 from Ref. [21] regarding the α-particle yield were arrived at by extrapolating the shape of the spectrum from the Gaussian. It seems that this extrapolation method will remain the most suitable until total energy and angular distributions for ternary fission α-particles are obtained.

There are also a large number of measurement results for the yield from ternary fission versus that of binary fission for other fissile nuclei, and at different excitation energies [26-35]. These data are generally less accurate than those in Table 10. None the less, it is worthwhile to try to systematize the results available in order to obtain information regarding the dependence of the ternary fission yield value on various fissile nucleus parameters. Finding this dependence could provide some information on the nature of ternary fission and enable us to predict the yield value of nuclei not yet studied. Several attempts have been made to find this dependence [2, 26-29, 36] and the result of another such attempt is shown in Fig. 7 [24], where the probability of the creation of α-particles in ternary fission is compared with the logarithm of the α-decay half-life of the original nucleus from the ground state.

The main difficulty in systematizing the data lies in assessing the reliability of existing results. The results of Ref. [21] for the yield measurement of α-particles from the thermal neutron fission of ^{233}U, ^{235}U and ^{239}Pu and the spontaneous fission of ^{252}Cf (see Table 10) were used to determine the parameters of the relationship $Y(\text{bin})/Y(\alpha) = F(\lg T_{\frac{1}{2}}\alpha)$ (where $Y(\alpha)$ is the α-particle yield from ternary fission, Y(bin.) is the binary fission yield and $T_{\frac{1}{2}}\alpha$ is the α-decay half-life of the original nucleus from the ground state). This relationship proved to be close to linear:

$$\frac{Y_i(\text{bin.})}{Y_i(\alpha)} = k \lg T_{1/2\alpha_i} + b \quad , \qquad (1)$$

where $k = 40.0 \pm 2.5$ and $b = 15 \pm 31$. The parameters k and b were obtained using the least squares method where $\chi^2 = 0.65$. The values $\lg T_{\frac{1}{2}}\alpha$ were calculated using the polyempirical relation from Ref. [37] and atomic nucleus mass tables [38].

How far does the relationship obtained agree with the data from other papers? The α-particle yield measurement results were taken from Refs [16, 20-22, 26, 30-34] for purposes of comparison (see Table 11). In those papers where ternary fission light nuclei were not divided according to A and Z, the experimental data were taken as equal to the total ternary fission yield value. In the case of nuclei where the ratio of the α-particle yield to that of all light nuclei was not known, the ratio was taken as 0.9.

In a number of papers [26, 31, 35], it was shown that the α-particle yield in induced fission does not depend on the excitation energy of the original nucleus, and the data in Table 11 also show this. The results for each individual compound nucleus were statistically averaged on this basis (see Table 11). With this method, the individual results for several nuclei proved to deviate considerably from the average value and were not therefore taken into account in the averaging process (in all, four points out of 48 were excluded, but not more than one per nucleus). Figure 7 shows the average values obtained for α-particle yields from the fission of various nuclei, together with the data from Ref. [21].

Table 11 also shows the α-particle yield values calculated from relationship (1).

Bearing it in mind that, in addition to statistical error, the α-particle yield measurement results for ternary fission contain a number of other uncertainties [21], we can take it that the assumed empirical dependence (1) is in satisfactory agreement with most of the available data.

Data on the α-particle yield from the thermal neutron ternary fission of $^{242}Am^m$ were obtained from relationship (1) (see Table 10).

To summarize, it proved possible to give the light nucleus yields from the thermal neutron fission of ^{233}U, ^{235}U, ^{239}Pu and $^{242}Am^m$ as well as from the spontaneous fission of ^{252}Cf per fission event (see Table 12). This was done on the basis of the recommendations mentioned above, which were obtained from the data in Tables 1-5 and 10, and also from the evaluations discussed above of the yield values of light nuclei with $Z > 2$ in the spontaneous fission of ^{252}Cf.

YIELD OF NUCLEI HEAVIER THAN ^{20}O FROM TERNARY FISSION

It follows from Tables 2 and 3 that ^{20}O is the heaviest nucleus which can be reliably observed in ternary fission, the yield of these nuclei being $\sim 10^{-7}$ per fission event. However, there are a number of experimental papers [39, 40] in which the light nucleus yield is determined in the mass range 20-60 and $Y \approx 10^{-3}-10^{-6}$. One fact stands out when we examine the results of these measurements: measurement methods which do not identify the charge and mass of the light nuclei give a probability of $10^{-3}-10^{-6}$ for these events, whereas techniques which accurately identify the Z and A parameters of the nucleus give a probability several orders of magnitude lower. One such example is Ref. [41], where a radiochemical analysis of the products of the thermal neutron fission of ^{235}U was carried out in order to determine the Ar isotopes in them. The upper limit for their yield was established as $< 10^{-9}$. The Ne and Ar isotope yield in the same reaction was studied by the mass spectrometry method [42] and here, too, only the upper limits for the occurrence of these nuclei in fission were obtained ($\sim 10^{-6}-10^{-10}$).

Normally, the search for fission products in this mass range is linked with the theory of the existence of true ternary fission. The ternary fission of ^{238}U by He ions at an excitation energy of 20-120 MeV was examined in Ref. [43]. Light fragments from true ternary fission were identified, and it was shown that at excitation energies below 20 MeV the probability of this process drops off sharply. We therefore doubt the existence of this process at low excitation energies (spontaneous fission and thermal neutron fission) and attribute the higher yield for events of this type discovered in some studies to the contribution of recoil nuclei which arise through the collision of fission fragments with light nuclei of the target material.

In Ref. [11] the question of the existence of true ternary fission was studied experimentally using a magnetic mass spectrometry method with time-of-flight and energy determination (MMSTED). The thermal neutron fission of ^{239}Pu was analysed. In the range $Z = 9-26$ and $A = 19-60$, a number of events were registered which made it possible to evaluate only the upper probability limit for the creation of these nuclei in fission. The presence of these events, however, can be explained by the scattering of heavy fragments by the light nuclei of the target material. Table 13 contains data on the yield of various elements created in the thermal neutron ternary fission of ^{235}U and ^{239}Pu.

In this paper, therefore, we have presented the most reliable results known to us for the energy spectra and yield measurements of light nuclei created in the thermal neutron ternary fission of ^{233}U, ^{235}U, ^{239}Pu and $^{242}Am^{m}$ and the spontaneous fission of ^{252}Cf, as well as individual results for the fission of certain other heavy nuclei. A number of characteristic empirical regularities in the energy spectra and yields of light nuclei from ternary fission have been indicated. Evaluations of the yield of light nuclei from fission were made on the basis of these.

In conclusion, the authors should like to express their gratitude to A.A. Vorob'ev for reading the manuscript, and to G.V. Val'skij, V.T. Grachev and N.N. Smirnov for their criticism and useful observations. The authors should also like to thank O.E. Nikiforov, G.N. Sergeev and M.F. Sobolevskaya for their help in carrying out the work.

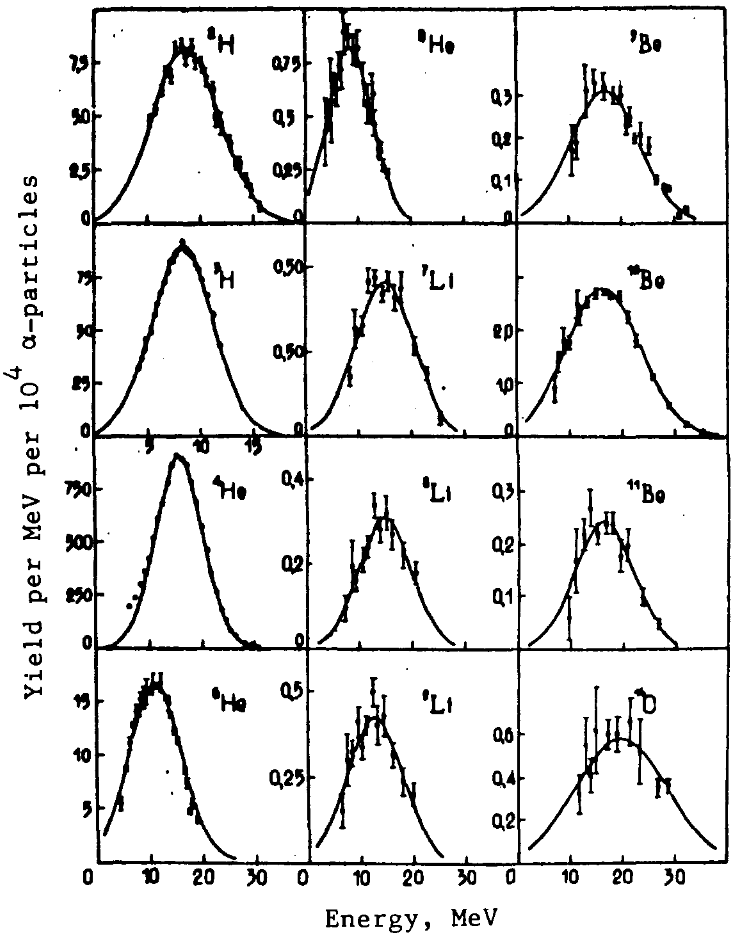

Fig. 1. Energy spectra of light nuclei created in the thermal-neutron fission of ^{239}Pu [11] (MMSTED method). Results are approximated by normal distributions.

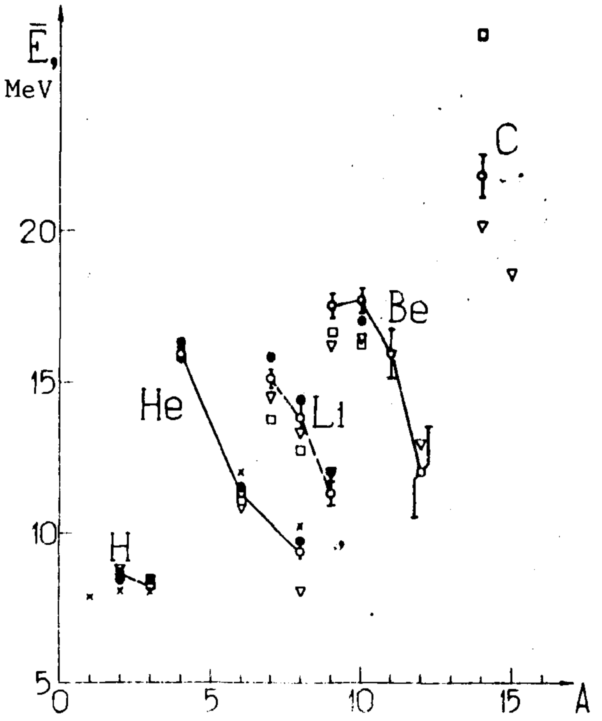

Fig. 2. Dependence of the most probable energies of light nuclei created in the thermal neutron fission of ^{233}U, ^{235}U, ^{239}Pu and ^{242}Am^{m} [4, 8, 11] and the spontaneous fission of ^{252}Cf [12] on their mass number.

Symbols: ● - ^{233}U, o - ^{235}U, ∇ - ^{239}Pu, □ - ^{242}Am^{m}, x - ^{252}Cf; the continuous lines link the isotopes and even Z values; the dashed lines link the isotopes and odd Z values. Measurement errors are given only for ^{235}U.

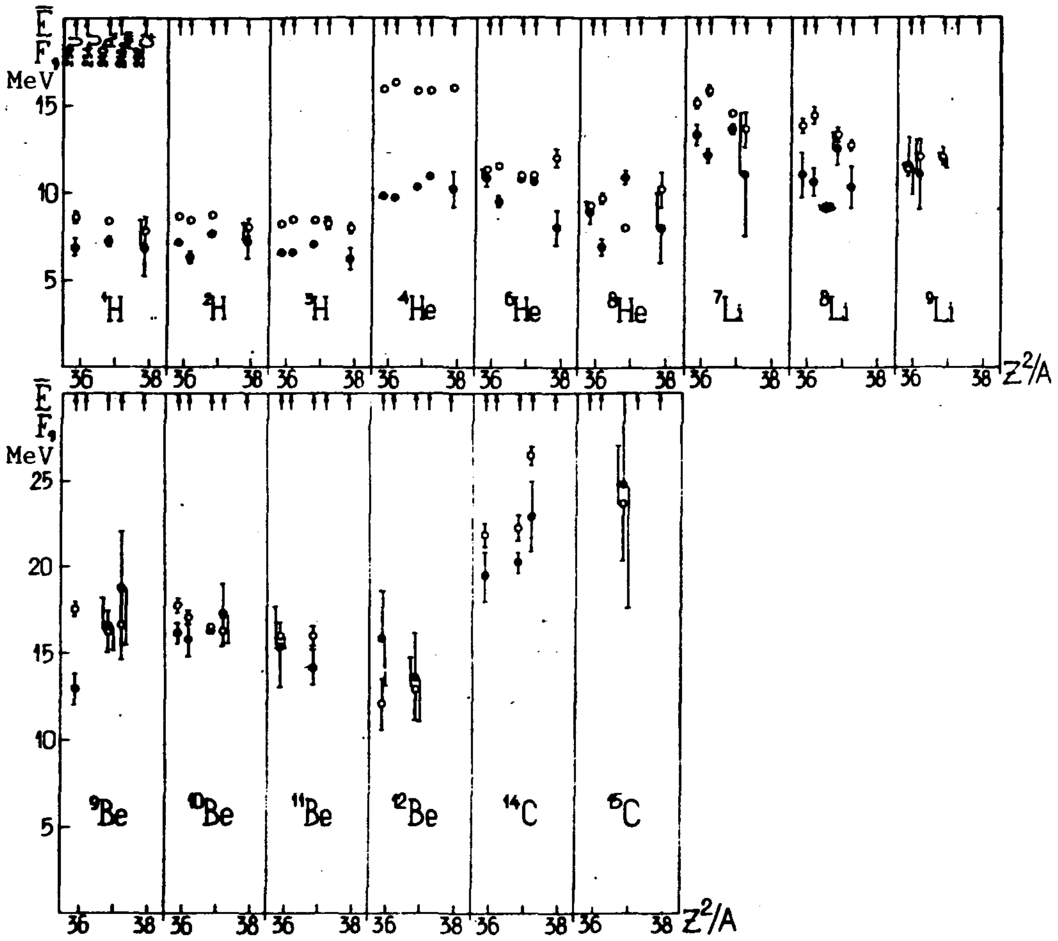

Fig. 3. Energy spectrum parameters of light nuclei (most probable energies - Ē(o) and FWHM-F(●)) created in the thermal-neutron fission of ^{233}U, ^{235}U, ^{239}Pu and ^{242}Am^{m} [4, 5, 8, 9, 11] and in the spontaneous fission of ^{252}Cf [12] as a function of Z^2/A of the fissile nucleus.

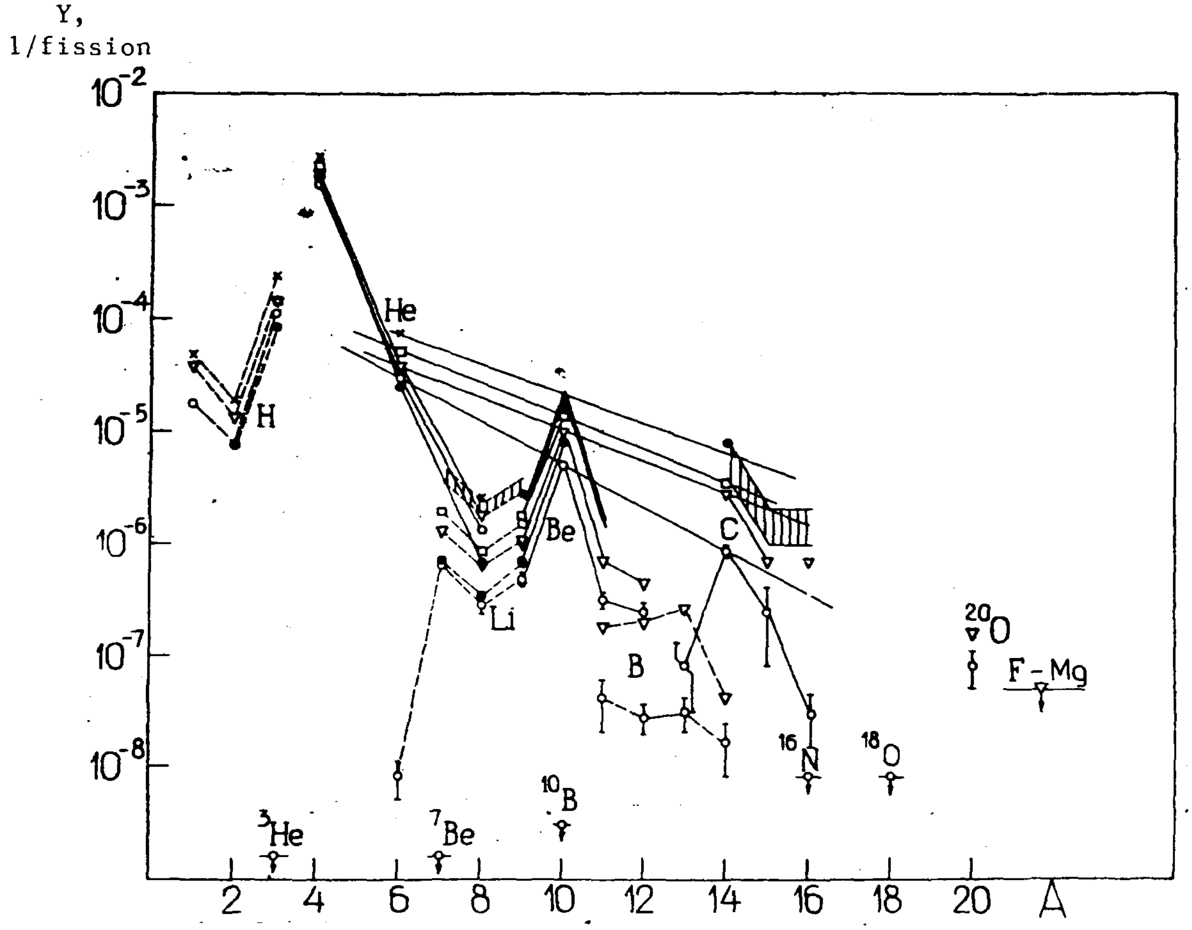

Fig. 4. Dependence of the yields of light nuclei created by the thermal neutron fission of ^{233}U, ^{235}U, ^{239}Pu and ^{242}Am^{m} [4, 8, 11] and spontaneous fission of ^{252}Cf ([12, 15] and results of the present work) on their mass number.

Symbols: ● - ^{233}U, o - ^{235}U, ▽ - ^{239}Pu, □ - ^{242}Am^{m}, x - ^{252}Cf. ◐ is the ^{9}Li, ^{10}Be, ^{14}C yield from the spontaneous fission of ^{252}Cf (from the results of Ref. [15]). The hatching denotes the range of yield values for the Li, Be and C isotopes evaluated in this paper. Measurement errors are given only for ^{235}U.

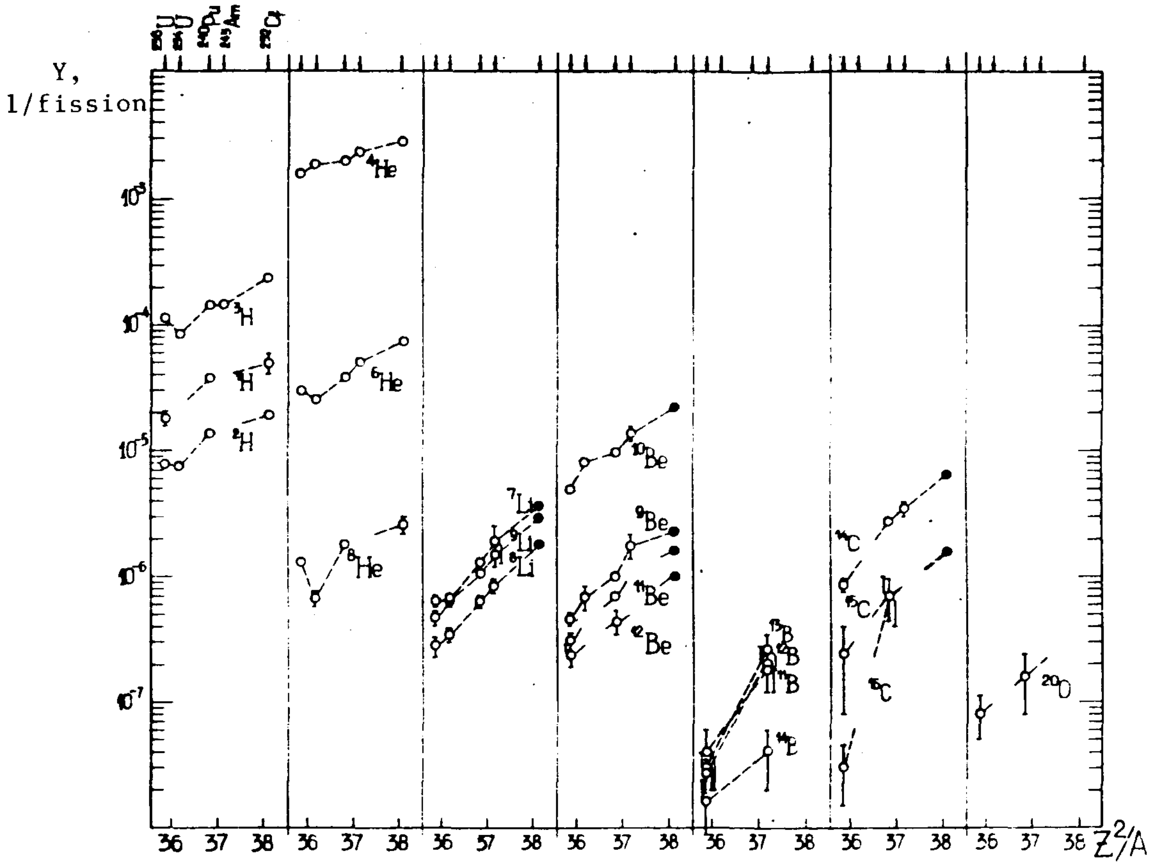

Fig. 5. Yields of light nuclei created by the thermal neutron fission of ^{233}U, ^{235}U, ^{239}Pu, $^{242}Am^m$ [4, 5, 8, 9, 11] and spontaneous fission of ^{252}Cf [12]. The black circles represent the yields of the Li, Be and C isotopes created in the spontaneous fission of ^{252}Cf and evaluated in this paper.

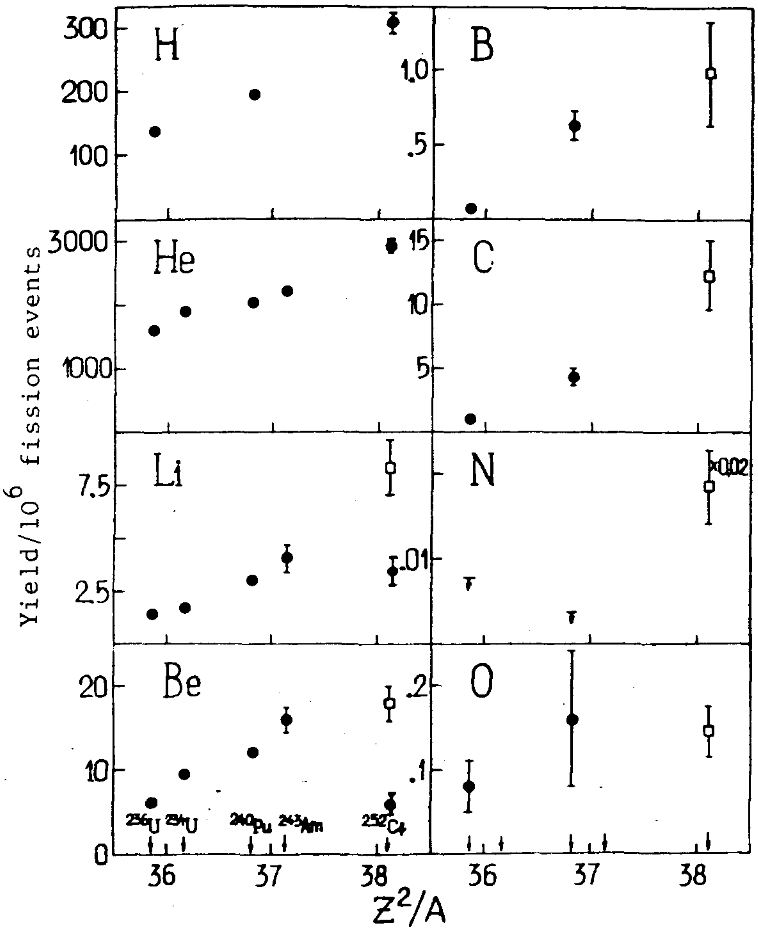

Fig. 6. Yield of various light elements created in the thermal neutron fission of ^{233}U, ^{235}U, ^{239}Pu, $^{242}Am^m$ and spontaneous fission of ^{252}Cf as a function of the Z^2/A parameter of the fissile nucleus.

Symbols: ● - data from Refs [4, 8, 11, 12]; □ - data from Ref. [15].

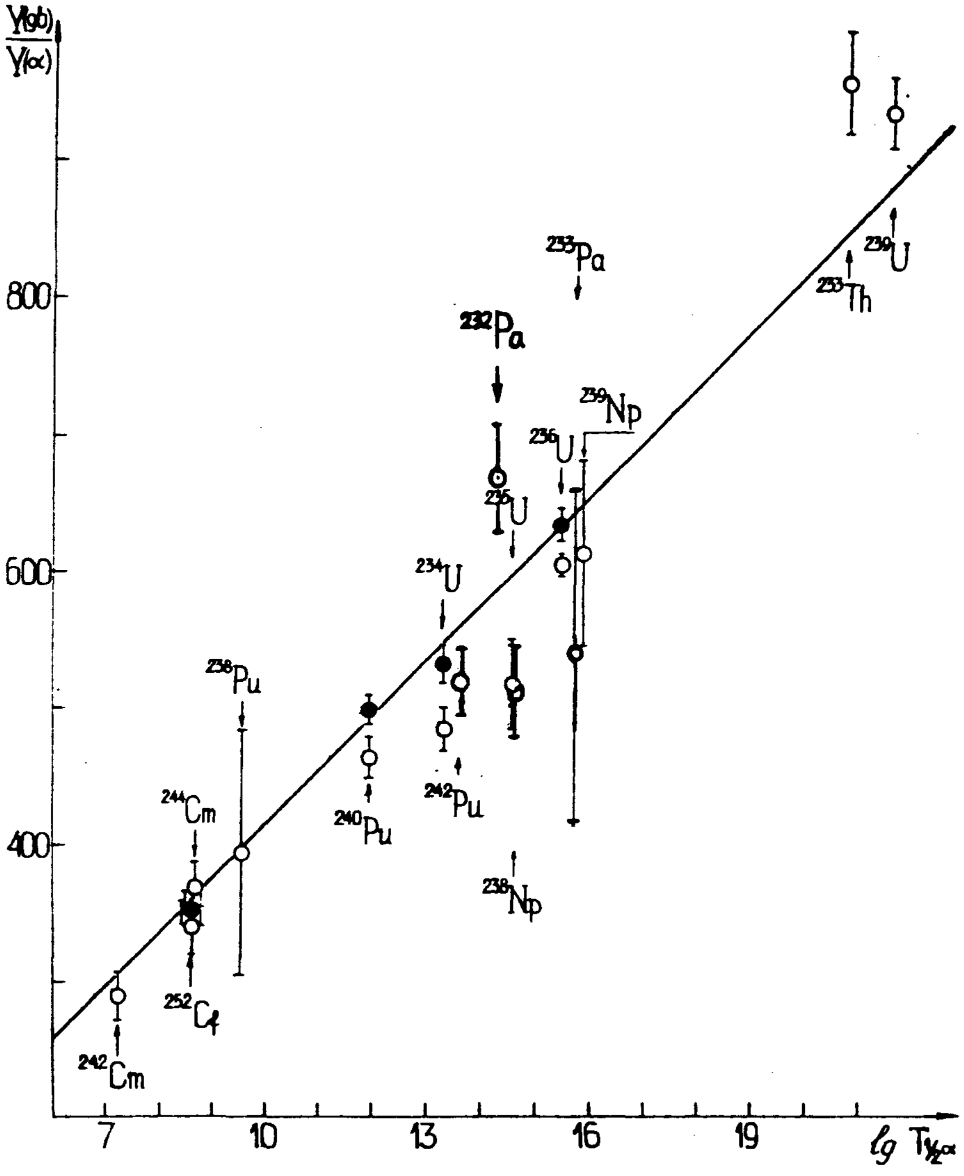

Fig. 7. α-particle yield from the ternary fission of various nuclei as a function of the logarithm of the α-decay half-life of the original (fissile) nucleus from the ground state.

The black circles represent data from Ref. [21], the white ones represent the results averaged over the data from Refs [18, 20, 22, 26, 30-34] (see Table 11). The straight line was calculated using the least squares method to pass through the black circles. The $T_{\frac{1}{2}}$ values are given in seconds. The result for ^{232}Pu is taken from Ref. [24]. The yield for ^{238}Np includes the data from the present work.

Table 1

Energy spectrum and relative yield parameters for light nuclei from the thermal neutron fission of ^{233}U

A_i	$E_{min} - E_{max}$, MeV	$\bar{E}$, MeV	F, MeV	$Y_{\blacktriangle}$ per 10^4 ^{4}He	Y per 10^4 ^{4}He	/n/	Measurement method
^{2}H	5,5÷I5,3	8,4±0,2	6,3±0,3	34,0±I,7	4I±2	/4/	MMSTEГ
^{3}H	4,0÷II,0	8,4±0,2	6,5±0,3	360±I6	460±20	-"-	-"-
^{3}He	I0,0÷34,0	-	-	≤0,I	-	-"-	-"-
^{4}He	3,0÷33,2	I6,3±0,I	9,7±0,2	(I,05±0,02)·10^4	10^4	-"-	-"-
^{6}He	2,7÷18,6	II,5±0,2	9,5±0,3	I43±8	I37±7	-"-	-"-
^{8}He	6,6÷I4,8	9,7±0,3	6,9±0,5	3,3±0,4	3,6±0,4	-"-	-"-
^{6}Li	II,0÷32,0	-	-	≤0,05	-	-"-	-"-
^{7}Li	II,0÷30,4	I5,8±0,3	I2,I±0,4	2,7±0,2	3,7±0,2	-"-	-"-
^{8}Li	II,0÷26,0	I4,4±0,5	I0,6±0,8	I,3±0,2	I,8±0,2	-"-	-"-
^{9}Li	II,8÷22,0	I2,0±I,0	II,0±I,5	I,6±0,3	3,6±0,5	-"-	-"-
^{7}Be	20,0÷44,0	-	-	≤0,0I	-	-"-	-"-
^{9}Be	I7,6÷30,3	-	-	I,9±0,3	3,7±0,8	-"-	-"-
^{10}Be	6,4÷25,6	I7,0±0,4	I5,7±0,9	36,0±2,5	43±3	-"-	-"-
^{11}Be	2I,0÷30,0	-	-	0,3	-	-"-	-"-

Table 2

Energy spectrum and relative yield parameters for light nuclei from the thermal neutron fission of ^{235}U

A_i	E_{min} - E_{max}, MeV	$\bar{E}$, MeV	F, MeV	Y_{Δ} per I0^4 ^{4}He	Y per I0^4 ^{4}He	/n/	Measurement method
^{I}H	4,5÷I7	8,6±0,3	6,9±0,5	-	II5±I5	/5/	ΔE - E
^{2}H	5,5÷I7	7,9±0,3	7,0±I,0	-	50±I0	/5/	ΔE - E
^{2}H	-	8,6±0,I5	7,I±0,2	-	50±2	/8/	MMSTED
^{3}H	6÷I7	8,6±0,3	6,7±0,6	-	620±50	/5/	ΔE - E
-"-	-	8,2±0,I5	6,5±0,2	-	720±30	/8/	MMSTED
^{3}He	-	-	-	≤0,0I	-	/8/	MMSTED
^{4}He	I2÷32	I5,7±0,3	9,8±0,4	-	I0^4	/5/	ΔE - E
-"-	-	I5,9±0,I	9,8±0,I	-	I0^4	/8/	MMSTED
^{6}He	I2,8÷30	I2,9±0,5$^{*)}$	8,7±0,7$^{*)}$	-	II0±20$^{*)}$	/5/	ΔE - E
^{6}He	-	II,3±0,I5	I0,8±0,4	-	I9I±8	/8/	MMSTED
^{8}He	-	9,3±0,25	8,9±0,6	-	8,2±0,6	/8/	MMSTED
^{6}Li	-	-	-	0,05±0,02	-	/8/	MMSTED
^{7}Li	-	I5,I±0,3	I3,3±0,6	-	4,I±0,3	/8/	MMSTED
^{8}Li	-	I3,8±0,4	II,0±I,3	-	I,8±0,3	/8/	MMSTED
^{9}Li	-	II,3±0,4	II,5±I,6	-	3,0±0,4	/8/	MMSTED
Li	-	-	-	-	9,0±0,6	/8/	MMSTED
Li	>II,0	-	-	6,3±0,4	9,05	/6/	ΔE - E
Li	>II,5	-	-	-	I2±2	/7/	ΔE - E
^{7}Be	-	-	-	0,0I	-	/8/	MMSTED
^{8}Be	> I5	-	-	2,4±I,0	4,8	/6/	ΔE - E
^{9}Be	-	I7,5±0,4	I2,9±0,9	-	2,9±0,3	/8/	MMSTED
^{I0}Be	-	I7,7±0,4	I6,I±0,6	-	32±2	/8/	MMSTED
^{II}Be	-	I5,9±0,8	I5,3±2,3	-	2±0,3	/8/	MMSTED
^{I2}Be	-	I2,0±I,5	I5,8±2,7		I,5±0,3	/8/	MMSTED

Table 2 (continued)

A_i	$E_{min} - E_{max}$ MeV	$\bar{E}$, MeV	F, MeV	Y_Δ per $I0^4$ ^{4}He	Y per $I0^4$ ^{4}He	/n/	Measurement method
Be	-	-	-	-	38,0±2,0	/8/	MMSTED
Be	> I5	-	-	I9,7±I,0	32,4	/6/	$\Delta E - E$
Be	>I7,I	-	-	-	37±4	/7/	$\Delta E - E$
^{I0}B	-	-	-	< 0,02	-	/8/	MMSTED
^{II}B	-	-	-	-	0,25±0,I	/8/	MMSTED
^{I2}B	-	-	-	-	0,I7±0,05	/8/	MMSTED
^{I3}B	-	-	-	-	0,2±0,06	/8/	MMSTED
^{I4}B	-	-	-	-	0,I±0,05	/8/	MMSTED
B	-	-	-	-	0,70±0,I4	/8/	MMSTED
B	> 20	-	-	0,48±0,I0	0,95	/6/	$\Delta E - E$
^{I3}C	-	-	-	-	0,5±0,3	/8/	MMSTED
^{I4}C	-	2I,8±0,7	I9,4±I,4	-	5,4±0,6	/8/	MMSTED
^{I5}C	-	-	-	-	I,5±I,0	/8/	MMSTED
^{I6}C	-	-	-	-	0,2±0,I	/8/	MMSTED
C	-	-	-	-	7,6±I,2	/8/	MMSTED
C	> 29	-	-	9,I±0,5	47,6	/6/	$\Delta E - E$
^{I6}N	-	-	-	≤ 0,05	-	/8/	MMSTED
N	> 33	-	-	0,42±0,I0	2,4	/6/	$\Delta E - E$
^{I8}O	-	-	-	≤ 0,05	-	/8/	MMSTED
^{20}O	-	-	-	-	0,5±0,2	/8/	MMSTED
O	>40	-	-	2,9±0,6	47,6	/6/	$\Delta E - E$
F	> 47	-	-	0,I0+0,03	~23,8	/6/	$\Delta E - E$

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* The authors found in subsequent measurements that these data were inaccurate[9].

Table 3

Energy spectrum and relative yield parameters for light nuclei from the thermal neutron fission of ^{239}Pu

A_i	E_{min}- E_{max}, MeV	$\bar{E}$, MeV	F, MeV	Y_{Δ} per I0^4 ^{4}He	Y per I0^4 ^{4}He	/n/	Measurement method
^{I}H	4÷I8	8,4±0,I5	7,2±0,3	-	I90±I0	/9/	ΔE - E
^{2}H	4,5÷I9	8,2±0,3	7,2±0,5	-	50±I0	/9/	ΔE - E
^{2}H	-	8,7±0,I	7,6±0,2	-	69±2	/II/	MMSTED
^{3}H	5,5÷20	8,2±0,I5	7,6±0,4	-	680±30	/9/	ΔE - E
^{3}H	-	8,4±0,I	7,0±0,I5	-	720±30	/II/	MMSTED
^{3}He	-	-	-	≤ 0,0I	-	/II/	MMSTED
^{4}He	I0÷29	I6±0,I	I0,6±0,2	-	I0^4	/9/	ΔE - E
^{4}He	-	I5,8±0,I	I0,3±0,I5	-	I0^4	/II/	MMSTED
^{6}He	II÷28	II,8±0,4	I0,6±0,6	-	I90±20	/9/	ΔE - E
^{6}He	-	I0,8±0,I5	I0,9±0,2	-	I92±5	/II/	MMSTED
^{6}He	> 8,5	-	-	I75±2I	250	/I0/	ΔE - E
^{8}He	I2÷23	< I2	>9	-	8±2	/9/	ΔE - E
^{8}He	-	8,0±0,2	I0,9±0,4	-	8,8±0,4	/II/	MMSTED
^{6}Li	-	-	-	≤ 0,05	-	/II/	MMSTED
^{7}Li	-	I4,5±0,2	I3,6±0,3	-	6,5±0,2	/II/	MMSTED
^{8}Li	-	I3,3±0,4	I2,5±0,9	-	3,2±0,3	/II/	MMSTED
^{9}Li	-	I2,0±0,3	I2,0±0,6	-	5,3±0,3	/II/	MMSTED
Li	-	-	-	-	I5±0,5	/II/	MMSTED
Li	I5	-	-	7,3±0,2	I5	/I0/	ΔE - E
^{7}Be	-	-	-	≤ 0,0I	-	/II/	MMSTED
^{9}Be	-	I6,2±I,2	I6,6±I,5	-	5,I±0,6	/II/	MMSTED
^{I0}Be	-	I6,4±0,2	I6,3±0,3	-	49±I	/II/	MMSTED
^{II}Be	-	I5,9±0,6	I4,I±I,0	-	3,5±0,3	/II/	MMSTED
^{I2}Be	-	I2,9±I,8	I3,6±2,5	-	2,2±0,5	/II/	MMSTED

Table 3 (continued)

A_i	E_{min} - E_{max} MeV	$\bar{E}$, MeV	F, MeV	Y_Δ per $I0^4$ ^{4}He	Y per $I0^4$ ^{4}He	/n/	Measurement method
^{I3}B	-	-	-	-	I,3±0,4	/II/	M M S T E D
^{I4}B	-	-	-	-	0,2±0,I	/II/	M M S T E D
B	-	-	-	-	3,4±0,7	/II/	M M S T E D
B	> 28	-	-	0,52±0,04	3,3	/I0/	ΔE - E
^{I3}C	-	-	-	≤I,0	-	/II/	M M S T E D
^{I4}C	-	20,2±0,6	22,2±0,7	-	I4±0,6	/II/	M M S T E D
^{I5}C	-	I8,6±3,3	I9,7±7,I	-	3,5±I,3	/II/	M M S T E D
^{I6}C	-	-	-	-	3,5±I,6	/II/	M M S T E D
C	-	-	-	-	2I,0±2,I	/II/	M M S T E D
C	> 36	-	-	2,7±0,I	50	/I0/	ΔE - E
^{I6}N	-	-	-	≤ 0,02	-	/II/	M M S T E D
^{20}O	-	-	-	-	0,8±0,4	/II/	M M S T E D

Table 4

Energy spectrum and relative yield parameters for light nuclei from the thermal neutron fission of ^{242}Am^m

A_i	E_{min} - E_{max} MeV	$\bar{E}$, Mev	F, MeV	Y_Δ per $I0^4$ ^{4}He	Y per $I0^4$ ^{4}He	/n/	Measurement method
^{3}H	-	8,2±0,3	8,2±0,8	-	620±60	/II/	M M S T E D
^{4}He	-	I5,8±0,I	I0,9±0,2	-	$I0^4$	/II/	M M S T E D
^{6}He	-	II,0±0,I5	I0,6±0,2	-	2I4±6	/II/	M M S T E D
^{7}Li	-	I3,7±I,0	II,0±3,5	-	8,2±2,6	/II/	M M S T E D
^{8}Li	-	I2,7±0,3	I0,3±I,2	-	3,6±0,4	/II/	M M S T E D
^{9}Li	-	-	-	-	6,4±I,3	/II/	M M S T E D
^{9}Be	-	I6,6±2,0	I8,7±3,2	-	7,5±I,5	/II/	M M S T E D
^{I0}Be	-	I6,2±0,9	I7,2±I,7	-	57±6	/II/	M M S T E D
^{I4}C	-	26,4±0,5	22,9±2,0	-	I4,5±I,5	/II/	M M S T E D

Table 5

Energy spectrum and relative yield parameters for light nuclei from the spontaneous fission of ^{252}Cf

A_i	$E_{min} - E_{max}$, MeV	$\bar{E}$, MeV	F, MeV	Y_A per I0^{4} ^{4}He	Y per I0^{4} ^{4}He	/n /
^{I}H	7,3÷I8,8	7,8±0,8	6,8±I,6	II0±I5	I75±30	/I2/
^{I}H	3,3÷I2	-	-	I44±I6	I59$^{*)}$	/I3/
^{I}H		7,8±0,2	6,I±0,3	-	I60±I0	/I4/
^{2}H	5,3÷2I,5	8,0±0,5	7,2±I,0	63±3	68±3	/I2/
^{2}H	4,2÷I8			47±6	53$^{*)}$	/I3/
^{3}H	6,5÷24,3	8,0±0,3	6,2±0,6	642±20	846±28	/I2/
^{3}H	5,0÷24			6I9±3I	7I0$^{*)}$	/I3/
^{3}He	I4,2÷2I,3	-	-	≤ 7,5	-	/I2/
^{4}He	8,3÷37,7	I6,0±0,2	I0,2±0,4	-	I0^{4}	/I2/
^{4}He	7,I÷4I			(0,947±0,03)I0^{4}		/I3/
^{6}He	I0,0÷33,3	I2,0±0,5	8,0±I,0	I95±I5	263±I8	/I2/
^{6}He	I4,6÷43			9I±6	409$^{*)}$	/I3/
^{8}He	9,3÷27,7	I0,2±I,0	8,0±2,0	6,2±0,8	9,0±I,2	/I2/
^{8}He	9,6÷46			5,9±0,9	I0,5$^{*)}$	/I3/
^{6}Li	24,0÷33,2	-	-	0,II±0,05		/I2/
^{7}Li	25,4÷38,3	-	-	0,8I±0,I2		/I2/
^{8}Li	26,8÷37,5	-	-	0,I5±0,06		/I2/
^{9}Li	28,I÷37,I	-	-	0,09-0,04		/I2/
Li	I5,2÷37,3	20,0±I,0	6,6±2,0	I2,6±I,5	I3,2±I,6	/I2/
Li	I5,7÷65			II,6±0,6		/I3/
Li	> I3	I8,5±I,0	-	-	29±5	/I5/
^{9}Be	39,3÷43,9	-	-	~ 0,02		/I2/
^{I0}Be	4I,0÷45,6	-	-	~ 0,04		/I2/

Table 5 (continued)

A_i	E_{min} - E_{max}, MeV	$\bar{E}$, MeV	Γ, MeV	Y_A per 10^4 ^4He	Y per 10^4 ^4He	/n/
Be	23,0÷49,I	~26	~II	I5,6±I,6	20,I±2,0	/I2/
Be	24,I÷73			I5,0±0,6		/I3/
Be	20,5÷70			28,4±0,9		/I3/
Be	> I3	I9,2±I	-	-	65±7	/I5/
B	3I,0÷75	~I9$^{*)}$	~I9$^{*)}$	0,28±0,I3	~ 4,0$^{*)}$	/I3/
B	25,3÷72			≤ 2,2	-	/I3/
B	>I6	-	-	-	3,5±I	/I5/
C	40,5÷78	-	-	0,4I±0,I3		/I3/
C	33,2÷75			4,4±0,6		/I3/
C	> I8	23±2	-	-	43±9	/I5/
	>22	-	-	6,6±I,5		/I5/
O	>27	-	-	0,5-0,I		/I5/

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*/ Value obtained in this paper (see text).

TABLE 6

Example of calculation of range of extrapolated ^{7}Li, ^{8}Li, ^{9}Li yield values (Y_{min},Y_{max}) from the spontaneous fission of ^{252}Cf, according to the data in Refs [4, 8, 11, 12, 15]*

			^{7}Li	^{8}Li	^{9}Li
Results of Refs. [4, 8, 11]	(for Y_{min})	MeV	15.8	14.4	12.0
		MeV	11.0	10.3	11.0
	(for Y_{max})	MeV	13.7	12.7	11.3
		MeV	12.1	12.5	12.0
	for isotope yield		2.03	1	1.66
Results of Ref. [12]	Measured energy range, MeV	E_{min}	15.2	15.2	15.2
		E_{max}	37.3	37.3	37.3
	Total yield (Y[illegible])		12.6		
Results of the present work	Part of measured spectrum for Y_{min}		0.551	0.428	0.247
	Part of measured spectrum for Y_{max}		0.385	0.320	0.223
	Y_{min}		13.1	6.4	10.7
	Y_{max}		17.4	8.6	14.2
	Y from [15]		12.6	6.2	10.3
	Total yield	Y_{min}	30.2		
		Y_{max}	40.2		
	Total yield from [15]		29.1 ± 5		

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* The Li yield of nuclei is given per 10^{4} ^{4}He nuclei.

Table 6A: Range of values for extrapolated ^{7}Li, ^{8}Li, ^{9}Li yields (Y_{min}, Y_{max}) from the spontaneous fission of ^{252}Cf, based on data from Refs [4, 8, 11-13, 15]*/

Isotope	^{7}Li		^{8}Li		^{9}Li	
[n]	[12]	[13]	[12]	[13]	[12]	[13]
Y_{min}	13.1	13.3	6.4	6.6	10.7	10.9
Y_{max}	17.4	17.9	8.6	8.8	14.2	14.6
$\langle Y_{min} \rangle_{av.}$	13.2		6.5		10.8	
$\langle Y_{max} \rangle_{av.}$	17.7		8.7		14.4	
Y from Ref. [15]	12.6		6.2		10.3	
Total $\langle Y_{min} \rangle_{av.}$ yield $\langle Y_{max} \rangle_{av.}$	30.5 40.7					
Total yield from Ref. [15]	29.1 ± 5					

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*/ The yield of Be nuclei is given per 10^{4} ^{4}He nuclei.

Table 7: Range of values for extrapolated ^{9}Be, ^{10}Be, ^{11}Be, ^{12}Be yields (Y_{min}, Y_{max}) from the spontaneous fission of ^{252}Cf, based on data from Refs [4, 8, 11-13, 15]*/

Isotope	^{9}Be	^{10}Be	^{11}Be	^{12}Be
[n]	[12][13][13]	[12][13][13]	[12][13][13]	[12][13][13]
Y_{min}	6.6 8.1 7.5	65 80 73	4.7 5.7 5.3	2.9 3.6 3.3
Y_{max}	7.6 9.2 8.8	75 91 86	5.4 6.5 6.2	3.4 4.1 3.9
$\langle Y_{min} \rangle_{av.}$	7.4	73	5.2	3.3
$\langle Y_{max} \rangle_{av.}$	8.5	84	6.0	3.8
Y from Ref. [15]	5.4	53.3	3.8	2.4
Total $\langle Y_{min} \rangle_{av.}$ yield $\langle Y_{min} \rangle_{av.}$		88.9 102.4		
Total yield from Ref. [15]		65 ± 7		

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*/ The yield of Be nuclei is given per 10^4 ^{4}He nuclei.

Table 8: Range of values for extrapolated ^{14}C, ^{15}C, ^{16}C yields (Y_{min}, Y_{max}) from the spontaneous fission of ^{252}Cf, based on data from Refs [4, 8, 11-13, 15]*/

Isotope	^{14}C		^{15}C		^{16}C	
[n]	[13]	[13]	[13]	[13]	[13]	[13]
Y_{min}	8.9	19.5	2.2	4.9	2.2	4.9
Y_{max}	19.7	39.5	4.9	9.9	4.9	9.9
$\langle Y_{min} \rangle_{av.}$	14.2		3.6		3.6	
$\langle Y_{max} \rangle_{av.}$	29.6		7.4		7.4	
Y from Ref. [15]	28.7		7.2		7.2	
Total $\langle Y_{min} \rangle_{av.}$	21.4					
yield $\langle Y_{max} \rangle_{av.}$	44.4					
Total yield from Ref. [15]	43 ± 9					

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*/ Yield of C nuclei is calculated per 10^4 ^4He nuclei.

Table 9

Energy spectrum parameters of α-particles created in the thermal neutron fission of ^{241}Pu and ^{241}Am and the spontaneous fission of ^{242}Cm and ^{244}Cm.

Compound nucleus	Reaction	$\bar{E}$, MeV	E, MeV	/n/	Measurement method
^{242}Pu	$^{241}Pu + n$ (thermal)	15,0 ± 0,6	8,3 ± 0,5	/17/	Photoemulsion
^{242}Am	$^{241}Am + n$ (thermal)	15,8 ± 1,2	11,2 ± 0,9	/17/	Photoemulsion
^{242}Cm	Spontaneous fission	15,5	13,0	/18/	Photoemulsion
^{244}Cm	Spontaneous fission	15,5 ± 0,5	11,5 ± 0,5	/19/	Photoemulsion

Table 10

Total yield of light nuclei from ternary fission ($\Sigma Y(Ai)$) and yield of ^{4}He nuclei ($Y(\alpha)$) relative to binary fission (Y(bin.)) in the thermal neutron fission of ^{233}U, ^{235}U, ^{239}Pu, ^{242}Am^m and the spontaneous fission of ^{252}Cf.

Fissile nucleus	$\frac{Y(\text{bin.})}{\Sigma Y(A_i)}$	$\frac{Y(\text{bin.})}{Y(\alpha)}$	$\frac{Y(\alpha)\ 10^6}{Y(\text{bin.})}$	/n/	Measurement method
^{234}U*	414 ± 26	-	-	/20/	Ionization chamber
^{234}U*	494 ± 13	533 ± 14	1880 ± 50	/21/	ΔE-E semi-conductor telescope
^{234}U*	460 ± 20	485 ± 20	-	/22/	Semiconductor E-detector
^{236}U*	499 + 30	-	-	/20/	Ionization chamber
^{236}U*	-	-	1450 ± 50*)	/23/	ΔE-E telescope and ionization chamber
^{236}U*	570 ± 11	635 ± 12	1570 ± 30	/21/	ΔE-E semiconductor telescope
^{236}U*	530 ± 20	615 ± 20	-	/22/	Semiconductor E-detector
^{240}Pu*	411 ± 26	-	-	/20/	Ionization chamber
^{240}Pu*	443 ± 9	499 ± 10	2000 ± 40	/21/	ΔE-E semiconductor telescope
^{240}Pu*	420 ± 20	475 ± 20	-	/22/	Semiconductor E-detector
^{252}Cf	299 ± 18	-	-	/20/	Ionization chamber
^{252}Cf	310 ± 11	352 ± 13	2840 ± 100	/21/	ΔE-E semiconductor telescope
^{243}Am*	-	453 ± 7	2210 ± 33	/24/	Extrapolation

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*/ In Ref. [23], the ^{4}He nuclei yield is determined for energies greater than 6.3 MeV.

Table 11

Total light nucleus yield and α-particle yield from the ternary fission of heavy nuclei at various excitation energies

Compound nucleus	Reaction	E_{min}, MeV	E^{*}, MeV	$\frac{Y\,(\text{bin.})}{Y\,(\text{ter.})}$	$\frac{Y(\alpha)}{Y\,(\text{ter.})}$	$\frac{Y\,(\text{bin.})}{Y\,(\alpha)}$	$\lg T_{1/2\,\alpha}$	/n/	$\left\langle\frac{Y\,(\text{bin.})}{Y(\alpha)}\right\rangle_{av}$	$\left(\frac{Y\,(\text{bin.})}{Y(\alpha)}\right)_{extr.}$
^{233}Th	^{232}Th + n (2,5 MeV)	2,4	7,4	883 ± 37$^{*)}$	0,9	98I ± 4I	20,76	/30/	957 ± 37	847 ± 22
-"-	^{232}Th ± n (I4 MeV)	-"-	I8,8	775 ± 73$^{*)}$	-"-	86I ± 8I	-"-	/30/	-"-	-"-
^{233}Pa	^{232}Th + p (I0,5 MeV)	II	I5,5	465 ± 247	0,9	529 ± 131	I5,7	/3I/	529 ± 131	644 ± I0
^{234}U	^{233}U + n (thermal)	6	6,5	4I4 ± 26	0,926	447 ± 28	I3,28	/20/	5I2 ± II	547 ± 6
-"-	-"- -"- -"-	2,4	-"-	303 ± I2$^{*)}$	-"-	327 ± I3$^{**)}$	-"-	/30/	-	-"- -"-
-"-	-"- -"- -"-	II,0	-"-	-	-"-	600 ± 78	-"-	/26/	5I2 ± II	-"- -"-
-"-	-"- -"- -"-	6,9	-"-	494 ± I3	-"-	533 ± I4	-"-	/2I/	-"-	-"- -"-
-"-	-"- -"- -"-	I2,5	-"-	460 ± 20	-"-	497 + 22	-"-	/22/	-"-	-"- -"-
-"-	^{233}U + n (I4 MeV)	II,0	20,4	-	-"-	485 ± 60	-"-	/26/	-"-	-"- -"-
^{235}U	^{234}U + n (I MeV)	6	6,3	466 ± 30	0,9	5I8 ± 33	I4,54	/20/	5I8 ± 33	598 ± 8
^{236}U	^{235}U + n (thermal)	6	6,5	499 ± 30	0,898	556 ± 33	I5,45	/20/	606 ± 8	634 ± I0
-"-	-"- -"- -"-	2,4	-"-	570 ± II$^{*)}$	-"-	635 ± I2	-"-	/30/	-"-	-"- -"-
-"-	-"- -"- -"-	II,0	-"-	-	-"-	582 ± 53	-"-	/26/	-"-	-"- -"-
-"-	-"- -"- -"-	6,9	-"-	570 ± II	-"-	635 ± I2	-"-	/2I/	-"-	-"- -"-
-"-	-"- -"- -"-	I2,5	-"-	530 ± 20	-"-	590 ± 22	-"-	/22/	-"-	-"- -"-

(Table 11 continued)

Compound nucleus	Reaction	E_{min}, MeV	E^*, MeV	$\frac{Y(\text{bin.})}{Y(\text{ter.})}$	$\frac{Y(\alpha)}{Y(\text{ter.})}$	$\frac{Y(\text{bin.})}{Y(\alpha)}$	$\lg T_{1/2\alpha}$	/n/	$\left\langle\frac{Y(\text{bin.})}{Y(\alpha)}\right\rangle_{av}$	$\left(\frac{Y(\text{bin.})}{Y(\alpha)}\right)_{extr.}$
^{236}U	^{235}U + n (I MeV)	6	7,5	534 ± 35	-"-	595 ± 39	-"-	/20/	606 ± 8	634 ± I0
-"-	^{235}U + n (2,5 MeV)	2,4	8,9	53I ± I5*)	-"-	59I ± I7	-"-	/30/	-"-	-"- -"-
-"-	^{235}U + n (I4 MeV)	2,4	20,4	5I0 ± 26*)	-"-	568 ± 29	-"-	/30/	-"-	-"- -"-
-"-	^{235}U + n (I4 MeV)	II,0	20,4	-	-"-	588 ± 48	-"-	/26/	-"-	-"- -"-
-"-	^{232}Th + α (42 MeV)	II,0	36,8	5I6 ± 58	-"-	587 ± 66	-"-	/3I/	-"-	-"- -"-
^{239}U	^{238}U + n (2,5 MeV)	2,4	7,3	8I9 ± 27*)	0,9	9I0 ± 30	2I,56	/30/	934 ± 26	879 ± 24
-"-	-"- -"- -"-	-	-"-	835 ± I00	-"-	928 ± III	-"-	/32/	-"-	-"- -"-
-"-	^{238}U + n (7,6 MeV)	-	I2,4	875 ± I00	-"-	972 ± III	-"-	/32/	-"-	-"- -"-
-"-	^{238}U + n (I4 MeV)	-	I8,8	I050 ± I00	-"-	I167 ± III	-"-	/33/	-"-	-"- -"-
-"-	-"- -"- -"-	2,4	-"-	590 ± 29*)	-"-	656 ± 32**)	-"-	/30/	-	-"- -"-
-"-	-"- -"- -"-	II,0	-"-	-	-	909 ± II8	-"-	/26/	934 ± 26	-"- -"-
^{239}U	^{238}U + n (I9 MeV)	-	23,8	900 ± I00	0,9	I000 ± III	-"-	/32/	-"-	-"- -"-
^{238}Np	^{237}Np + n (I4 MeV)	II,0		-	-	448 ± 53	I4,59	/26/	448 ± 53	600 ± 8
^{239}Np	^{238}U + p (I0,5 MeV)	II,0	I5,4	553 ± 33	0,9	629 ± 38	I5,85	/3I/	629 ± 38	650 ± II
^{238}Pu	Spontaneous fission	I3,0	0	355 ± 80	0,9	394 ± 89	9,53	/34/	394 ± 89	397 ± 9
^{240}Pu	Spontaneous fission	6	0	3I4 ± 20	0,888	354 ± 23**)	II,9	/20/	-	492 ± 6
-"-	-"-	I3	0	400 ± 60	-"-	450 ± 68	-"-	/18/	488 ± 8	-"- -"-

(Table 11 continued)

Compound nucleus	Reaction	E_{min}, MeV	E^*, MeV	$\frac{Y(\text{bin.})}{Y(\text{ter.})}$	$\frac{Y(\alpha)}{Y(\text{ter.})}$	$\frac{Y(\text{bin.})}{Y(\alpha)}$	$\lg T_{1/2\alpha}$	/n/	$\left\langle\frac{Y(\text{bin.})}{Y(\alpha)}\right\rangle_{av}$	$\left(\frac{Y(\text{bin.})}{Y(\alpha)}\right)_{extr}$
^{240}Pu	^{239}Pu + n (thermal)	6	6,6	4II ± 26	-"-	463 ± 29	II,9	/20/	488 ± 8	492 ± 6
-"-	-"- -"- -"-	6,9	-"-	443 ± 9	-"-	499 ± I0	-"-	/2I/	-"-	-"- -"-
-"-	-"- -"- -"-	I2,5	-"-	420 ± 20	-"-	473 ± 23	-"-	/22/	-"-	-"- -"-
-"-	^{239}Pu + n (I MeV)	6	7,6	403 ± 25	-"-	454 ± 28	-"-	/20/	-"-	-"- -"-
^{242}Pu	Spontaneous fission	6	0	365 ± 29	0,9	406 ± 32**)	I3,57	/20/	-	559 ± 7
-"-	^{241}Pu + n (thermal)	6	6,2	440 ± 28	-"-	489 ± 3I	-"-	/20/	514 ± 25	-"- -"-
-"-	^{238}U + α (29 MeV)	II	24	5I6 ± I00	-"-	587 ± II4	-"-	/3I/	-"-	-"- -"-
-"-	^{238}U + α (35,5 MeV)	-"-	30,5	470 ± 66	-"-	535 ± 75	-"-	/3I/	-"-	-"- -"-
-"-	^{238}U + α (42 MeV)	-"-	37	498 ± 50	-"-	567 ± 57	-"-	/3I/	-"-	-"- -"-
^{242}Cm	Spontaneous fission	6	0	257 ± I7	0,9	286 ± I9	7,23	/20/	289 ± I8	305 ± I4
-"-	-"- -"- -"-	I3	0	280 ± 50	-"-	3II ± 56	-"-	/I8/	-"-	-"- -"-
^{244}Cm	Spontaneous fission	6	0	3I4 ± 20	0,9	349 ± 22	8,64	/20/	364 ± I9	36I ± II
-"-	-"- -"- -"-	II	0	-	-	4I6 ± 4I	-"-	/26/	-"-	-"- -"-
^{252}Cf	Spontaneous fission	6	0	299 ± I8	0,879	340 ± 20	8,48	/20/	349 ± II	355 ± II
-"-	-"- -"- -"-	8	0	3I0 + II	-"-	353 + I3	-"-	/2I/	-"-	-"- -"-

*) The data in Ref. [30] are normalized to the value of the α-particles yield from the thermal neutron fission of ^{235}U obtained in Ref. [21].

**) This result was not taken into account when averaging the values Y(bin.)/Y(α) over the data for the same compound nucleus.

Table 12

Yields of light nuclei from the thermal-neutron fission of ^{233}U, ^{235}U, ^{239}Pu, ^{242}Am^{m} [4, 5, 8, 9, 11] and the spontaneous fission of ^{252}Cf [12, 14] (yield per 10^{6} fissions)*

A_i	^{234}U*	^{236}U*	^{240}Pu*	^{243}Am*	^{252}Cf
^{I}H	-	I8,I ± 2,4	38 ± 2	-	49,7 ± 8,7
^{2}H	7,7 ± 0,4	7,9 ± 0,4	I3,8 ± 0,5	-	I9,3 ± I,I
^{3}H	87 ± 4,3	II3 ± 5	I44 ± 7	I37 ± I3	240 ± I2
^{3}He	-	$\leqslant$0,00I6	$\leqslant$0,002	-	-
^{4}He	I880 ± 50	I570 ± 30	2000 ± 40	22I0 ± 33	2840 ± I00
^{6}He	25,7 ± I,5	30,0 ± I,4	38,4 ± I,3	47,3 ± I,5	75 ± 6
^{8}He	0,67 ± 0,08	I,3 ± 0,I	I,8 ± 0,I	-	2,6 ± 0,4
^{6}Li	-	0,008 + 0,003	$\leqslant$0,0I	-	-
^{7}Li	0,69 ± 0,04	0,64 ± 0,05	I,3 ± 0,05	I,8I ± 0,57	$3,7^{**)}$
^{8}Li	0,34 ± 0,04	0,28 ± 0,05	0,64 ± 0,06	0,80 ± 0,09	$I,8^{**)}$
^{9}Li	0,67 ± 0,09	0,47 ± 0,06	I,06 ± 0,06	I,4I ± 0,29	$3,0^{**)}$
^{7}Be	-	$\leqslant$0,00I6	$\leqslant$0,002	-	-
^{9}Be	0,69 ± 0,I5	0,46 ± 0,05	I,0 ± 0,I	I,66 ± 0,33	$2,3^{**)}$
^{I0}Be	8,0 ± 0,6	5,0 ± 0,3	9,8 ± 0,3	I2,6 ± I,3	$22^{**)}$
^{II}Be	-	0,3I ± 0,05	0,7 ± 0,06	-	$I,6^{**)}$
^{I2}Be	-	0,24 ± 0,05	0,44 ± 0,I	-	$I,0^{**)}$
^{I0}B	-	$\leqslant$ 0,003	$\leqslant$0,004	-	-
^{II}B	-	0,04 ± 0,02	0,I8 ± 0,06	-	-
^{I2}B	-	0,027 ± 0,008	0,2 ± 0,08	-	-
^{I3}B	-	0,03 ± 0,0I	0,26 ± 0,08	-	-
^{I4}B	-	0,0I6 ± 0,008	0,04 ± 0,02	-	-
^{I3}C	-	0,08 ± 0,05	$\leqslant$ 0,2	-	-
^{I4}C	-	0,85 ± 0,I	2,8 ± 0,I	3,20 ± 0,33	$6,5^{**)}$
^{I5}C	-	0,24 ± 0,I6	0,7 ± 0,26	-	$I,6^{**)}$
^{I6}C	-	0,03 ± 0,0I5	0,7 ± 0,3	-	-
^{I6}N	-	$\leqslant$0,008	$\leqslant$0,004	-	-
^{I8}O	-	$\leqslant$0,008	-	-	-
^{20}O	-	0,08 ± 0,03	0,I6 ± 0,08	-	-

* The α-particle yield from ternary fission is taken from Refs [21 and 24].

** Results are taken from evaluations in this paper.

Table 13

Yield values per fission event for various elements created in the thermal neutron fission of ^{235}U and ^{239}Pu

Reaction	Element	Mass or mass range	Yield	/n/	Measurement method
$^{235}U + n_{thermal}$	H	I ÷ 3	I,39 IO^{-4}	/II/	M M S T E D
	He	3 ÷ 8	I,6 IO^{-3}	-"-	
	Li	6 ÷ 9	I,4 IO^{-6}	-"-	
	Be	7 ÷ I2	0,6 IO^{-5}	-"-	
	B	I0 ÷ I4	I,I IO^{-7}	-"-	
	C	I3 ÷ I6	I,I IO^{-6}	-"-	
	N	I6	≤ 8 IO^{-9}	-"-	
	O	20	0,8 IO^{-7}	-"-	
	Ne	20	< 5,8 IO^{-8}	/42/	Mass-spectrometry
	-"-	2I	< 3,4 IO^{-I0}	-"-	
	-"-	22	< 5,9 IO^{-9}	-"-	
	Ar	36	< 2,4 IO^{-9}	-"-	
	-"-	37	≤ I IO^{-9}	/4I/	Radiochemical
	-"-	38	< 2 IO^{-9}	/42/	
	-"-	39	< 7,8 IO^{-I0}	-"-	
	-"-	39	≤ 4 IO^{-9}	/4I/	
	-"-	40	< 6,9 IO^{-7}	/42/	
	-"-	4I	≤ 3 IO^{-9}	/4I/	
	-"-	42	≤ 3 IO^{-I3}	-"-	
	-"-	42	< 2,2 IO^{-9}	/42/	
	Co	56	≤ 8 IO^{-I0}	/4I/	

Table 13 (continued)

Reaction	Element	Mass or mass range	Yield	/n/	Measurement method
$^{239}Pu + n_{thermal}$	H	I ÷ 3	I,96 IO^{-4}	/II/	MMSTED
	He	3 ÷ 8	2,04 IO^{-3}		
	Li	6 ÷ 9	3,0 IO^{-6}		
	Be	7 ÷ I2	I,I9 IO^{-5}		
	B	I0 ÷ I4	6,8 IO^{-7}		
	C	I3 ÷ I6	4,2 IO^{-6}		
	N	I6	≤ 4 IO^{-9}		
	0	20	I,6 IO^{-7}		
	F ÷ Mg	I9 ÷ 26	≤ 4 IO^{-8}		
	Si ÷ Ar	28 ÷ 42	≤ 8 IO^{-9}		
	K ÷ Fe	38 ÷ 60	≤ 4 IO^{-8}		

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