International Atomic Energy Agency

INDC(CCP)-135/L

INDC

INTERNATIONAL NUCLEAR DATA COMMITTEE

EVALUATED NEUTRON DATA FOR THERMAL REACTOR CALCULATIONS

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Translation from Nuclear Constants 4(43) 24 (1981)

August 1982

IAEA NUCLEAR DATA SECTION, WAGRAMERSTRASSE 5, A-1400 VIENNA

Reproduced by the IAEA in Austria
August 1982
82-5031

INDC(CCP)-185/L

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L82-20792
Translated from Russian

UDC 539.171: 539.172.4

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THE KORT NEUTRON DATA LIBRARY

The paper describes a library of evaluated neutron data designed for thermal reactor calculations and other low energy neutron physics applications. The name of the library is KORT (Evaluated Thermal Reactor Constants).

The KORT library was established for a number of reasons. At present we have no library or reference work combining all the information needed for thermal reactor physics calculations. Existing libraries with files of evaluated neutron data contain complete data on neutron interactions with many nuclei, but the large size of these libraries makes it difficult or even impossible to use them directly for reactor calculations. Furthermore, what is needed for thermal reactor calculations is in reality only a small part of the total amount of information contained in the evaluated neutron data files, and the available information is not always in explicit form (for example the resonance integrals). Furthermore, the complete files are oriented mainly towards fast reactor calculations, and in the slow neutron region the data need to be revised.

Thanks to its comparatively small size and the completeness of the information contained in it, the KORT library can be used directly for routine computer-based reactor calculations and also for reference purposes. By the beginning of 1980 KORT held information on 135 nuclides and 8 reactor moderators, including the main fissile and raw material isotopes, structural materials, absorbers, detectors, strongly absorbing fragments and heavy isotopes formed during reactor operation. The full list is given below.

KORT Library

1. Hydrogen
2. Deuterium
3. Helium
4. Helium-3
5. Lithium
6. Lithium-6
7. Lithium-7
8. Beryllium
9. Boron
10. Boron-10
11. Boron-11
12. Carbon
13. Nitrogen
14. Oxygen
15. Fluorine
16. Sodium
17. Magnesium
18. Aluminium
19. Silicon
20. Phosphorus
21. Sulphur
22. Chlorine
23. Argon
24. Potassium
25. Calcium
26. Titanium
27. Vanadium
28. Chromium
29. Manganese
30. Iron
31. Cobalt
32. Nickel
33. Copper
34. Zinc
35. Gallium
36. Zirconium
37. Niobium
38. Molybdenum
39. Rhodium
40. Cadmium-113
41. Indium-115
42. Xenon-135
43. Samarium-149
44. Samarium-151
45. Europium
46. Europium-151
47. Europium-153
48. Gadolinium-155
49. Gadolinium-157
50. Dysprosium-164
51. Erbium
52. Erbium-162
53. Erbium-164
54. Erbium-166
55. Erbium-167
56. Erbium-168
57. Erbium-170
58. Lutetium
59. Lutetium-175
60. Lutetium-176
61. Tungsten
62. Tungsten-180
63. Tungsten-182
64. Tungsten-183
65. Tungsten-184
66. Tungsten-186
67. Gold
68. Lead
69. Bismuth
70. Thorium-228
71. Thorium-229
72. Thorium-230
73. Thorium-231
74. Thorium-232
75. Thorium-233
76. Protactinium-231
77. Protactinium-232
78. Protactinium-233
79. Protactinium-234m
80. Protactinium-234g
81. Uranium-232
82. Uranium-233
83. Uranium-234
84. Uranium-235
85. Uranium-236
86. Uranium-237
87. Uranium-238
88. Uranium-239
89. Neptunium-236m
90. Neptunium-236g
91. Neptunium-237
92. Neptunium-238
93. Neptunium-239
94. Neptunium-240m
95. Neptunium-240g
96. Plutonium-236
97. Plutonium-237
98. Plutonium-238
99. Plutonium-239
100. Plutonium-240
101. Plutonium-241
102. Plutonium-242
103. Plutonium-243
104. Americium-241
105. Americium-242m
106. Americium-242g
107. Americium-243
108. Americium-244m
109. Americium-244g
110. Curium-242
111. Curium-243
112. Curium-244
113. Curium-245
114. Curium-246
115. Curium-247
116. Curium-248
117. Curium-249
118. Berkelium-249
119. Berkelium-250
120. Berkelium-251
121. Californium-249
122. Californium-250
123. Californium-251
124. Californium-252
125. Californium-253
126. Californium-254
127. Californium-255
128. Einsteinium-153
129. Einsteinium-254m
130. Einsteinium-254g
131. Einsteinium-255
132. Einsteinium-256
133. Fermium-254
134. Fermium-255
135. Fermium-256
136. Water
137. Heavy water
138. Zirconium hydride
139. Benzene
140. Polyethylene
141. Beryllium crystal
142. Beryllium oxide
143. Graphite

The following information is given in KORT:

- A general characterization of the nucleus (mass, energy of capture and fission reactions, parameters of radioactive decay);
- Partial cross-sections for neutrons of thermal energy, and the number of secondary fission neutrons (estimated errors in the measurements of these quantities are indicated);
- Coefficients defining the deviation of capture and fission cross-sections from the 1/v law in a Maxwellian spectrum;

- Resonance capture and fission integrals and the estimated errors in these quantities (for nuclei with $Z \geqslant 90$);
- Detailed energy dependence of the cross-sections in the 10^{-4} - 5 eV region at T = 300 K.

For moderators the atomic oscillation frequency spectra are given. This information makes it possible to calculate the differential slow neutron scattering cross-sections with allowance for the thermal motion and the chemical load of the atoms - using Majorov's data [1] for example. The response speed of this programme is such that we have been able to do without the storage of scattering laws, as in the American ENDF/B library [2].

The LIPAR library of resonance parameters, which is linked with a programme for calculating cross-sections in the resolved resonance region [3], is a component of the KORT library.

The information which has gone into the KORT library comes from various sources. The data on cross-sections, resonance integrals and resonance parameters resulted from an evaluation of experimental studies carried out by the authors and from a critical analysis of the evaluations of other authors. For elements with $Z \leqslant 90$ and the main fissionable elements, papers published up to August 1978 were considered, and for elements with $Z > 90$ (the actinides) papers published up to August 1979. The data on ν (the number of secondary neutrons per induced or spontaneous fission event) are taken largely from the handbook cited as Ref. [4], the nuclear mass data from Ref. [5] and the data on radioactive nuclear decay parameters from Refs [6] and [7].

The energy released in neutron capture is calculated from the mass balance. The energy of fission is evaluated by P. Eh. Nemirovskij: this is the total fission energy less the energy carried off by the neutrino and less the energy released in the decay of long-lived ($T_{\frac{1}{2}} \geqslant$ 2-3 years) fission products (amounting to about 0.15 MeV). The atomic oscillation frequency spectra for the moderators were selected in accordance with the recommendations of Ref. [9].

The KORT library is recorded on computer magnetic tapes in a format similar to that of the UKNDL [10] and SOKRATOR [11] libraries. It can effectively use all the aids available from the service complex of the TEKDA libraries [12], and in particular the user has the possibility of extracting the desired information from FORTRAN programs for input into the KORT working memory.

NEUTRON DATA FOR ACTINIDES

In this section we describe the part of the KORT library concerned with the actinides, i.e. fissile and raw material isotopes of thorium, uranium and plutonium and the isotopes from ^{228}Th to ^{256}Fm produced in the operation of a thermal reactor.

Formation of actinide isotopes

Figure 1 is a diagram of the radioactive transformations which occur in a thermal reactor. In preparing this diagram we took only (n,γ) reactions into account; (n,2n), (n,p) and other reactions were not considered as they are not characteristic for thermal reactors [the (n,2n) reactions in ^{232}Th and ^{237}Np are an exception because they are pathways for the formation of ^{232}U]. Chains with Z = const end with short-lived nuclei having a half-life not greater than ten hours. Horizontal arrows denote (n,γ) reactions, the slanting arrows β-decay.

To avoid complicating the diagram, we have not indicated α-decay and electron conversion processes except where they lead to the formation of additional isotopes. For ease of analysis we have separated out the main chain leading to the formation of heavy isotopes. Nuclei with a half-life less than ten days are shown within dashed lines.

The list of isotopes included in the KORT library is drawn up in accordance with the radioactive transformation scheme. The amount of information given for particular isotopes is governed by the level of experimental investigation they have reached. Thus for the short-lived isotopes which are last in the Z = const chain we have only the lifetime and the type of decay; but this is quite enough for reactor problems.

Thermal cross-sections and resonance integrals

The evaluation of the thermal capture and fission cross-sections and resonance integrals is described later. Here we give only the final results included in the KORT library.

Table 1 gives capture and fission cross-sections for a neutron energy of 0.0253 eV, σ_c^T and σ_f^T; resonance capture and fission integrals below 0.5 eV, RI_c and RI_f; and the numbers of secondary neturons for induced fission (ν, ν_p, ν_α) and spontaneous fission (ν_{sp}). For isotopes in which the capture of a neutron leads to the formation of a nucleus in the ground (g) and metastable (m) states, the partial cross-sections and partial resonance integrals are also given.

In Table 1 we give g_c and g_f factors describing the deviation of the capture and fission cross-sections from the 1/v law:

$$g(T) = \int_0^{\infty} \sigma(E)\frac{E}{kT}\exp\left(-\frac{E}{kT}\right)dE \Bigg/ \int_0^{\infty} \sigma(kT_0)\sqrt{\frac{kT_0}{E}}\,\frac{E}{kT}\exp\left(-\frac{E}{kT}\right)dE \,.$$

For T = 300 K the g factors are calculated from the energy dependence of the cross-sections, which is included in the KORT library. If no g factor is given, this indicates that the energy dependence of the cross-sections is not known for the element in question. The second column of the table gives half-lives of unstable nuclei ($T < 10^9$ years) and the main type of decay. Percentage ratios between the different types of decay are included in the KORT library but are not shown in Table 1.

Unresolved resonance parameters and cross-section energy dependence

For some of the nuclei considered the energy dependence of the cross-sections has been measured and the resonance parameters obtained. For these nuclei, resonance-parameter-reduced cross-sections are included in the KORT library. The calculation of these cross-sections appears in the earlier CROS program [3]. Since various methods of cross-section parametrization were used for the different isotopes, the CROS program relies on a number of calculation algorithms:

1. The Breit-Wigner formalism, allowing for interference from potential and resonance scattering and the Doppler effect;
2. The Adler-Adler multi-level R-matrix formalism, allowing for the effects mentioned above and also for interference between resonances in the first approximation; and
3. The Kadura-Peierls multi-level formalism.

Table 2 contains a brief characterization of the resolved resonance region and also indicates the method of cross-section characterization used and the source of the resonance parameters quoted for particular isotopes. For the actinides not mentioned in Table 2, the energy dependence of the cross-sections in the low-neutron energy range of interest to us is not known.

Certain changes have been introduced in order to adjust the independently evaluated thermal cross-sections and those determined from the resonance parameters to the parameters evaluated by other authors. All these changes - which as a rule relate to fictitious negative levels - are shown in Table 3.

The resonance parameters evaluated in the present paper are set out in Tables 4–13. Only the parameters of the first resonances are given (not more than 50), although the resonance parameter library [3] contains the parameters of all resolved resonances, all of which were taken into account in calculating the cross-sections.

Brief remarks about the evaluation

In 1973 the manual BNL-325 [4] was published, containing what was at that time the most complete information available on evaluated thermal cross-sections and resonance integrals. The IAEA organized, at Karlsruhe in 1975 and again at Cadarache in 1979, international meetings of experts to elaborate recommendations for various users of actinide nuclear data. At the first meeting, P. Benjamin [13] presented a survey paper on data for thermal reactors, giving a complete analysis of differential and integral experiments designed to measure the cross-sections and resonance integrals of the actinides from ^{231}Pa to ^{254}Es – excluding only the main reactor isotopes (^{232}Th, ^{233}U, ^{235}U, ^{238}U, ^{239}Pu). Papers published up to 1975 were considered – including work not available to us. The proceedings of the second meeting contained no review paper on thermal cross-sections; there is a review of existing nuclear data libraries [25], but it concentrates on the fast neutron region.

In compiling the KORT library, the evaluations in Refs [4, 13] were revised to take account of new experimental data. The results of the evaluation are set out in Table 1.

For the main fissile isotopes (^{233}U, ^{235}U, ^{239}Pu, ^{241}Pu) the IAEA has organized periodic evaluations of cross-sections and other thermal neutron data [26-28]. The evaluation method is a multiparametric fitting process which yields values with minimum mean-square deviation from the totality of the experimental results. At the same time certain normalizing parameters are fitted as well (the number of fission neutrons from ^{252}Cf etc.). The experiments were divided into two groups which were analysed separately. One group included experiments with 0.0253 eV neutrons, the other experiments with neutrons in a Maxwellian spectral distribution. For the isotopes of plutonium the two groups gave results that were in agreement to within the experimental errors, but for the isotopes of uranium they diverged. The average values have been taken as recommended data.

In 1977 the author of the latter IAEA evaluation [14] once again evaluated the same experimental material and analysed the reasons for the divergence. Table 14 gives the results of this work for ^{233}U and ^{235}U.

It is possible to harmonize the results of spectrometric and spectral experiments only by accepting Westcott g-factor values which are inconsistent with the evaluated energy dependence of the cross-sections (for example, for ^{235}U $g_c = \bar{\sigma}/\sigma^o = 1.06$ whereas the calculated $g_c = 0.981$). Lemmel has come to the conclusion that this discrepancy is linked with a systematic error in some measurements or other, but the source of the error has not been found.

The spectrometric experiments are the more reliable, since they are not affected by uncertainties regarding the neutron spectrum, the high energy contribution and so on. Furthermore, measurements on the Maxwellian spectrum give an unjustifiably high value for $\nu = \eta(\sigma_a/\sigma_f)$, namely 2.50 for ^{233}U and 2.46 for ^{235}U.

Accordingly, the data included in the KORT library for ^{233}U, ^{235}U ^{239}Pu and ^{241}Pu are those from Lemmel's evaluation [14] of the 0.0253 eV neutron experiments and g-factors calculated on the basis of the evaluated cross-section energy dependence.

It is important to note that the discrepancies between the spectrometric and spectral measurements are significant for the fission and capture cross-sections. The quantities which govern the criticality of a reactor (the absorption cross-section, σ_a, and the number of secondary neutrons per absorption, η) are the same for the two methods of measurement to within the error limits.

The resonance integrals for ^{233}U, ^{235}U, ^{239}Pu and ^{241}Pu are taken in accordance with the multigroup system of constants in the BNAB-78 library [29].

The most complete compilation of resonance parameters in the literature published up to 1973 is to be found in Ref. [30], but this work contains no recommendations. Evaluated resonance parameters are given in the manual of Mughabghab and Garber [4], an evaluation based essentially on the same experimental material as Ref. [30]. After 1973 there appeared a large number of measurements and evaluations. For isotopes for which the evaluations were out of date we have evaluated the resonance parameters anew. The evaluations for each isotope are discussed below, and the results are reproduced in part in Tables 4-13.

Cross-sections calculated on the basis of the evaluated resonance parameters have been compared whenever possible in the energy range up to 5 eV with the experimental data in Garber and Kinsey's compilation [31] or with more recent data. The results of this evaluation were in turn compared with the evaluated nuclear data files submitted for international exchange [32]. The most complete libraries of files on the actinides are the American ENDF/B-V [2] and ENDL-A [33] libraries. By and large KORT is in agreement with these libraries; the discrepancies that do exist are due to the fact that the KORT library includes later experimental work.

The ENDF/B-V and ENDL-A files lay claim to completeness, which means that in some cases cross-sections are "constructed" artificially, in our view, without sufficient justification. Thus in the ENDF/B library the cross-sections in the low-energy region are determined from average resonance parameters measured in the high-energy region, in accordance with the GENPAR library formula [34]. This procedure is justified for the fast neutron region, but in the first resonance region it is bound to lead to large and indeterminate errors.

The KORT library includes the energy dependence only in cases where there is at least one measurement in the region up to 5 eV from which the resonance parameters can be determined. In what follows we offer brief explanations concerning the individual isotopes. Elements for which all the available experimental work has been taken into account in earlier evaluations are not discussed.

^{228}Th. For this isotope the parameters of two resonances at 1.896 and 7.55 eV are known [4]. The capture cross-section calculated on the basis of these parameters is five times less than the recommended value. This discrepancy might be explained by, for example, the presence of a resonance below 1 eV. It was decided not to attempt to give the cross-section energy dependence in the KORT library in situations like this.

^{229}Th. The thermal cross-sections and resonance integrals for this isotope are taken from Ref. [4]. The number of secondary neutrons per fission, ν, is based on Refs [35, 36], i.e. with allowance for the new normalization. The resonances of this isotope are resolved below 51 eV [4]. However, above 9.15 eV the neutron width has not been determined and we know only the area beneath the fission curve $\sigma_o\Gamma_f$ for certain resonances. The LIPAR library includes parameters up to 9.15 eV: the fission widths are determined on the basis of $\sigma_o\Gamma_f$ data and the radiation widths are taken to be 40 meV.

^{231}Pa. The thermal capture and fission cross-sections in the evaluations cited as Refs [4] and [13] coincide although there is some inconsistency in the data given in Ref. [4]. Thus the total cross-section in accordance with the measurement report in Ref. [37] is taken to be 211 $\pm$ 4 b, whereas the capture cross-section is 210 $\pm$ 20 b. Just recently activation measurements of the fission cross-section have been published giving a value of 201 $\pm$ 22 b [38], and there are preliminary data giving 201 $\pm$ 20 b [39]. This prompted a revision of the recommended capture cross-section values in Refs [4, 13].

The thermal fission cross-section is several orders of magnitude less than the capture cross-section, which explains the large scatter of the data on the fission cross-section: 0.010 ± 0.005 b [4], 0.006 ± 0.001 b [40] and 0.020 ± 0.001 b [41]. We have taken the average fission cross-section from all the measurements with a 50% error derived as a root-mean-square deviation.

In Mughabghab and Garber's evaluation [4] the neutron width of the resonance (0.494) represents an average value between the data of Refs [37] and [42]. However, judging from the total cross-section peak, Patterson and Harvey's experimental data [42] were obtained with poorer resolution and we did not take them into account.

The resonance integral for ^{231}Pa is very sensitive to the lower limit of the integral E_c. This is explained by the influence on the resonance capture integral of resonances with E_o = 0.396 and 0.494 eV. Figure 2 shows the resonance capture integral calculated by us, $RI_c(E_c) = \int_{E_c}^{0.5\ eV} \sigma_c(E)\frac{dE}{E}$ as a function of E_c and also the measurement results and evaluations of other authors. From the figure it can be seen that when E_c goes from 0.3 to 0.5 eV the resonance capture integral decreases by 1000 b, and it is this circumstance which causes the substantial data scatter we have noted for this resonance. For RI_c above 0.5 eV a value of 470 b has been taken, derived as the sum of the integral calculated on the basis of the resonance parameters below 10.7 eV (305 b) and the integral evaluated in Ref. [37] for the region above 10.7 eV (165 b).

<u>^{233}Pa</u>. The resonance parameters of the first two levels are taken from Ref. [45] whereas the parameters of the resonances from 0.795 to 17 eV are based on the data of Ref. [4]. Since the 0.4 eV level is extremely weak ($2g\Gamma_n$ = 0.000253 meV) the resonance capture integral is almost completely insensitive to the magnitude of E_o.

<u>^{232}U</u>. The recommended value of the fission resonance integral is based on measurements of Gryntakis and Kim [40] performed in 1976 (RI_f (0.55 eV) = 348 ± 116 b). The thermal fission cross-section from this work (74 ± 8 b) was not included in earlier evaluations but it is in agreement with the recommendation of Benjamin [13] which we have in fact taken (75.2 ± 4.7 b).

^{234}U. James, Dabbs and Harvey [18], whose resonance parameters are used here, made simultaneous measurements of the total cross-section in the region above 20 eV and of the fission cross-section above 3 eV. Harvey's measurements of the total cross-section made in 1958 with much poorer resolution (see Ref. [4]) were not taken into account. All other measurements were made only for the resonance at 5.16 eV and their results are in agreement with the data of Ref. [18]. The radiation widths of all the resonances were taken to be equal to Γ_γ for the first resonance. The evaluations of the resonance capture integral, which have given 630 b [13], 665 b [46] and 645 b [40], while not the same, are in agreement to within the error limits. The recommendation of Gryntakis and Kim [40] is taken.

^{236}U. The resonance parameters for this isotope have been evaluated again because Ref. [4] did not include two analyses: Ref. [47], where transmission was measured by the time-of-flight method for the 40 eV-4 keV range with high resolution, and Ref. [48] in which the time-of-flight method was used to measure the capture and scattering cross-section as well as transmission in the energy region up to 2 keV.

Since the data in Ref. [47] cover a larger energy range than all the other studies and since the energy spread is not large, the resonance locations have been taken in the main from Ref. [47]. The neutron and radiation widths for each resonance were averaged over all the available experimental data. If the radiation width of the resonance had not been measured, it was assumed to be $\Gamma_\gamma = 23$ meV. Values of Γ_f are given for some resonances, but the fission cross-section was not calculated in view of its small size. The parameters of the first fifty resonances are given in Table 4.

^{237}U. The energy dependence of the cross-sections has been measured only in the region above 43 eV [49], and the positions of the resonances and the areas beneath the fission cross-section curve have also been determined. From these data it is apparent that the average level spacing is about 4 eV, which means that the cross-section is most unlikely to have a non-resonance character in the region up to 5 eV.

There is a discrepancy in the resonance integrals between Refs [4] and [13]. Our choice follows the recommendation of Ref. [13].

^{238}U. The data on this isotope are taken entirely from the evaluation in Ref. [20].

^{237}Np. In Ref. [4] the resonance parameters of this isotope are evaluated on the basis of a number of transmission, capture and fission cross-section measurements, including the measurements of $\sigma_f(E)$ in Ref. [50]. Recently there have appeared simultaneous measurements of the capture, elastic scattering and total cross-sections by the time-of-flight method in the 8-204 eV range [51]; from an analysis of these measurements the authors of the paper obtained neutron widths for 200 levels and radiation widths for 25 levels. The resonance locations are in agreement with the evaluation in Ref. [4]. Monotonic resonance omission (Fig. 3) is observed with the variation in energy. For this reason the authors of the present paper included resonance parameters only up to 150 eV in the LIPAR library.

The resonance spins, J, were not determined for all levels, and the statistical weight (g) data were supplemented on the basis of the rule that the level density is proportional to 2J+1. Ref. [51] does not give the values of g which were used in determining Γ_n from $2g\Gamma_n$. For this reason we did not take Γ_n from Ref. [51] into account, but we have noted that these values are close to the neutron width in Ref. [4]. The radiation widths for each level were averaged over the different data sources. When data on Γ_γ were missing, it was assumed that $\Gamma_\gamma = \Gamma - \Gamma_n$ (since $\Gamma_f << \Gamma_\gamma$) or $\Gamma_\gamma = <\Gamma_\gamma>$. The value $<\Gamma_\gamma> = 40$ meV was taken from Ref. [51].

Table 5 shows the resonance parameters of ^{237}Np for the first 50 levels. The level at $E_o = 0.489$ eV makes the resonance integral for ^{237}Np sensitive to E_c - the lower limit of the integral. This, in particular, explains the strong scattering of the integral measurement results. The same scatter is found in the evaluations: 660 b [4, 13], 756 b [52] and 946 b [40].

Calculation of the resonance capture integral on the basis of the resolved resonances up to 150 eV gives a value of 760 b. Of this 190 b represents the contribution of the resonance at 0.489 eV up to 0.5 eV (Fig. 4). We recommend the evaluation of Ref. [13], i.e. RI_c (0.5 eV) = 660 ± 50 b.

^{238}Np. The evaluations of thermal cross-sections and resonance integrals for this isotope are not very reliable because of its short half-life. Thus the recommended value of σ_f^T = 1600 b from the evaluation in Ref. [52] is 25% lower than the recommendation in Ref. [13], viz. 2070 ± 30 b.

For the recommended fission resonance integral no lower limit is indicated by Benjamin [13]. At the same time, since the position of the resonances is not known, the question of the sensitivity of the fission resonance integral to E_c cannot be answered either. The resonance capture integral in Ref. [46] was evaluated on the basis of an approximate relationship $RI_c \approx RI_f(\langle\Gamma_\gamma\rangle/\langle\Gamma_f\rangle)$. We have taken the values of σ_f^T and RI_f from Benjamin's evaluation [13] and σ_c^T and RI_c from Menapace [46].

<u>^{238}Pu</u>. The independent evaluations of this isotope in Refs [4] and [21] are based on the same experimental information and give closely agreeing values of the thermal cross-sections, resonance integrals and resolved resonance parameters. The cross-sections recommended in Ref. [13] diverge somewhat because the author has left a number of analyses out of consideration. For the thermal cross-sections and resonance integrals we have taken the evaluation of Ref. [4]; the resonance parameters are based on the evaluation in Ref. [21]. Note that the $\sigma_t(E)$ and $\sigma_f(E)$ curves in the ENDF/B-IV library (see Ref. [31]) do not agree with the experimental data in Ref. [31] as well as the cross-sections calculated by us.

<u>^{240}Pu</u>. The thermal cross-sections for this isotope are based on the multigroup constants of the BNAB-78 library [29]. The energy dependence of the cross-sections was calculated from resonance parameters evaluated by us in 1977. Table 6 shows the parameters of the first fifty resonances. In the energy region under consideration sub-threshold fission occurs; for example, at the peak of the first resonance (E_o = 1.059 eV) it amounts to 37 b. However, against the background of a 170 000 b capture cross-section, fission can be disregarded. The KORT library includes only $\sigma_c(E)$.

The resonance capture integral is taken from the system of constants in Ref. [29]. The 12% error quoted by Benjamin [13] seems somewhat high as the resonance capture integral is determined to the extent of 97% by the parameters of a thoroughly studied resonance at 1.059 eV. We have accordingly assigned an error of 3% to this quantity.

<u>^{241}Pu</u>. The resonance integrals for this isotope were taken from Ref. [13]. The resonance parameters have been evaluated independently by different authors [4, 22, 53, 54]. It would seem natural to use the results of the most recent evaluation [54], but for a number of reasons this has not been done. In the second part of the review in Ref. [54] we find evaluated Adler-Adler resonance parameters with two negative levels, and from these the single-level Breit-Wigner parameters have been derived. However, as the authors of Ref. [54] point out, these parameters should not be used in calculating the detailed cross-section behaviour (Part II, p. 23). The authors themselves used them only to obtain the average parameters. At the same time Reich-Moore parameters without a negative level from Ref. [55] have been entered in the ^{241}Pu file.

In calculating the energy dependence of the fission and capture cross-sections, the authors of the present paper have used multi-level parameters derived by Weston and Todd [22] from a simultaneous analysis of the σ_c and σ_f cross-sections using the Adler formalism. The calculated cross-sections were compared both with the experimental data of Ref. [31] (and the measurements [55-57] not included therein) and with the evaluated cross-section curves from various libraries [25].

$\underline{^{242}Pu}$. All existing evaluations and Bendt's new measurement of the capture cross-section [58], not included in the evaluations, are in good agreement with each other. There are large discrepancies (orders of magnitude) in the fission cross-section because of the fact that $\sigma_f^T << \sigma_c^T$. Accordingly, we have assigned an error of 100% to the fission cross-section. The resonance integral was taken from the evaluation in Ref. [13], corrected by the value of RI in the 0.5-0.625 eV range.

$\underline{^{241}Am}$. Neutron capture in ^{241}Am leads to the formation of ^{242}Am in the ground ($T_{\frac{1}{2}}$ = 16.01 a) and metastable ($T_{\frac{1}{2}}$ = 141 a and 13 s) states. The cross-section of the $^{241}Am(n,\gamma)^{242}Am^{m_2}$ reaction, namely 0.1 ± 0.05 mb, is several orders of magnitude smaller than the total cross-section and therefore has not been included in the library.

After Benjamin's evaluation [13] had been completed, there appeared a paper by Gavrilov and co-workers [59] who used the cadmium difference method in the channels of the high-flux SM-2 reactor to measure thermal cross-sections and resonance fission and capture integrals on microgram samples. In deriving the recommended values of the capture cross-section we have taken this experiment into account. The isomeric ratio of our evaluation agrees to within the error limits with the results of the measurements performed in Refs [59], [60] and other evaluations (notably Ref. [61]).

In evaluating the fission cross-section not only Gavrilov's measurements [59] (2.8 ± 0.25 b) but also the data of Ref. [62] (3.2 ± 0.15 b) obtained in a horizontal channel of the SM-2 reactor were taken into account. The value ν_p = 3.121 ± 0.030 is recommended in accordance with Benjamin [13] and differs from the value given in Ref. [4], namely ν_p = 3.219 ± 0.038.

The resonance parameters in the present paper were evaluated with allowance for the new data in Refs [63-66]. The results of the measurements in Ref. [67] have not been included in our evaluation because they were not available to us. The authors of Refs [63] and [65] measured the fission cross-section in the ranges up to 150 and 10 eV respectively. In Ref. [64] resonance parameters up to 50 eV were obtained from measurements of the absorption cross-section.

Finally, Ref. [66] also determined resonance parameters on the basis of the transmission measurements of Refs [68, 69] up to 30 eV. For a number of reasons the resolved resonance region was limited to E = 50 eV. In the first place, above 50 eV parameter data are to be found only in one paper [63] and analysis of <D> (the average level spacing) indicates that in this region a systematic omission of resonances begins. Secondly, large Γ_γ (2-2.5 x $\langle\Gamma_\gamma\rangle$) appear in this energy region.

Let us give a short description of the evaluation. The resonance energies E_o are taken from Ref. [63], apart from the first two levels which are taken from Ref. [64]. The spin of the target nucleus, I = $^5/2$, was the same as for ^{237}Np; accordingly the spins of the compound nuclei were taken on the basis of that isotope, as detailed measurements are available for it. The neutron widths, $2g\Gamma_n$, were averaged over all the papers with a weight equivalent to the inverse square of the errors. It should be noted, however, that the results of the early measurements which Mughabghab and Garber's evaluation [4] took into account had very little effect on the averaging results owing to the large errors, despite the very different values of $2g\Gamma_n$. The radiation widths were also averaged. However, in the region above 4 eV the Γ_γ values are virtually the same as those given by Lucas and co-workers [63], since the Γ_γ in Ref. [66] are quoted with much larger errors. To resonances with unknown Γ_γ we have assigned the average radiation width derived by us, namely $\langle\Gamma_\gamma\rangle$ = 44 meV. Below 10 eV the fission widths were averaged in accordance with Refs [4, 63-65]. Above 10 eV the value of Γ_f follows the data of Lucas and co-workers [63]: we have averaged the two Γ_f systems given in that paper. One system, derived from our own measurements of the fission cross-section in the range up to 40 eV gives $\langle\Gamma_f\rangle$ = 0.23 meV and obeys a relatively broad χ^2-distribution with four degrees of freedom; the second system, derived from the measurements of Ref. [70] in the 22-52 eV region, gives $\langle\Gamma_f\rangle$ = 0.52 meV with a very narrow χ^2-distribution (15 degrees of freedom).

Thus the discrepancies between the two Γ_f systems are large and systematic. Nevertheless, in the 22-40 eV region, where the fission width data overlap, we have averaged them. For levels with unknown fission widths it would have been possible to take $\Gamma_f = \langle\Gamma_f\rangle$ in view of the narrowness of the χ^2-distribution; however, given the large scatter around the average fission width [63] we did not do this, especially as $\Gamma_f \ll \Gamma_\gamma$ (see Table 7) and accordingly $\sigma_f(E) \ll \sigma_c(E)$.

A few words about the parameters of the negative level. Ref. [64] introduced a level with E_o = -0.22 eV, but it was assumed that a background equal to $(20.5/\sqrt{E})$ b had to be added to the calculated cross-section. The authors of the present paper, using the parameters in Ref. [66] as their guide, took the energy of the resonance to be -0.425 eV, the remaining parameters being varied. The recommended parameters of the first 50 resonances are given in Table 7. The cross-sections calculated on the basis of these parameters were compared both with the experimental curves of Ref. [31] and with the σ_t values of Ref. [68] and the σ_a of Ref. [71]. These papers also quote the ENDF/B-IV evaluation, which is in poorer agreement with experiment.

Figure 5 shows a plot of the resonance integrals as a function of E_c, since ^{241}Am has low-lying resonances (E_o = 0.31 and 0.584 eV). A comparison of the calculated curve with the experimental and evaluated values of the resonance capture integral shows that the largest discrepancies are found for data with indeterminate E_c.

<u>^{242}Am</u> (isomeric state with $T_{\frac{1}{2}}$ = 141 years [92]). Benjamin [13] recommends a thermal fission cross-section of 7600 ± 300 b. Allowing for the measurements in Ref. [62], where the fission cross-section is 6100 ± 500 b, we have taken σ_f^T = 6900 b. On the basis of Hann's measurements from 1951 (see Ref. [4]) with σ_t^T = 8000 b, the thermal capture cross-section has been determined as the difference $\sigma_t^T - \sigma_f^T$.

The resonance parameters quoted in Ref. [4] are based entirely on Ref. [72], where the relative measurements of $\sigma_f(E)$ normalized to σ_f^T = 6600 b are described. We have renormalized $\sigma_f(E)$ to σ_f^T = 6900 b. As a consequence the parameter $2g\Gamma_n$ has been proportionally changed for all resonances. Since $2g\Gamma_n \ll \Gamma_f + \Gamma_\gamma$, we have assumed that all levels relate to a single system with g = 0.5. The resonance parameters of Bowman and co-workers [72] were obtained for the range up to 3.25 eV, and $\sigma_f(E)$ was accordingly calculated for this same range. From Bowman's $\sigma_f(E)$ curve [72] it is apparent that up to 5 eV there is at least one more resonance.

Table 8 gives the recommended resonance parameters. The fission resonance integral for $^{242}Am^m$ was measured by Perkin in 1968 (1570 ± 110 b - see Ref. [13]) and by Zhuravlev (2260 ± 200 b) [62]. As can be seen, the scatter of the data goes well beyond the error limits. A calculation on the basis of the resonance parameters indicates that Benjamin's recommendation [13] is somewhat too low. At the same time, the data of Zhuravlev and co-workers [62] may have been affected by the uncertainty of the cadmium cut-off (Fig. 6). We have taken the fission resonance integral to be the average value between the data of Refs [13] and [62].

The data on the capture resonance integral are not altogether accurate. In Mughabghab and Garber's evaluation [4] it is given as 7000 $\pm$ 2000 b. This is erroneous if only because RI_c cannot be greater than RI_f when $\sigma_c^T << \sigma_f^T$ and $\Gamma_\gamma < \Gamma_f$. The capture resonance integral has been evaluated approximately in the following manner: up to 3.25 eV we have $RI_c^{(1)} \approx 170$ b on the basis of the resonance parameters; above 3.25 eV we have $RI_c^{(2)} \approx RI_f^{(2)}(<\Gamma_\gamma>/<\Gamma_f>) \approx 60$ b; and finally $RI_c = RI_c^{(1)} + RI_c^{(2)} = 230$ b.

<u>^{243}Am</u>. Independent evaluations of the thermal capture cross-section [13, 21] are in agreement with each other and with Ref. [4], but none of these take the results of Ref. [59] into account. Inclusion of these data in the evaluation in Ref. [21] gives a capture cross-section of 79 $\pm$ 4 b instead of 75.3 b. Capture of a neutron by the ^{243}Am nucleus leads to the formation of ^{244}Am in the ground and metastable states. The ratio between these two reactions was taken in accordance with the work of Van der Bosch in 1964 (see Ref. [45]).

The fission cross-section is much smaller than the capture cross-section, and there is a broad scatter of the data around it: les than 0.07 b [4], around zero [13], 0.45 b [46], 0.9 b [33]. We took $\sigma_f^T = 0.20 \pm 0.11$ b, following Gavrilov's measurements [59].

The resonance parameters for ^{243}Am were re-evaluated in the present paper in view of the publication of new transmission measurements up to 35 eV [66]. The resonance energies were taken in accordance with the data of Simpson and co-workers [73], where the parameters were determined up to 250 eV; $2g\Gamma_n^o$ and Γ_γ were averaged over all the papers, and $<\Gamma_\gamma>$ was taken to be 37 meV. The parameters of the first 50 resonances are given in Table 9.

It should be noted that the evaluated $\sigma_c(E)$ curves in contemporary libraries are not in agreement with each other [25]. We find for example at 0.01 eV a discrepancy by a factor of four. Our calculation of $\sigma_c(E)$ agrees with the data of the JENDL-2 library [25].

Despite the fact that there is a resonance at 0.42 eV, the resonance capture integral is not sensitive to E_c because the resonance in question is very weak (0.5% RI_c). The evaluated resonance capture integral was obtained with due allowance for the measurements in Ref. [59]. If the resonance capture integral in the reaction leading to the formation of a ^{244}Am nucleus in the ground state is taken in accordance with Schumann's 1968 data (see Ref. [4]), then the isomeric ratio of RI_c is close to the ratio measured by Van der Bosch in a reactor spectrum (see Ref. [45]), i.e. close to the thermal cross-section ratio. The fission resonance integral is less than 1% RI_c. Even so we evaluated it, allowing for Benjamin's data [13] and the measurements in Refs [59] and [62].

^{242}Cm. At present there exists only one time-of-flight measurement [23] of $\sigma_t(E)$ in the region above 1 eV; there are no other measurements for the energy dependence of the cross-sections. The first resonance of ^{242}Cm is found at $E_o \sim 13.6$ eV and the average level spacing is evaluated at about 18 eV. This gives some (though not a very convincing) reason to suppose that there are no resonances below 5 eV. However the capture cross-section determined from the parameters from Ref. [23] amounts to only 0.9 b instead of the 16 b previously assumed. This discrepancy has been removed by the introduction of a negative level. The cross-section energy dependence curve has no basis for comparison, and so we must be cautious in accepting the $\sigma_c(E)$ dependence given in the library.

^{243}Cm. The recommended fission cross-section was obtained by averaging three sets of measurements: Hewlett, 1957 (see Ref. [13]) - 690 ± 50 b; Bemis et al. [74] - 609 ± 26 b; and Zhuravlev [75] - 672 ± 60 b.

There are large discrepancies in the capture cross-section. Mughabghab and Garber [4] derived the cross-section as $\sigma_a^T - \sigma_f^T$ and quote a result of 225 b. Benjamin [13] offers no recommendation. We have taken the capture cross-section to be 131 ± 10 b in accordance with the most recent and most accurate experiment [74].

Transmission measurements are available in the resonance region [76]. Multi-level Reich-Moore resonance parameters have been obtained. This formalism is not performed in the CROS program [3], so we have not taken the magnitude of $\sigma(E)$ into account, even though there are no less than five resonances in the region below 5 eV.

The fission resonance integral for ^{243}Cm was averaged over the results of three measurements: Thompson, 1971 (see Ref. [13]) - 1860 ± 400 b; Bemis et al. [74] - 1575 ± 136 b; and Zhuravlev [75] - 1480 ± 150 b. The resonance capture integral was taken from Ref. [74] for $E_c = 0.54$ eV. We have introduced no corrections in E_c.

^{244}Cm. The cross-sections of this isotope have been evaluated by a number of authors: apart from Refs [4] and [13] we have comparatively complete evaluations, for example, in Refs [21] and [24]. As a basis we have taken the most recent evaluation [24] supplemented by resonance integral measurements [62, 77] and measurements of the thermal capture cross-section [77].

^{245}Cm. Refs [4], [13] and [78] show a scatter which goes beyond the error limits in the evaluated data, giving for the thermal capture cross-section 345 ± 20, 383 ± 20 and 328 ± 31 b, and for the thermal fission cross-section 2020 ± 40, 2161 ± 110 and 2000 ± 35 b, respectively. We re-evaluated the thermal cross-sections allowing for the measurements in Ref. [77] for capture and Refs [59, 62 and 79] for fission, obtaining values of $\sigma_c^T = 350 \pm 30$ b and $\sigma_f^T = 2030 \pm 60$ b.

The resonance parameters of ^{245}Cm were evaluated on the basis of parameters derived from Berrett's $\sigma_t(E)$ measurements (see Ref. [4]) and Moore's $\sigma_f(E)$ measurements [80]; the data in Ref. [81] and [82] are for the total cross-section up to 20 eV and the data in Ref. [79] for the fission cross-section up to 36 eV. The resonance energies E_o up to 20 eV were based on Ref. [82] where the 13.75 eV doublet is resolved (13.58 and 13.91 eV); there is also a level at 3.44 eV which was noted by Dabbs et al. [81]. In the 20-60 eV range the resonance energies are based on Ref. [80] inasmuch as the E_o values up to 36 eV coincide fairly precisely with the data in Ref. [79], whereas for the region above 36 eV Ref. [80] is the only experimental paper. Let us just note that by now the value of $\sigma_f(E)$ has been measured throughout the energy range 0.001-10 000 eV [83], but we do not yet have these data. Up to 36 eV the neutron and fission widths were averaged taking into account all the results mentioned above except Ref. [81], where apart from E_o only σ_o, namely the cross-sections at the resonance peaks, were determined. Since $\Gamma_\gamma << \Gamma_f$, the values of Γ_γ are not determined, and for all levels we have taken $\Gamma_\gamma = <\Gamma_\gamma> = 40$ meV. The cross-sections show little sensitivity to the resonance spin: nevertheless, in the interest of more precise determination, we have taken the J sequence to be the same as for ^{239}Pu where the target nucleus spin has the same value (0.5). The evaluated resonance parameters are given in Table 10.

The resonance integrals for ^{245}Cm were evaluated on the basis of $RI_c = 108 \pm 80$ b [77] and $RI_f = 805 \pm 80$ b [62] and 850 ± 60 b [59].

<u>^{246}Cm</u>. The data of Refs [62, 77] have been added to the thermal cross-section and resonance integral measurements taken into account by Benjamin [13]. For this reason the evaluation was carried out anew, and the resonance parameters were evaluated as well. The parameters of the first six resonances (up to $E \approx 160$ eV) obtained from σ_t measurements are given in four papers, two of which [66, 84] did not figure in the evaluation in Ref. [4]. Furthermore, for energies above 80 eV we have Moore's measurements of the fission and capture cross-sections (see Ref. [4]). Below 80 eV there are two levels for which the fission width was selected arbitrarily in order to harmonize the calculation with independently evaluated thermal cross-section values. This approach is justified in part by the fact that $\Gamma_f << \Gamma_\gamma$ and Γ_n. The remaining resonance parameters were averaged on the basis of all the papers. The evaluated resonance parameters are shown in Table 11.

^{247}Cm. In obtaining recommended values of the thermal capture and fission cross-sections for this isotope we have taken into account, in addition to Benjamin's evaluation [13], the data of Ref. [77] on the capture cross-section and Ref. [62] on the fission cross-section. In the region below 20 eV there is just one measurement of the total cross-section [85] from which single-level Breit-Wigner parameters have been derived. In the region above 20 eV Ref. [4] gives multi-level Reich-Moore parameters derived from a burst experiment to determine $\sigma_f(E)$. In Ref. [86] these multi-level parameters were transformed into single-level Breit-Wigner pseudo-parameters on the basis of which the cross-sections can be constructed by the addition of a small background. Since in Ref. [86] there are certain imprecisions (level with E_o = 37.76 eV follows a level with E_o = 37.8 eV; the neutron width quoted for the resonance with E_o = 39.5 eV is negative; the radiation width fluctuates by an order of magnitude for the levels at 39.5 and 41.72 eV), we have used these parameters only up to 37.8 eV, i.e. we have left out of account 19 resonances up to 60 eV. A negative level has been introduced in the cross-sections in place of the background. The recommended parameters are given in Table 12.

Note that the quantities σ_f^T, RI_c and RI_f are showing a marked tendency to decline over the years. New measurements of the resonance capture integral [77] and the resonance fission integral [62] confirm this pattern. Nevertheless, we have not altered RI_c = 500 b [13] since calculation of this integral up to 38 eV on the basis of the resonance parameters already gives a value of 500 b. The calculated value RI_f = 510 b is substantially smaller than the experimental value. The existing imbalance between experimental and calculated resonance integrals indicates that the resonance parameters need further refinement, especially in the range below 20 eV, which contributes to the resonance integral.

^{248}Cm. The recommended values of the thermal capture cross-section in different evaluations [4, 13, 52, 87] vary almost by a factor of two. The new measurement of σ_c^T on the SM-2 reactor using the cadmium difference method [77] worsens the situation rather than improving it. The lowest value, 2.9 b evaluated by Benjamin [13], took account of Drushel's 1973 measurement (see Ref. [13]) which gave 2.63 $\pm$ 0.02 b, and which was carried out with high precision. In Gavrilov's measurements [77] with σ_c^T = 10.7 $\pm$ 1.5 b the error is an order of magnitude larger and the cross-section four times larger. We have not taken Gavrilov's measurements [77] into account and have adopted Benjamin's recommendations [13]. The thermal fission cross-section was derived on the basis of Benjamin's measurements [88] (0.34 $\pm$ 0.07 b) and Zhuravlev's [62] (0.39 $\pm$ 0.07 b).

The evaluation of the resonance parameters for ^{248}Cm in Ref. [4] was based on measurements of $\sigma_f(E)$ above 20 eV [80] and the preliminary data (only E_o) of Benjamin [88]. Later work of Benjamin [84] involved a complete analysis of $\sigma_t(E)$ and provided a set of single-level Breit-Wigner parameters for 47 resonances up to 3 keV. Further, parameters for the first five resonances were obtained by Kolesov and co-workers [66] in the course of transmission measurements. In evaluating the resonance parameters we took resonance energies in accordance with Benjamin [84]. The neutron and radiation widths of the first resonances were averaged over the results of all papers. The radiation widths of the remaining resonances were taken at 26 meV. A point to note is that the fission widths in Refs [4] and [80] differ even though they ought to be the same. Since the authors of Ref. [4] observe that their data are preliminary, we have taken the fission width directly from Ref. [80]. The evaluated resonance parameters are given in Table 13. The measurement giving RI_c = 250 ± 24 b [77] is in excellent agreement with Benjamin's recommendation [13] (251 ± 25 b). Nevertheless, Drushel's measurement in 1973 (267 ± 27 b) and Thompson's in 1971 (275 ± 75 b) (see Ref. [13]), as well as Benjamin's calculations in 1974 [84] (259 ± 12 b) and our own calculation (264 b), give higher values. For this reason we have recommended RI_c = 265 b, a value obtained by averaging all the experimental data.

The situation with regard to the fission resonance integral is different. Benjamin [13] revised the value of RI_f = 13.2 ± 0.8 b recommended in Ref. [4] which he himself had measured in 1972 [88] and quoted 14.7 ± 2.2 b. Then Zhuravlev's measurements appeared [62], giving 13.1 ± 1.5 b. The value recommeded in the present paper was obtained by averaging the results of Refs [13] and [62], where E_c = 0.625 eV. However, as the first resonance is located at E_o = 7.25 eV, the resonance integral does not depend on the value of E_c. We were unable to calculate RI_f because fission width data are not available for most of the levels.

<u>^{249}Bk</u>. A 50% error has been assigned to the thermal cross-sections for this isotope ($\sigma_c^T \approx \sigma_a^T$ = 1600 ± 800 b) recommended by Benjamin [13]. Gavrilov's later measurements [59] giving σ_c^T = 1800 ± 100 b were done with greater accuracy (by a factor of 8) on samples with a mass of less than 1 microgram for which blocking effects are small. We have taken Gavrilov's results [59]. The agreement among all evaluators on $\sigma_f^T \simeq 0$ fails only in the case of Kon'shin's data [87] where the thermal fission cross-section is given as 554 b. In the present paper we have taken $\sigma_f^T \approx 0$.

The energy dependence $\sigma_t(E)$ has been measured only by Benjamin [89]. Below 20 eV the energies of only 17 resonances have been determined, five of these being located in the region below 5 eV. Since the first resonances are located at 0.197 and 1.343 eV, the resonance capture integral should not depend strongly on the magnitude of E_c. This being so, it is hard to explain the large (factor of four) scatter of the data on the resonance capture integral. Apart from the work included in Mughabghab and Garber's evaluation [4], we have taken into account Harbour's results [60] where RI_a = 1850 b and Gavrilov's [59] where RI_c = 1100 ± 100 and 1300 ± 300 b. A 50% error (as in Ref. [13]) has been assigned to the resonance capture integral thus obtained. Note that the recommendation of RI_c = 4000 b [13] does not agree with ours (difference about a factor of three), but the paper upon which Benjamin [13] based his evaluation proved to be unavailable.

<u>^{249}Cf</u>. In evaluating the thermal cross-sections and resonance integrals for this isotope, account was taken of the results of Refs [59, 60, 62] which did not figure in Benjamin's work [13]. In Benjamin's measurements of $\sigma_t(E)$ [89], 12 resonance energies were determined, two of these resonances being below 5 eV (E_o = 0.7 and 3.89 eV). For energies below 16 eV we have no information on the widths of the resonances, which means that it is impossible to construct the $\sigma(E)$ curve in the region of interest to us. Above 16 eV multi-level parameters are available (see Ref. [4]), derived from measurements of $\sigma_f(E)$.

<u>^{250}Cf</u>. In recommending the thermal capture cross-section we have taken account not only of the experimental data included in Benjamin's evaluation [13], where σ_c^T = 1700 b, but also of Gavrilov's measurements [77] giving σ_c^T = 1800 b. It can be said that the evaluations of the fission cross-section in Ref. [4] (< 350 b) and Ref. [13] ($\sigma_f \approx 0$) are in agreement.

We have no measurements of the energy dependence of the cross-sections, so it is impossible to say anything about how E_c affects the resonance integral. Refs [4] and [13] recommend a resonance capture integral based on Halperin's measurements in 1971 which were performed with high accuracy (11 600 b). At the same time we have three sets of measurements which are in agreement, namely Folger, 1968, Rukhe, 1971 (see Ref. [4]), and Gavrilov [77], which give a value only half as large for this integral (about 5100 b). We have recommended RI_c = 8300 b with a 50% error.

^{252}Cf. The number of secondary neutrons per fission (ν) for this isotope is based on Boldeman's recommendation [90], derived from a detailed analysis of ν measurements for fission by thermal neutrons. The energy dependence of the fission cross-section has been measured only above 20 eV [91]. The area beneath the $\sigma_f(E)$ curve has been determined for 35 resonances.

^{253}Es. For this isotope Benjamin's evaluation [13] was used, although it is difficult to reconcile the small thermal cross-section (155 b) with the large value RI_c = 7300 b. The resonance integral is given for E_c > 0.412 eV, and the influence of E_c on the resonance capture integral is not known.

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Table 1. Principal characteristics of elements in the KORT library

Isotope	Period (and mode) of decay	σ_c^T, б	g_c	RI_c, б	σ_f^T, б	g_f	RI_f, б	ν	Literature
^{228}Th	I,9I3 yr (α)	I23±I5	-	>I000	<0,3	-	-	-	[4]
^{229}Th	7300 yr (α)	54±6	I,043	I000±I80	30,5±3,0	I,025	464±70	2,08±0,03	present paper
^{230}Th	80000 yr (α)	23,2±0,6	I,0I3	I0I0±30	<0,00I2	-	-	-	[4]
^{231}Th	I,063 d (β)	-	-	-	-	-	-	-	-
^{232}Th	-	7,40±0,08	0,995	85+3	$0,0^{4}39\pm0,0^{5}4$	-	0,6I9	ν_{sp}=2,I2±0,I0	[4]
^{233}Th	22,3 months (β)	I500±I00	—	400±I00	I5±2	-	-	-	[4]
^{231}Pa	32760 yr (α)	20I±20	I,020	470±I00	0,0I2±0,006	-	-	-	present paper
^{232}Pa	I,3I d (β)	760±I00	-	-	700±I00	-	-	-	[4]
^{233}Pa	27 d (β)	4I±6;	0,98	895±30	<0,I	-	-	-	[I3]
^{233}Pa	27 d (β)	20±3(g);	-	-	-	-	-	-	[I3]
^{233}Pa	27 d (β)	2I±3(m)	-	-	-	-	-	-	[I3]
^{234}Pa (g)	6,75 h(β)	-	-	-	-	-	-	-	-
^{234}Pa (m)	I,I75 months (β)	-	-	-	-	-	-	-	-
^{232}U	72 yr(α)	73,I±I,5	0,973	280±I5	75,2±4,7	0,976	350±I00	ν_p=3,I3±0,06	present paper
^{233}U	I59200 yr (α)	40,6±2,5	I,022	I40±6	533,2±3,0	0,998	764±I3	2,469±0,008	[I4]
^{234}U	244600 yr (α)	I00±I,5	0,989	645±70	<0,65	-	-	-	[I3]
^{235}U	-	9I,9±2,3	0,98I	I44±6	588,I±I,9	0,980	275±5	2,404+0,006	[I4]
^{236}U	2,342·I0^{7} yr (α)	5,2±0,3	I,002	365±20	-	-	-	ν_{sp}=I,89±0,06	[I3]
^{237}U	6,75 d (β)	380±I00	—	I200±200	<0,35	-	-	-	[I3]
^{238}U	-	2,7I±0,02	I,002	278±5	$0,0^{5}53$	-	2,03	ν_{sp}=I,98±0,03	[20]
^{239}U	23,5 months (β)	22±5	-	-	I4±3	-	-	-	[4]
^{236}Np (g)	I,I·I0^{6} yr (β)	-	-	-	2500±I50	-	-	ν_{sp}=3,I2±0,I4	[4]
^{236}Np (m)	22,5 h (EC,β)	-	-	-	-	-	-	-	-
^{237}Np	2,I4·I0^{6} yr (α)	I69±3	0,952	660±50	0,0I9±0,003	-	6,9	-	[I3]
^{238}Np	2,II7 d (β)	-	-	-	2070±30	-	880±70	-	present paper

Table 1 (continued)

^{239}Np	2,354 d (β)	45±20	-	-	< 1	-	-	-	/4/
^{239}Np	2,354 d (β)	I4±I4(g)	-	-	-	-	-	-	/4/
^{239}Np	2,354 d (β)	3I±6(m)	-	-	-	-	-	-	/4/
^{240}Pu (g)	I,II7 h (β)	-	-	-	-	-	-	-	-
^{240}Pu (m)	7,5 months (β)	-	-	-	-	-	-	-	-
^{236}Pu	2,85 yr (α)	-	-	-	162±30	-	-	ν_{sp}=2,2I±0,I8	/I3/
^{237}Pu	45,4 d (EC)	-	-	-	2200±400	-	-	-	/I3/
^{238}Pu	87,74 yr (α)	547 ±20	0,956	162±15	I6,5±0,5	0,956	23±5	ν_p=2,90±0,03; ν_{sp}=2,24±0,08	present paper
^{239}Pu	24110 yr (α)	265,9±4,I	1,13I	190±20	748,1±2,8	I,065	310±10	2,860±0,009	/I4/
^{240}Pu	6553 yr (α)	287±I,4	1,028	8260±250	0,05±0,05	-	-	2,85±0,30; ν_{sp}=2,I7±0,01	present paper
^{241}Pu	14,7 yr (β)	355±8	I,04	162±8	1023±11	I,046	570±17	2,915±0,010	ibid
^{242}Pu	$3,76\cdot10^5$ yr (α)	I8,5±0,4	1,01	1280±50	0,2	-	4,7±4,7	ν_{sp}=2,I±0,02	"
^{243}Pu	4,956 h (β)	87±I3	-	265±60	180±30	-	540±I40	-	/I3/
^{241}Am	432,6 yr (α)	835,6±20	0,994	1400±90	3,I4±0,I0	I,0I4	22±2	ν_p=3,12±0,03	present paper
^{241}Am	432,6 yr (α)	752±20(g)	-	I190±80(g)	-	-	-	-	ibid
^{241}Am	432,6 yr (α)	83,6±2,6(m)	-	220±I5(m)	-	-	-	-	"
^{242}Am(g)	16,0I h (β)	-	-	~300	2100±I200	-	-	-	/I3/
^{242}Am(m)	I4I yr(IT)	1100±1100	1,I04	230±100	6900±400	I,I00	1900±300	ν_p=3,264±0,024	present paper
^{243}Am	7380 yr (α)	79±4	I,0I3	2060±I00	0,20±0,I1	-	10±6	-	ibid
^{243}Am	7380 yr (α)	4,I±0,2(g)	-	110±10(g)	-	-	-	-	"
^{243}Am	7380 yr (α)	75,2±1,8 (m)	-	I940±I00 (m)	-	-	-	-	"
^{244}Am(g)	10,1 h (β)	-	-	-	2300±300	-	-	-	/4/
^{244}Am(m)	26 months (β)	-	-	-	I600±300	-	-	-	/4/
^{242}Cm	162,8 d (α)	20±I0	0,927	I50±40	< 5	-	-	ν_{sp}=2,48±0,03	/I3/
^{243}Cm	28,5 yr (α)	13I±10	-	215±20	609±25	-	1550±200	ν_p=3,43±0,05	present paper
^{244}Cm	18,I1 yr (α)	I3,5±2,0	I,00I	625±50	I,0±0,2	0,998	19±2	3,24±0,02; ν_{sp}=2,69±0,01	ibid

Table 1 (continued)

Isotope	Period (and mode) of decay	σ_c^T, b	g_c	RI_c, b	σ_f^T, b	g_f	RI_f, b	ν	Literature
^{245}Cm	8500 yr (α)	350±30	0,936	104±8	2030±60	0,942	790±40	ν_p =3,832±0,34	present paper
^{246}Cm	4700 yr (α)	I,3±0,3	I,005	II7±8	0,I5±0,07	I,006	I2±2	ν_{sp} =2,96±0,08	ibid
^{247}Cm	I,6·I0^7 yr (α)	59±6	I,002	500±75	80±7	0,995	750±I00	ν_p =3,79±0,I5	"
^{248}Cm	3,6·I0^5 yr (α)	2,9±0,3	I,002	265±25	0,37±0,07		I4±2	ν_{sp}=3,I57±0,0I5	"
^{249}Cm	I,083 h (β)	-	-	-	-	-	-	-	
^{249}Bk	32I,4 d (β)	I800±I00	-	I400±700	-	-	-	ν_{sp}=3,39±0,03	"
^{250}Bk	3,22 h (β)	-	-	-	960±I50	-	-	-	[4]
^{251}Bk	56 months (β)	-	-	-	-	-	-	-	-
^{249}Cf	35I yr (α)	500±30	-	660±I20	I660±50	-	I900±I00	ν_p =4,06±0,04	present paper
^{250}Cf	13,I yr (α)	I750±250	-	8300±4000	<350	-	-	ν_{sp}=3,50±0,09	ibid
^{251}Cf	900 yr (α)	2850±290	-	I590±70	4800±480	-	5400±800	-	[13]
^{252}Cf	2,64 yr (α)	20,4±I,5	-	43±4	32±4	-	II0±20	ν_{sp}=3,745±0,0I0	[13]
^{253}Cf	I7,8 d (β)	I2±2	-	I2±2	II00±220	-	2000±500	-	[13]
^{254}Cf	60,5 d (SF)	σ_u =90±30	-	-	-	-	-	ν_{sp}=3,93±0,05	[4]
^{255}Cf	2,0 h (β)	-	-	-	-	-	-	-	
^{253}Es	20,47 d (α)	I55±20	-	7300±400	-	-	-	-	[13]
^{253}Es	20,47 d (α)	< 3(g)	-	4300±220(g)	-	-	-	-	[13]
^{253}Es	20,47 d (α)	I55±20(m)	-	3000±I80(m)	-	-	-	-	[18]
^{254}Es(g)	276 d (α)	$\sigma_u \approx \sigma_f$	-	-	2900±II0	-	2200±I00	-	[13]
^{254}Es(m)	I,637 d (β)	$\sigma_u \approx \sigma_f$	-	-	I840±80	-	-	-	[13]
^{255}Es	38,3 d (β)	43±I0	-	-	-	-	-	-	[13]
^{256}Es	7,6 h (β)	-	-	-	-	-	-	-	[4]
^{254}Fm	3,24 h (α)	76±76	-	-	-	-	-	ν_{sp} =3,96±0,I9	[4]
^{255}Fm	20,I h (α)	26±3	-	-	3400±I70	-	-	-	[4]
^{256}Fm	2,63 h(SF)	45±45	-	-	-	-	-	ν_{sp} =3,73±0,I8	[4]

Table 2

CHARACTERISTICS OF THE RESOLVED RESONANCE REGION

Isotope	Energy of last resonance, eV	Total number of reso-nances	Number of reso-nances in 0-5 eV range	Mode of cross-section calcu-lation	Literature
^{229}Th	9,I5	I2	8	I	[4]
^{230}Th	294	22	I	2	[4]
^{232}Th	3994	35I	0	2	[4]
^{231}Pa	99	II9	II	I	[4]
^{233}Pa	I7	23	8	I	[4]
^{232}U	74,2	I4	0	2	[4]
^{233}U	64,3	70	7	3	[I7]
^{234}U	I486	II8	0	2	[I8]
^{235}U	I0I	I43	7	3	[I6]
^{236}U	3967	I88	0	I	Present paper
^{238}U	5756	480	I	2	[I9,20]
^{237}Np	I50	I88	7	I	Present paper
^{238}Pu	496	53	I	I	[2I]
^{239}Pu	647	255	I	I	[4]
^{240}Pu	5692	262	I	2	Present paper
^{241}Pu	I00	86	3	3	[22]
^{242}Pu	3836	I3I	I	I	[4]
^{241}Am	49,3	78	8	I	Present paper
^{242}Am	3,3	6	≥6	I	" "
^{243}Am	250	220	7	I	" "
^{242}Cm	265	I3	≥0	I	[23]
^{243}Cm	25,8	I5	5	-	[4]
^{244}Cm	972	65	0	I	[24]
^{245}Cm	60	4I	5	I	Present paper
^{246}Cm	3I3	9	I	I	" "
^{247}Cm	38	I6	3	I	" "
^{248}Cm	239I	47	0	I	" "

Table 3

CHANGES MADE IN RESONANCE PARAMETERS PUBLISHED EARLIER IN OTHER PAPERS (see Table 2)

Isotope	Energy of resonance, eV	$2g\Gamma_n^0$, meV	Γ_γ, meV	Γ_f, meV
^{229}Th	0,609	0,I52	40	I0
^{230}Th	-7,9	7,26	24	-
^{232}Th	-4,4	3,2	2I	-
^{231}Pa	-0,3I8	0,I08	55	0,0028
^{231}Pa	0,494	0,0242	40	0,0I3
^{233}Pa	-0,2	0,009I7	50	-
^{233}Pa	0,4	0,00040	55	-
^{232}U	-0,6	0,287	45	-33
^{233}U	-2,8I	-	G_c=I02,9; H_σ=0,48	G_f=-23I5,3; H_f= -55I,99
^{234}U	-2,0	7,45	25	-
^{235}U	-I,05	-	G_σ=340,8; H_c= 20,0	G_f=I200; H_f= I9,97
^{238}U	-I,I4	I,I6	23,5	-
^{238}Pu	-I0	I0	36	I,0
^{238}Pu	- 0,4	I,322	36	I,06
^{239}Pa	- I,3	I,87	22,7	I7I,27
^{239}Pa	- I,478	-	G_c=445,0	G_f=6960
^{241}Pa	- 0,209	-	G_c= 2I,76	G_f= I9,2
^{242}Pa	2,67	2,48	25	0,0I53
^{242}Cm	- 0,I	0,0038	40	-
^{244}Cm	- 6,8	2,68	36	6,I

Notes: (1) Altered values are underlined;

(2) The parameters H and G are in units of $\sigma/eV^{3/2}$

Table 4

EVALUATED RESONANCE PARAMETERS FOR ^{236}U (FIRST 50 RESONANCES)

i	E_0, eV	Γ_n, meV	Γ_γ, meV	Γ_f, meV	i	E_0, eV	Γ_n, meV	Γ_γ, meV	Γ_f, meV
I	-9,7	5,5	23	-	26	335,0	6,4	23	
2	5,45	2,I6	24,5	0,29	27	357,0	0,65	23	-
3	29,7	0,585	23	0,I6	28	367,0	0,4	23	-
4	34,0	2,4	20,9	0,I6	29	37I,2	I4	24	0,42
5	43,92	I3	20	0,43	30	379,8	93	23	0,30
6	63,I	0,035	23	-	3I	4I5,4	I6	22	-
7	7I,47	I9	23	0,29	32	43I,0	59	22	-
8	86,57	27	22	0,30	33	440,6	6I	24	-
9	I02,25	0,8	23	-	34	465,5	I4	I8	-
I0	I20,95	5I	22	0,34	35	478,4	38	2I	-
II	I24,88	I7	2I	0,2I	36	500,4	2,8	23	-
I2	I34,57	I,2	23	-	37	507,I	I9	22	-
I3	I37,76	0,49	23	-	38	536,4	30	22	-
I4	I64,70	2,I	23	-	39	542,8	I0,3	30	-
I5	I89,90	2,5	23	-	40	563,8	80	22	-
I6	I92,90	9,0	23	-	4I	576,2	I45	26	-
I7	I94,40	44,4	20	-	42	607,I	I4	20	-
I8	2I2,80	87	23	0,32	43	6I7,8	53	24	-
I9	229,6	2,I	23	-	44	637,8	77	24	-
20	243,0	0,3	23	-	45	647,6	6,6	23	-
2I	26I,9	I,0	23	-	46	655,6	99	23	-
22	272,9	30	24	0,52	47	673,6	57	24	-
23	286,7	I3	25	0,53	48	691,3	33	27	-
24	303,2	77	23	0,48	49	706,0	29	2I	-
25	320,5	5,4	23	-	50	720,6	96	2I	-

Table 5

EVALUATED RESONANCE PARAMETERS FOR ^{237}Np (FIRST 50 RESONANCES)

i	E_0, eV	J	$2g\Gamma_n^0$, meV	Γ_γ, meV	Γ_f, meV	i	E_0, eV	J	$2g\Gamma_n^0$, meV	Γ_γ, meV	Γ_f, meV
I	-0,2	2	0,0392	4I	0,005I	6	3,86	3	0,24	4I,4	0,003
2	0,489	2	0,032	34	0,00I24	7	4,26	2	0,027	37,5	0,0002
3	I,33	3	0,032	39,8	0,005I	8	4,87	2	0,034	36,7	0,00007
4	I,48	2	0,I43	48,2	0,00I4I	9	5,77	3	0,628	44,2	0,005
5	I,97	3	0,0I66	4I,2	0,00543	I0	6,38	3	0,094	38,I	0,00I4

Table 5 (continued)

i	E_0, eV	J	$2g\Gamma_n^0$, meV	Γ_γ, meV	Γ_f, meV	i	E_0, eV	J	$2g\Gamma_n^0$, meV	Γ_γ, meV	Γ_f, meV
II	6,67	2	0,0I2	48	0,0029	3I	I9,I2	3	0,I06	42,6	0,003I
I2	7,I9	2	0,0078	35	0,00I5	32	I9,90	3	0,07I	36	0,003
I3	7,43	3	0,I48	40	0,0042	33	20,39	2	I,I3	42	0,0007
I4	8,3I	3	0,I07	38	0,002I	34	2I,09	3	0,53	48	0,00I9
I5	8,98	3	0,I25	39	0,0086	35	2I,30	2	0,023	40	0,0058
I6	9,30	2	0,522	4I	0,0003	36	22,0I	2	I,26	4I	0,00I0
I7	I0,23	2	0,025	38	0,00I3	37	22,86	3	0,44	43	0,004I
I8	I0,68	3	0,5I	36	0,00I5	38	23,67	3	I,69	4I	0,0003
I9	I0,84	3	0,87	44	0,0008	39	23,97	2	0,I7	6I	0,0006
20	II,09	2	0,89	43	0,0004	40	24,97	3	4,6I	4I	0,0036
2I	I2,20	3	0,062	50	0,00I9	4I	26,I9	3	0,26	40	0,0306
22	I2,62	2	0,795	42	0,0005	42	26,56	3	2,8	4I	0,0225
23	I3,I4	3	0,02	40	0,00I6	43	27,07	3	0,025	40	0,0043
24	I5,8I	3	0,I2	4I	0,00I8	44	28,48	2	0,I46	40	0,0002
25	I6,08	2	0,93	50	0,0005	45	28,92	2	0,I7	40	0,000I
26	I6,87	2	0,243	42	0,0003	46	29,46	3	0,086	40	0,0099
27	I7,02	3	0,006	4I	0,0049	47	30,42	3	3,76	4I	0,0798
28	I7,59	3	0,I84	40	0,0005	48	30,75	2	0,30	54	0,005I
29	I7,89	2	0,0I8	40	0,0039	49	3I,32	3	0,26	36	0,0069
30	I8,88	2	0,037	40	0,0026	50	3I,65	2	0,048	40	0,0039

Table 6

EVALUATED RESONANCE PARAMETERS FOR ^{240}Pu (FIRST 50 RESONANCES)

i	E_0, eV	Γ_n, meV	Γ_γ, meV	Γ_f, meV	i	E_0, eV	Γ_n, meV	Γ_γ, meV	Γ_f, meV
I	I,059	2,38	32,2	0,007	I2	I35,3	I8,5	32	-
2	20,45	2,65	32,2	0,5	I3	I5I,9	I4,2	29,5	-
3	38,32	I7	28,5	0,2	I4	I62,7	8,6	28	-
4	4I,62	I5,5	3I	0,I3	I5	I70,I	I3,7	29,5	-
5	66,62	52	30,5	0,38	I6	I85,8	I6,3	3I,5	-
6	72,78	2I	29,5	0,49	I7	I92,0	0,2	30,8	-
7	90,77	I3,5	28	0	I8	I99,6	0,94	30,8	-
8	92,5I	3	30,8	I,I	I9	239,2	I2,2	29	-
9	I05,0	43	34	0,5	20	260,5	23,2	32	-
I0	I2I,6	I4,5	3I,5	0,5	2I	287,I	I32	30,5	-
II	I30,7	0,I5	30,8	–	22	304,9	7,2	30,8	-

Table 6 (continued)

i	E_0, eV	Γ_n, meV	Γ_γ, meV	Γ_f, meV	i	E_0, eV	Γ_n, meV	Γ_γ, meV	Γ_f, meV
23	318,3	5,2	30,8	-	37	514,3	21,5	30,8	-
24	320,7	19,3	30,8	-	38	526,1	0,91	30,8	-
25	336,4	5,7	30,8	-	39	530,8	0,7	30,8	-
26	346,0	16,5	30,8	-	40	546,4	31,0	34,5	-
27	363,7	32,5	34	-	41	553,2	16,5	30,8	-
28	372,0	13,8	28,5	-	42	566,3	31,5	28	-
29	405,0	106	30	2,0	43	596,8	57,5	32	-
30	419,0	6,1	30,8	-	44	606,1	22,8	30	0,06
31	445,6	1,6	30,8	-	45	632,5	13,3	30,8	0,44
32	449,8	16,5	30,8	-	46	637,5	11,7	30,8	0,17
33	466,5	3,1	30,8	-	47	665,1	195	31,5	0,48
34	473,3	4,2	30,8	-	48	678,6	28	30,8	0,78
35	493,9	5,8	30,8	-	49	712,1	1,3	30,8	0,8
36	499,3	19,3	34,5	-	50	743,3	1	30,8	3,0

Table 7

EVALUATED RESONANCE PARAMETERS FOR ^{241}Am (FIRST 50 RESONANCES)

i	E_0, eV	J	Γ_n, meV	Γ_γ, meV	Γ_f, meV	i	E_0, eV	J	Γ_n, meV	Γ_γ, meV	Γ_f, meV
1	-0,425	2	0,9415	45	0,1463	17	9,85	2	0,415	44	0,97
2	0,306	2	0,055	46,7	0,29	18	10,11	3	0,025	44	0,16
3	0,584	3	0,092	47	0,15	19	10,4	3	0,325	42,5	0,06
4	1,28	2	0,316	48,7	0,34	20	11,0	2	0,407	46,6	0,13
5	1,93	3	0,112	44,5	0,07	21	11,58	3	0,017	44	-
6	2,37	3	0,072	42,6	0,17	22	12,14	2	0,007	44	-
7	2,60	2	0,152	46,2	0,14	23	12,88	3	0,131	44	0,06
8	3,97	2	0,193	44,3	0,14	24	13,87	3	0,011	44	-
9	4,97	3	0,177	43,6	0,33	25	14,36	2	0,071	44	-
10	5,42	3	0,766	44,1	0,52	26	14,68	2	2,31	40,4	0,27
11	5,80	2	0,002	44	-	27	15,69	3	0,244	39,2	0,10
12	6,12	2	0,127	43,7	0,35	28	16,39	3	1,214	42	0,11
13	6,75	3	0,029	44	0,15	29	16,85	2	0,629	41	0,32
14	7,66	3	0,036	44	0,10	30	17,73	2	0,394	37,4	0,30
15	8,17	3	0,108	42,6	0,15	31	18,17	3	0,43	44	-
16	9,11	2	0,381	44,3	0,12	32	19,45	3	0,212	37	0,03

Table 7 (continued)

i	E_0, eV	J	Γ_n, meV	Γ_γ, meV	Γ_f, meV	i	E_0, eV	J	Γ_n meV	Γ_γ, meV	Γ_f, meV
33	20,33	2	0,044	44	-	42	26 ,50	3	0,54	22	0,26
34	20,88	3	0,088	44	-	43	26,67	3	0,208	44	0,34
35	2I,74	2	0,080	44	0,27	44	27,58	2	0,I67	44	2,54
36	22,75	2	0,069	44	0,58	45	27,73	2	0,58	7I	0,44
37	23,08	3	0,4I5	42	0,50	46	28,36	3	0,567	45	0,35
38	23,34	3	0,446	42	0,24	47	28,90	3	0,474	49	0,26
39	24,I9	2	I,3	39	0,3I	48	29,50	2	0,694	45	0,27
40	25,0I	3	0,0I4	44	-	49	29,96	3	0,080	44	-
4I	25,63	3	I,26	38	0,56	50	30,82	2	0,I76	44	I,2

Table 8

EVALUATED RESONANCE PARAMETERS FOR $^{242}Am^m$

i	E_0, eV	$2g\Gamma_n$, meV	Γ_γ, meV	Γ_f, meV	i	E_0, eV	$2g\Gamma_n$, meV	Γ_γ, meV	Γ_f, meV
I	0,I73	0,2I44	4I	243	4	I,65	0,II3	50	400
2	0,6I0	0,08I	50	I70	5	2,09	0,I95	50	325
3	I,02	0,356	50	I000	6	3,25	0,844	50	650

Table 9

EVALUATED RESONANCE PARAMETERS FOR ^{243}Am (FIRST 50 RESONANCES)

i	E_0, eV	J	$2g\Gamma_n^0$, meV	Γ_γ, meV	i	E_0, eV	J	$2g\Gamma_n^0$, meV	Γ_γ, meV
I	-2,0	2	I,0	39	I2	7,863	3	0,50	38
2	0,42	3	0,00I3	39	I3	8,377	3	0,003	40
3	0,983	3	0,0I47	38	I4	8,77	2	0,040	40
4	I,356	2	0,89	47	I5	9,3I4	3	0,047	4I
5	I,744	3	0,I75	39	I6	I0,3I4	2	0,I3	48
6	3,I4	2	0,0066	37	I7	I0,877	3	0,004	37
7	3,424	3	0,I5	4I	I8	II,278	3	0,083	45
8	3,845	3	0,006I	32	I9	II,693	2	0,03I	30
9	5,I25	2	0,I3	5I	20	I2,I22	3	0,047	39
I0	6,554	3	0,36	43	2I	I2,877	2	0,65	40
II	7,067	2	0,027	43	22	I3,I52	3	0,36	43

Table 9 (continued)

i	E_0, eV	J	$2g\Gamma_n^0$, meV	Γ_γ, meV	i	E_0, eV	J	$2g\Gamma_n^0$, meV	Γ_γ, meV
23	15,143	2	0,023	36	37	24,454	3	0,17	22
24	15,404	3	0,26	40	38	25,415	3	0,031	40
25	16,210	2	0,131	43	39	26,237	2	0,009	31
26	16,563	2	0,045	31	40	26,750	3	0,270	37
27	17,874	3	0,055	38	41	27,355	2	0,09	37
28	18,156	3	0,013	27	42	28,735	3	0,19	37
29	19,533	2	0,017	27	43	29,300	3	0,13	37
30	19,915	3	0,022	40	44	30,130	2	0,098	37
31	20,974	2	0,11	29	45	31,070	3	0,14	37
32	21,115	3	0,22	16	46	31,490	2	0,026	37
33	21,872	2	0,030	27	47	32,420	3	0,09	37
34	22,011	3	0,011	37	48	33,200	2	0,25	37
35	22,600	3	0,15	33	49	33,940	3	0,23	37
36	22,739	2	0,21	19	50	34,990	2	0,17	37

Table 10

EVALUATED RESONANCE PARAMETERS FOR ^{245}Cm

i	E_0, eV	J	$2g\Gamma_n^0$, meV	Γ_γ, meV	Γ_f, meV	i	E_0, eV	J	$2g\Gamma_n^0$, meV	Γ_γ, meV	Γ_f, meV
1	-0,1	0	0,041	41	222	18	25,8	1	0,043	40	550
2	0,9	1	0,09	40	720	19	26,8	1	0,8	40	130
3	2,0	1	0,26	40	210	20	27,6	0	0,73	40	200
4	2,49	1	0,11	40	340	21	29,4	0	3,7	40	350
5	3,44	0	0,02	40	160	22	31,7	1	0,6	40	730
6	4,71	1	2	40	340	23	33,0	1	0,37	40	4,0
7	5,75	1	0,11	40	300	24	34,6	1	0,23	40	61
8	7,53	1	1,9	40	260	25	35,3	0	7,6	40	4200
9	8,9	0	0,52	40	520	26	36,3	0	1,54	40	189
10	9,22	1	0,45	40	130	27	39,4	1	0,65	40	102
11	10,17	1	0,35	40	350	28	40,44	0	4,48	40	585
12	11,39	1	0,75	40	130	29	42,45	1	5,37	40	10,0
13	13,56	1	0,059	40	45	30	43,1	1	1,73	40	537
14	13,91	0	0,263	40	120	31	44,57	1	2,61	40	694
15	15,60	0	0,79	40	330	32	45,74	1	0,59	40	901
16	21,4	1	2,9	40	490	33	47,51	1	3,56	40	28
17	24,8	1	3,4	40	210	34	49,2	0	5,04	40	1400

Table 10 (continued)

i	E_0, eV	J	$2g\Gamma_n^0$, meV	Γ_γ, meV	Γ_f, meV	i	E_0, eV	J	$2g\Gamma_n^0$, meV	Γ_γ, meV	Γ_f, meV
35	50,48	I	I,79	40	75I	39	56,32	I	I,4	40	505
36	5I,64	I	0,63	40	207	40	58,54	I	I3,9	40	393
37	53,63	0	I2,4	40	896	4I	59,99	0	0,6I	40	5I8
38	54,63	I	0,33	40	I057						

Table 11

EVALUATED RESONANCE PARAMETERS FOR ^{246}Cm

i	E_0, eV	Γ_n, meV	Γ_γ, meV	Γ_f, meV	i	E_0, eV	Γ_n, meV	Γ_γ, meV	Γ_f, meV
I	4,3I	0,33	32	4,2	6	250,7	9	34	0,36
2	I5,29	0,54	32	0,I	7	278,3	7	34	I,3
3	84,43	22	34	0,7	8	286,2	59	34	0,3I
4	9I,84	I2	34	0,I7	9	3I3,4	25	34	0,I5
5	I58,4	30	34	0,73					

Table 12

EVALUATED RESONANCE PARAMETERS FOR ^{247}Cm

i	E_0, eV	J	$2g\Gamma_n^0$, meV	Γ_γ, meV	Γ_f, meV	i	E_0, eV	J	$2g\Gamma_n^0$, meV	Γ_γ, meV	Γ_f, meV
I	-I,0	5	0,33I	40	73	9	25,35	5	0,00I	39,6	30
2	I,247	4	0,50I5	40	34	I0	26,20	4	0,00I5	40,9	3I0
3	2,9I9	5	0,0585	40	30	II	28,04	5	0,0055	40,5	73
4	3,I89	4	0,56	40	63	I2	30,25	4	0,3I34	40	4
5	9,55	5	0,294	40	I26	I3	30,62	5	0,0I7I	39	72
6	I8,I	4	0,87	40	I70	I4	32,23	4	0,0446	40	27
7	2I,3I	5	0,0I33	40,5	549	I5	36,36	5	0,I353	40,I	84
8	24,04	4	0,0045	40	I76	I6	37,87	4	0,0078	49,9	708

Table 13

EVALUATED RESONANCE PARAMETERS FOR ^{248}Cm

i	E_0, eV	$g\Gamma_n$, meV	Γ_γ, meV	Γ_f, meV	i	E_0, eV	$g\Gamma_n$, meV	Γ_γ, meV	Γ_f, meV
1	-13,0	0,48	26	28,8	24	887,1	3,3	26	-
2	7,247	0,66	23	0,06	25	956,6	3,5	26	-
3	26,9	4,2	32	0,06	26	994,2	3,9	26	-
4	35,01	1,8	30,2	-	27	1042,0	5,9	26	-
5	78,1	11,4	26	3,3	28	1103,3	6,6	26	-
6	98,95	16	26	0,47	29	1193,6	9,5	26	-
7	140,3	0,129	26	-	30	1209,7	1,0	26	-
8	188,4	0,311	26	-	31	1262,0	7,6	26	-
9	237,93	1,07	26	-	32	1276,6	5,0	26	-
10	258,7	3,9	26	-	33	1288,1	1,5	26	-
11	321,8	1,47	26	-	34	1389	10,9	26	-
12	380,6	4,8	26	-	35	1505	17,6	26	-
13	415,7	2,45	26	-	36	1646	3,2	26	-
14	457,7	3,53	26	-	37	1812	12,8	26	-
15	484,9	0,44	26	-	38	1910	2,7	26	-
16	541,8	16,5	26	-	39	2040	4,4	26	-
17	605,3	3,0	26	-	40	2071	17,2	26	-
18	647	4,3	26	-	41	2138	10,2	26	-
19	688,6	1,4	26	-	42	2156	3,4	26	-
20	694,3	2,7	26	-	43	2215	13,9	26	-
21	721,5	5,4	26	-	44	2234	1,8	26	-
22	769,4	2,2	26	-	45	2291	6,9	26	-
23	865,9	16,7	26	-	46	2369	10,2	26	-
					47	2391	6,6	26	-

Table 14

Parameter measurements by different methods for ^{233}U and ^{235}U

Parameter	Measurements with E = 0.0253 eV	Maxwellian spectrum average: Measurement with E = 0.0253 eV and calculated g_c, g_f	Maxwellian spectrum average: Measurement over the spectrum	Difference between columns 3 and 4
I	2	3	4	5
		^{233}U		
σ_a	573,8±I,8	573,I±2,I	574,3±3,7	+0,8
σ_f	533,2±3,0	53I,4±3,I	526,9±3,4	-4,5(0,9%)
σ_c	40,6±2,5	4I,7±2,7	47,4±0,4	+5,7(I3%)
α	0,076±0,005	0,076±0,005	0,090±0,00I	+0,0I2(I5%)
η	2,294±0,009	2,289±0,0I0	2,296±0,0I9	+0,007
ν	2,469±0,008	-	-	-
		^{235}U		
σ_a	680,0±I,8	665,I±2,0	663,6±4,5	-I,5
σ_f	588,I±I,9	574,9±2,0	566,0±3,8	-8,9(I,5%)
σ_c	9I,9±2,3	90,3±2,3	97,5±0,8	+7,2(8%)
α	0,I56±0,004	0,I57±0,004	0,I72±0,004	+0,0I5(I0%)
η	2,079±0,008	2,077±0,008	2,090±0,0I6	+0,0I3
ν	2,404±0,006	-	-	-

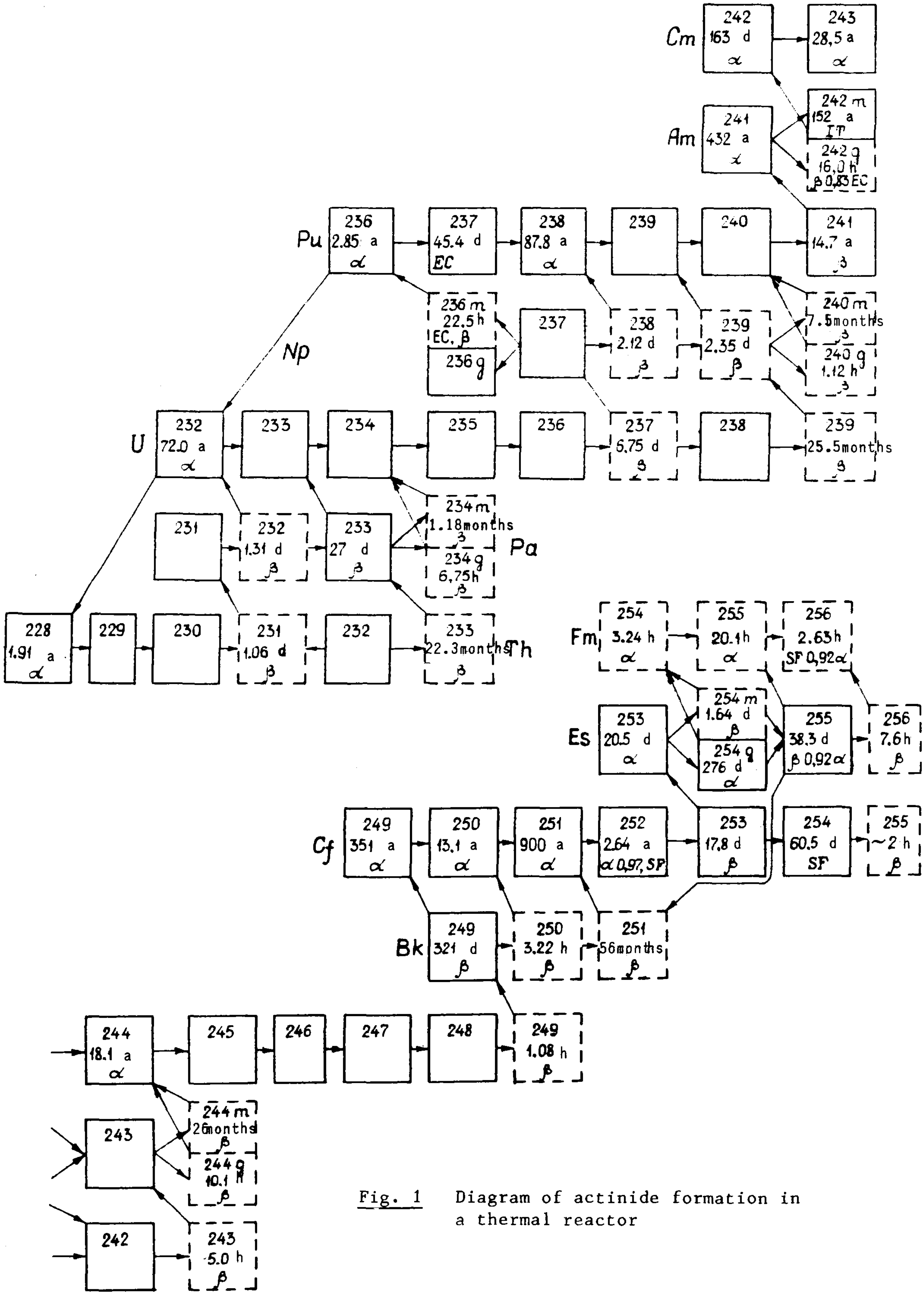

Fig. 1 Diagram of actinide formation in a thermal reactor

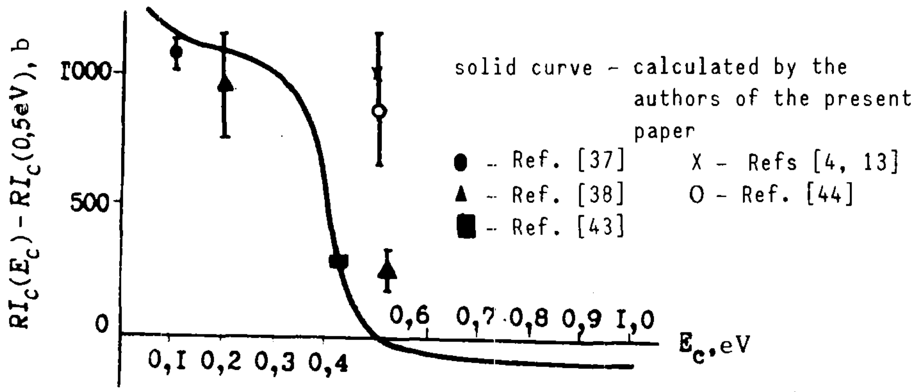

Fig. 2 Energy dependence of the resonance capture integral for ^{231}Pa

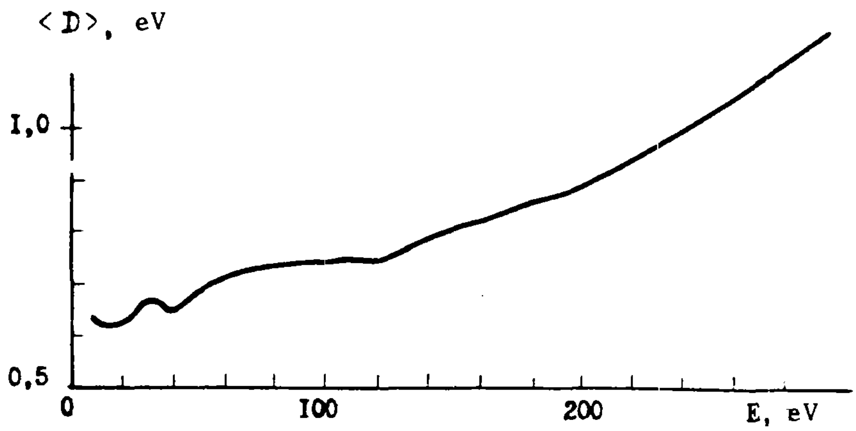

Fig. 3 Mean level spacing <D> versus energy for ^{237}Np

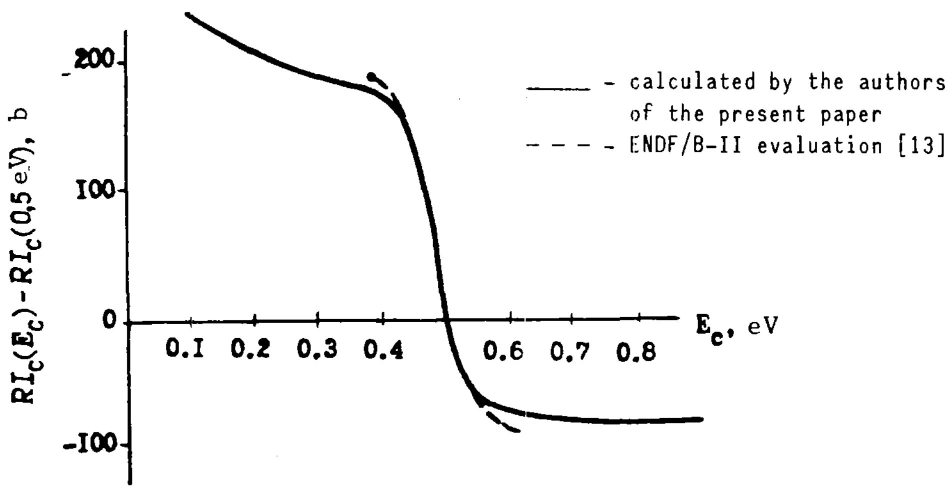

Fig. 4 Energy dependence of the ^{237}Np resonance capture integral

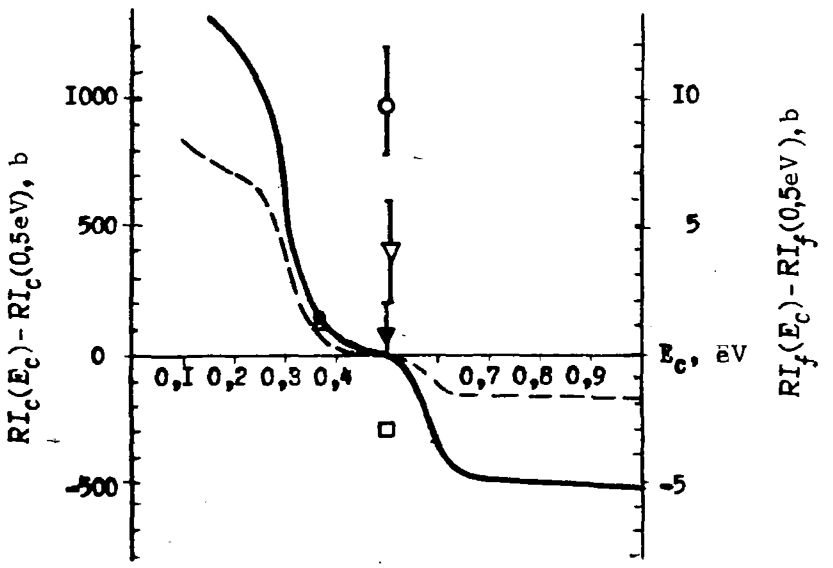

Fig. 5 Energy dependence of resonance capture (____) and fission (_ _ _) integrals for ^{241}Am [RI_c (0.5 eV) = 1400 b; RI_f (0.5 eV) = 22 b]:

▼ - Ref. [4], E_c = 0.5 eV

∇ - Gavrilov et al. [59], E_c not determined

O - Bak, 1968, taken from Ref. [13], E_c not determined

● - Macmurdo, 1973, taken from Ref. [13], E_c = 0.369 eV

□ - Schumann, 1969, taken from Ref. [13], E_c not determined

Δ - Ref. [64], E_c = 0.369 eV

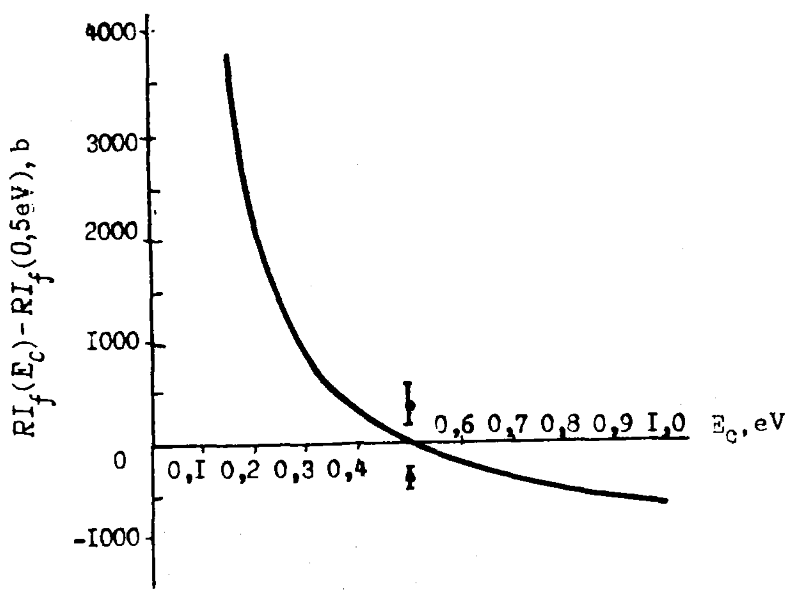

Fig. 6 Energy dependence of the resonance fission integral for $^{242}Am^m$ [RI_f (0.5 eV) = 1900 b]:

● - Ref. [62]; ▲ - Perkins (see Ref. [13])