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EVALUATION OF THE ^{235}U FISSION CROSS-SECTION

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1. INTRODUCTION

In this paper we evaluate the cross-section for ^{235}U fission in the energy region 1 keV-15 MeV, which is the most important from the point of view of fast reactor physics. We have not tried to re-evaluate the effects of resonance self-shielding; in the case of ^{235}U their influence in the keV region can hardly be evaluated from data obtained with the well-known 26-group system of constants. Only the fission cross-section averaged over many resonances has been evaluated.

The need for a new evaluation of the ^{235}U fission cross-section has arisen because the past two years have seen the publication of a considerable number of new experimental results relating to this very important cross-section and because, by taking these results into account, the reliability of the evaluated curve can be improved.

It should be noted, however, that the accuracy of the existing experimental results is still not high enough to meet the requirements of fast reactor designers. Consequently, although the results of the new fission cross-section evaluation are more accurate and reliable than the results of earlier evaluations, the accuracy of a computational prediction of the physical characteristics of fast reactors based on the results of this evaluation may prove to be no higher - perhaps even lower - than the accuracy achieved if one uses the existing systems of group constants, which are devised not only on the basis of an evaluation of the results of direct cross-section measurements, but also with allowance for the degree of agreement between the results of calculations relating to actual reactors and existing experimental data.

Thus, the results of our work cannot be recommended for direct use in practical calculations; they should first be verified and, if possible, corrected through analysis of the results of all macroscopic experiments involving fast neutrons. Only then will the resulting data ensure a computational accuracy higher than that which can be achieved at present.

Accordingly, our first aim was to obtain the most accurate and reliable zeroth approximation possible for further correction of the ^{235}U fission cross-section in the analysis of the results of macroscopic experiments. Our second aim was to obtain the most accurate ^{235}U fission cross-section values possible as a standard to be used in measuring cross-sections for the fission and capture of other elements and isotopes.

In the energy region 100 keV-1 MeV, the ^{235}U fission cross-section is a comparatively smooth function of energy and one of the cross-sections known with the greatest precision. Consequently, and because of the simplicity of recording the ^{235}U fission reaction, ^{235}U is widely used as a standard in measuring cross-sections.

At energies above 1 MeV the ^{235}U fission cross-section is known with considerably less precision, while at energies below 100 keV major fluctuations are observed in the fission cross-section, so that the use of this cross-section as a standard in these energy regions is less justified.

Nevertheless, in these energy regions also ^{235}U has been used as a standard in many studies relating to the measurement of cross-sections.

In evaluating nuclear data it is important that the same standard cross-sections be used throughout. The result of our evaluation of the ^{235}U fission cross-section can probably be recommended as a standard for 1972.

2. EXPERIMENTAL DATA USED IN EVALUATING THE ^{235}U FISSION CROSS-SECTION

From the large number of experimental studies on the ^{235}U fission cross-section, we have selected for evaluation primarily those in which the cross-section was measured either absolutely (flux determination by the associate-particle, associate-activity, manganese-bath and other methods) or relative to the cross-sections for neutron scattering in hydrogen.

In cases where the cross-section was measured absolutely at one or two energy points to which a curve measured relatively at many points was then fitted, we tried to select for evaluation only the results of absolute measurements, for both the measurement of the relative shape of a fission cross-section curve and the fitting operation may have involved additional errors not taken into account by the authors, so that the reliability of these data is reduced.

However, it was not always possible to discard the results of such measurements. At energies above 1 MeV, for example, the number of reliably measured points on the fission cross-section curve is not sufficient for one to draw a smooth curve through them without recourse to the results of measurements of the fission cross-section energy dependence.

At low energies (below 100 keV), in addition to the results of absolute measurements we used time-of-flight data normalized to cross-sections for the reactions $^{10}B(n,\alpha)$ and $^{6}Li(n,\alpha)$.

Below we discuss briefly the works selected by us. The results reported in most of them were used in our evaluation.

(a) Experiment of Szabo et al. [1]

Ref. [1] contains corrected data previously presented at the Second International Conference on Nuclear Data for Reactors, held at Helsinki [13]. In the paper presented at the Helsinki Conference, the correction for neutron scattering in the fission chamber walls was made by means of a programme which did not take into account the angular trajectory of a scattered neutron relative to the plane of the fission foils. This angular effect gives rise to a significant increase in the effective thickness of the fission foils for the scattered neutrons.

The measurements reported in Ref. [1] were performed in the energy region 17 keV-1 MeV with monoenergetic neutrons from a Van de Graaff accelerator. The neutron flux was measured by means of BF_3 counters in a paraffin moderator, the efficiency of the counters being determined by three methods - the manganese-bath method, the recoil-proton method and the associate-particle method.

Neutron scattering in the fission chamber walls and in the target holders was calculated by the Monte Carlo method.

In their experiment, Szabo et al. used the same type of fission chamber as White in Ref. [3]. Their results are presented in Table 1.

Table 1

Results obtained by Szabo et al. [1]

E_n (keV)	σ_f (barn)	E_n (keV)	σ_f (barn)
I7,5±3,5	2,I50±0,090	227 ± I6	I,295±0,035
27±3,5	2,I0 ± 0,08	25I ± II	I,285±0,035
42±5	I,80 ± 0,06	257 ± I5	I,275±0,055
68±5	I,765±0,045	272 ± I5	I,275±0,045
72,5±6,5	I,740±0,055	286 ± I5	I,270±0,035
95±5	I,540±0,055	3I3 ± I5	I,285±0,045
II0±I0	I,530±0,050	320 ± 8	I,I90±0,045
I20±8	I,570±0,055	33I ± I5	I,2I0±0,045
I25±7	I,500±0,050	369 ± I5	I,2I5±0,045
I45±9	I,500±0,055	407 ± I5	I,205±0,035
I50±6	I,45±0,045	506 ± I7	I,I60±0,030
I52±I0	I,440±0,040	540 ± I0	I,I60±0,045
I54±I4	I,440±0,035	665 ± 22	I,I40±0,035
I56±I2	I,450±0,045	8I0 ± 35	I,I35±0,035
I95±II	I,365±0,055	I0I0 ± 40	I,205±0,035
2I5+I0	I,325±0,045		

(b) Experiment of Szabo et al. [2]

Measurements with a Van de Graaff accelerator were also performed by Szabo et al. in the energy region 10-200 keV. The measurement techniques employed in Ref. [2] were the same as those used in Ref. [1]. The only difference was that, instead of a chamber of the type used by White [3], a new fission chamber with thinner walls (to reduce neutron scattering) was constructed and ^{235}U fission foils were prepared (at Geel, Belgium). The results obtained by Szabo et al. in Ref. [2] are presented below.

Table 2

Values of $\sigma_f(^{235}U)$ obtained by Szabo et al. [2]

E_n (keV)	σ_f (barn)
II,5 ± 3	2,7I ± 0,09
I5,0 ± 3	2,45 ± 0,07
22,5 ± 2,5	2,I6 ± 0,06
33,0 ± 5,0	I,98 ± 0,06
46,0 ± 5,0	I,8I ± 0,05
58,0 ± 3,0	I,79 ± 0,05
78 ± 2,5	I,67 ± 0,05
83,5 ± II,0	I,62 ± 0,05
93,0 ± 4,0	I,52 ± 0,04
I03,5 ± 5,5	I,50 ± 0,04
II6,0 ± I5,0	I,49 ± 0,04
I35,0 ± 5,0	I,39 ± 0,04
I50,0 ± 5,0	I,43 ± 0,04
I72,0 ± 5,5	I,43 ± 0,04
I99,0 ± 5,5	I,39 ± 0,04

(c) Experiment of White [3]

White [3] made absolute measurements of the ^{235}U fission cross-section in the energy region 0.04-14 MeV using the cross-section for scattering in hydrogen as reference cross-section. The weight of the foils was known to within less than 1%. The measurements were performed at an angle of 135^o to the direction of the proton beam.

The fission cross-section obtained by White at 40 keV is open to criticism. In his absolute ^{235}U fission cross-section measurements [3] White used the same fission chamber and foils as in his measurement of the ratio $\sigma_f(^{239}Pu)/\sigma_f(^{235}U)$ [14]. In both cases there is observed at 40 keV a difference of the order of

16% between the results of White and those of Szabo et al. [1, 2]. White found that the correction for neutron scattering in the fission chamber and in the target was 1-4%.

In their first series of measurements [1], Szabo et al. used the same type of fission chamber as White, but their correction for neutron scattering in the chamber and the target (calculated by the Monte Carlo method) was 13% in the energy region 28-40 keV.

In the second series of measurements [2], Szabo et al. used a chamber with very thin walls made of iron (not titanium as in the case of the fission chamber type used by White), so that the correction for neutron scattering from the chamber walls was only 4% at 40 keV. As the two series of independent measurements by Szabo et al. yielded results which are in good agreement, it would appear that White's correction for neutron scattering was applied incorrectly. This correction is important only at low neutron energies.

White's results are presented below.

Table 3

Results obtained by White [3]

E_n (keV)	$\sigma_f(^{235}U)$ (barn)
40 ± 4	2,10 ± 3%
67 ± 5	1,786 ± 3%
127 ± 15	1,54 ± 2,5%
160 ± 20	1,52 ± 2,5%
207 ± 20	1,38 ± 2,5%
312 ± 20	1,30 ± 2,5%
404 ± 20	1,22 ± 2,5%
505 ± 20	1,17 ± 2,5%
1000 ± 50	1,22 ± 2,5%
2250 ± 50	1,31 ± 3%
5400 ± 100	1,00 ± 5%
14100 ± 50	2,17 ± 2%

The influence of neutrons scattered in the fission chamber walls was taken into account by reducing the cross-section at the point corresponding to 40 keV by 11% in accordance with the data of Szabo et al. [2]; the error assumed in order to take into account the uncertainties associated with this correction was increased to 7%. It is therefore assumed that $\sigma_f(^{235}U) = 1.89 \pm 0.13$ at 40 keV.

(d) Experiment of Gorlov et al. [4]

The absolute measurements were performed at only one energy - 270 keV. Relative measurements were performed in the region 3-800 keV. In the case of the absolute measurements, the neutron flux was determined by means of a long counter calibrated using a standard Ra-Be source which produced a flux known to within ± 3.5%. The amount of uranium was determined by weighing and by alpha counting (agreement to within 1%). The error given by the authors was 7%. The results of Gorlov et al. are presented below.

Table 4

Results obtained by Gorlov et al. [4]

E_n (keV)	$\sigma_f(^{235}U)$ (barn)
3,4 ± 0,8	4,83 ± I,0
9	3,33 ± 0,36
29	2,66 ± 0,I9
36	2,I7 ± 0,I5
39	2,30 ± 0,I6
48	I,83 ± 0,I3
50	2,I0 ± 0,I5
65	2,07 ± 0,I5
76	I,80 ± 0,I3
95	I,62 ± 0,II
I00	I,68 ± 0,I2
II5	I,57 ± 0,II
I25	I,77 ± 0,I2
I70	I,40 ± 0,I0
2I0 ± 28	I,35 ± 0,I0
270	I,30 ± 0,09
280	I,40 ± 0,I0
340 ± I3	I,20 ± 0,09
355	I,20 ± 0,09
430	I,20 ± 0,09
490	I,I0 ± 0,08
530	I,I2 ± 0,08
560	I,05 ± 0,07
780	I,05 ± 0,07

It is not clear from this work whether a correction was made for neutron scattering in the fission chamber and the target and, if so, how large the correction was. Bearing in mind that the results of the relative measurements may reflect an additional error which cannot be estimated on the basis of the published experimental information, in carrying out our evaluation we took into account only the point corresponding to 270 keV, at which the authors measured the cross-section absolutely.

(e) Experiment of Diven [5]

Absolute measurements of $\sigma_f(^{235}U)$ were performed at an energy of 1.27 MeV and relative measurements in the energy region 0.4-1.6 MeV. The neutron flux was measured by recording recoil protons with a thin hydrogen-filled counter. The main uncertainty associated with the experiment lies in the extrapolation of the pulse amplitude of the recoil protons to zero amplitude. The accuracy of the measurement is poorer at low energies. Diven's results are presented below.

Table 5

Results obtained by Diven [5]

E_n (MeV)	$\sigma_f(^{235}U)$ (barn)
0,403 ± 0,039	I,28 ± 0,08
0,5I3 ± 0,039	I,24 ± 0,07
0,562 ± 0,039	I,27 ± 0,07
0,673 ± 0,04I	I,I7 ± 0,06
0,770 ± 0,040	I,I9 ± 0,06
0,865 ± 0,039	I,23 ± 0,06
0,944 ± 0;039	I,27 ± 0,05
I,025 ± 0,039	I,26 ± 0,05
I,095 ± 0,039	I,27 ± 0,04
I,I7I ± 0,037	I,27 ± 0,04
I,272 ± 0,035	I,27 ± 0,04
I,424 ± 0,035	I,27 ± 0,04
I,545 ± 0,032	I,30 ± 0,05
I,620 ± 0,030	I,3I ± 0,05

Diven's results as a whole were taken into account when we carried out our evaluation, although the absolute measurement was performed at only one energy. We think Diven's curve fitting to the 1.27 MeV point is more reliable than that of Gorlov et al. especially as the neutron energy difference was comparatively small.

(f) Photoneutron counter measurements by Dorofeev and Dobrynin [8] and by Perkin [6]

Dorofeev and Dobrynin [8] measured $\sigma_f(^{235}U)$ absolutely using the following photoneutron sources: Sb + Be (30 keV), Na + D_2O (400 keV) and Na + Be (900 keV). Their sources were considerably smaller than "standard" sources (a Be or D_2O sphere 1.8 cm in diameter enclosing a NaF sphere 1.3 cm in diameter), so that the neutron energies were slightly higher than those usually given for "standards". For the Sb + Be sources, the authors therefore give an energy of 30 keV. The absolute measurements were performed only at 30 keV, the measurements at the other energies being performed relative to the Sb + Be source.

Dorofeev and Dobrynin obtained the following results: $\sigma_f(^{235}U) = 2.21 \pm 0.12$ barns at 30 keV (Sb + Be), 1.28 $\pm$ 0.88 barns at 400 keV (Na + D_2O) and 1.24 $\pm$ 0.08 barns at 900 keV (Na + Be).

After studying the experimental conditions we came to the conclusion that in this experiment there may have been an additional uncertainty, associated with the manner of calculating the source-detector geometric factor. In addition to the geometric uncertainty, there may have been an error at 400 keV caused by the complexity of the design of the Na + D_2O source (D_2O containment, H_2O concentration). In the measurements with the Sb + Be source, there is a major uncertainty associated with the lack of precise knowledge of the mean energy of the neutrons in the source and with the structure of the ^{235}U fission cross-section.

Perkin et al. [6] also measured the ^{235}U fission cross-section with an Sb + Be source - at 24 keV. The intensity of the source was measured by means of a manganese bath, an oil bath and a boron prism. Perkin et al. obtained a ^{235}U fission cross-section $\sigma_f(^{235}U) = 2.36 \pm 0.06$ barns, this value being assigned to an energy of 25 keV. The authors considered the maximum energy of the first neutron group emitted by the Sb + Be source to be 24.8 keV, in accordance with the estimate of Schmitt [15] (24.8 $\pm$ 2.4 keV). They then calculated that 72% of the neutrons were within an energy group having a width of 2 keV and lying below the maximum neutron energy. Later measurements by Ryves and Beale [16] showed that the maximum energy of the first neutron group was 22.8 $\pm$ 1.0 keV.

Recently, however, Lalovic and Werle [17] reported that the maximum energy of the first group was 26.0 ± 1.3 keV and the width 3.5 ± 1.5 keV.

The mean energy of neutrons in an Sb + Be source has therefore still not been established with sufficient accuracy. Between 20 keV and 25 keV the ^{235}U fission cross-section fluctuates rather strongly. According to the data of Patrick et al. [18], the ^{235}U fission cross-section averaged over an interval of 1 keV changes by 5-15% as the energy changes from 20 keV to 35 keV. The mean ^{235}U fission cross-section with respect to the spectrum of an Sb + Be source varies by 8% as the neutron energy varies from 22.5 keV to 24 keV [19].

In view of the poor reliability of fission cross-section data obtained with an Sb + Be source, these data were not taken into account by us in our evaluation.

(g) Measurements by Knoll and Poenitz [7]

Knoll and Poenitz carried out absolute measurements of $\sigma_f(^{235}U)$ at 30 keV using neutrons produced in the reaction $^7Li(p,n)^7Be$ near the threshold. The fission fragments were recorded by means of a gas-filled scintillation counter, and the neutron flux was measured by determining the ^7Be activity and by making parallel measurements of the ^{198}Au activity in gold foil. The ^{235}U cross-sections obtained by Knoll and Poenitz were 2.19 ± 0.06 barns at 30 keV and 1.78 ± 0.13 barns at 64 keV. The basic question which arises when one analyses this experiment concerns the accuracy with which the neutron spectrum at 30 keV is known.

Knoll and Poenitz did not give complete information concerning this question, so that we were obliged to assign a lower weight to their data.

(h) Measurements by Lemley et al. [9]

Lemley et al. measured $\sigma_f(^{235}U)$ by the time-of-flight method using a nuclear explosion as pulse source. They investigated the energy region 20 eV-100 keV. The neutron flux was determined on the basis of the reaction $^6Li(n,\alpha)$. The amount of ^{235}U was determined by alpha counting and by counting the thermal neutron fission fragments. The total absolute error was ± 8% at 10 keV, declining to 5% at 100 keV. The error in the cross-section for the reaction $^6Li(n,\alpha)$ was assumed to be ± 3%, which corresponds to the accuracy achieved so far. The data on the cross-section for the reaction $^6Li(n,\alpha)$ in the energy region 1-100 keV were taken from the work of Schwartz et al. [20].

The latest measurements by Uttley and Diment [21] confirm Schwartz's data, with an accuracy better than 3% at energies below 100 keV.

The results were not corrected for the angular distribution of the ^{6}Li reaction (about 1%) or for the anisotropy of the angular distribution of the fission fragments (~ 1%).

The results obtained by Lemley et al. are presented below.

Table 6

Results of measurements of $\sigma_f(^{235}U)$ performed by Lemley et al. [9]

E_n (keV)	$\sigma_f(^{235}U)$*/ (barn)
I - 2	6,74I
2 - 3	5,057
3 - 4	4,5II
4 - 5	4,0I0
5 - I0	3,I05
I0 - 20	2,338
20 - 25	2,I40
25 - 30	2,062
30 - 40	I,902
40 - 50	I,806
50 - 60	I,770
60 - 70	I,7I0
70 - 80	I,622
80 - 90	I,590
90 - I00	I,554

*/ Error ± 8%

(i) Measurements by Käppeler [10]

The ^{235}U fission cross-section was measured absolutely at two energies - 440 keV and 530 keV. The neutron source was a Van de Graaff accelerator, the reaction being $^{7}Li(p,n)^{7}Be$. The neutron flux was determined absolutely by recording recoil protons relative to (n,p) scattering. A gas-filled scintillation chamber was used for counting the fission events. The results were as follows: $\sigma_f(^{235}U)$ = 1.17 ± 0.041 barns at 440 ± 25 keV and 1.17 ± 0.041 barns at 530 ± 30 keV.

(j) Measurements by Poenitz [11]

The ^{235}U fission cross-section was recently measured absolutely by Poenitz [11] at a neutron energy of about 600 keV, using the associate-activity method. The activity of the ^{51}Cr produced in the reaction $^{51}V(p,n)^{51}Cr$ was used for determining the neutron flux. The fission events were recorded by means of a spherical ionization chamber. The results were as follows: $\sigma_f(^{235}U) = 1.085 \pm 0.043$ barns at 552 keV and 1.066 ± 0.042 barns at 644 keV.

Poenitz does not give sufficient information about the experimental conditions; in particular, he does not describe the procedure for normalizing the source and determining the amount of material in it. Moreover, he does not show how the total measurement error is made up. For this reason, less weight was assigned to this work.

(k) Measurements by Allen and Ferguson [12]

Absolute measurements were performed at only two energies - 550 keV and 1500 keV; relative measurements were performed in the region 30 keV-3 MeV. The neutron flux was determined by means of a proportional counter which recorded the recoil protons. The results of the absolute measurements were as follows: $\sigma_f(^{235}U) = 1.22 \pm 0.023$ barns at 550 keV and 1.38 ± 0.02 barns at 1800 keV (the indicated errors are only statistical). The relative trend of the fission cross-section curve as measured by Allen and Ferguson disagrees with the results of other, more precise measurements. In making our evaluation, we used the results only of the absolute measurements performed by these authors.

(l) Measurements by Poenitz [28]

Poenitz [28] measured the ^{235}U fission cross-section in the region 55 keV-1.5 MeV relative to $\sigma_f(^{235}U)$ as measured by Knoll and Poenitz [7] at 30 keV. The results are considered by Poenitz to be tentative. The results obtained by Poenitz in Ref. [28] were not used by us in the present work - firstly, because they contradict results of measurements of the ratio $\sigma_f(^{239}Pu)/\sigma_f(^{235}U)$ performed in various laboratories at various times; secondly, because it is difficult to understand Poenitz's data if one takes into account the results of the calculations by Benzi [32] of critical masses and spectra for leakage from bare ^{235}U assemblies; thirdly, because it is difficult to understand why - at a normalization point higher than the evaluated curve for 30 keV - Poenitz obtained a fission cross-section value substantially lower than the other results.

(m) Measurements by Blons et al. [22], De Saussure et al. [23], Michaudon et al. [26, 27], Wilburk et al. [24] and Van-Shi-Di et al. [25]

All these results were obtained by the time-of-flight method. The fission cross-section was normalized to a fission integral in the low-energy region, the value of which had been determined in experiments with lower resolution. The neutron flux was normalized with respect to the reactions $^{10}B(n,\alpha)$ or $^{6}Li(n,\alpha)$. The data used by us were obtained by averaging the detailed energy dependence of the cross-section over intervals with a width of 1 keV in the energy region 1-10 keV (Michaudon's data were averaged over the interval 5-10 keV). The numerical data for these integrals are presented below.

(n) Data obtained by Smith, Henkel and Nobles [29]

The data from this old paper (published in 1957) underwent substantial correction in 1970 [30]. A number of experimental factors were taken into account and the cross-sections reduced as a consequence. It is not clear from Ref. [30] which factors were taken into account and how correctly this was done. After correction, these data were found to be in better agreement with the results of White [3] at 2.25 MeV and 5.4 MeV, but at 14 MeV they were found to be substantially lower than the averaged result of the other authors. We used these data only as a guide when evaluating the energy dependence of the cross-section in the region above 2.5 MeV. The corrected numerical data of Smith, Henkel and Nobles are presented below.

Table 7

Numerical data of Smith, Henkel and Nobles [29, 30]

E (MeV)	$\sigma_f(^{235}U)$ (barns)	E (MeV)	$\sigma_f(^{235}U)$ (barns)
2,23	I,27	8,00	I,655
2,60	I,23	8,50	I,72
3,00	I,65	9,00	I,72
4,00	I,I0	9,50	I,72
5,00	I,04	I0,0	I,64
6,00	I,06	I0,5	I,57
6,40	I,25	II,0	I,56
7,00	I,45	I2,0	I,65
7,50	I,60	I4,0	I,94

(o) Measurements by Pankratov et al. [33]

These authors measured only the shape of the ^{235}U fission cross-section curve. Similar measurements were performed by them for ^{238}U.

In the latter case, normalization of their data at 3.2 MeV results in a ^{238}U fission cross-section curve which is in good agreement with the data of other authors up to 14 MeV. This provides good grounds for hoping that in the experiments of this group the method of measuring the relative trend of the cross-sections was sufficiently reliable.

In the case of ^{235}U, Pankratov's data were normalized by us to the evaluated curve in the region below 10 MeV and used for evaluating the energy dependence curve of the cross-section in the interval 9-14 MeV.

Measurements in the region 14-15 MeV

Absolute measurements of the ^{235}U fission cross-section in the region 14-15 MeV were performed by White [3], Nyer [34], Moat [35], Berezin et al. [37] and Uttley [39]. The following results were obtained(barn):

Nyer (1950):	2.19 $\pm$ 0.06 at 14.0 MeV
Moat (1958):	2.13 $\pm$ 0.09 at 14.0 MeV
Berezin et al. (1959):	2.30 $\pm$ 0.15 at 14.6 MeV
Uttley (1956):	2.20 $\pm$ 0.07 at 14.1 MeV
White (1965):	2.17 $\pm$ 0.04 at 14.1 MeV

After averaging with a weight inversely proportional to the square of the error, we obtain $\sigma_f(^{235}U) = 2.16 \pm 0.03$ barn at 14.0 MeV.

3. EVALUATION OF THE FISSION CROSS-SECTION

The general principle of our evaluation was as follows. Firstly, from all the available experimental data we selected data which were "absolute" in the sense indicated in section 2. Then, a smooth curve was drawn by hand through the experimental points entered on a graph. From this smooth curve we calculated the mean cross-section in energy intervals containing a sufficiently large number of points from the various authors. For these intervals we then calculated mean cross-sections from the data of each author on the assumption that the hand-drawn curve correctly described the energy dependence of the cross-section. The results were averaged with a weight inversely proportional to the square of the measurement error assumed by us. In estimating the errors, we took into account not only the cross-section measurement errors indicated by the authors, but also the qualitatively estimated reliability of the results. Within the limits of the assumed errors, the data of the various authors were in agreement, which justified averaging with a weight inversely proportional to the square of this error. The results obtained by averaging the mean data of different authors for various energy intervals were compared with the mean calculated using the smooth curve. In those intervals where the difference exceeded 0.3-0.5%, the curve was adjusted and the procedure repeated. In drawing the curve we also used information obtained in non-"absolute" measurements which determined only the shape of the energy dependence curve of the cross-section.

Energy region 1-10 keV

This energy region was broken down into nine intervals each 1 keV in width. The data of the following authors were averaged within each of the intervals: Lemley et al. [9], Blons et al. [22], De Saussure et al. [23], Wilburk et al. [24], Van-Shi-Di et al. [25] and Michaudon et al. [27]. In the last five energy intervals, the data of Lemley et al. and Michaudon et al. were taken into account only to the extent of considering the average over all five intervals, for we had no detailed information about the results of these studies.

Within the 1-10 keV region, the data of all the above-mentioned authors agreed to within 6-10%. As can be seen from Fig. 1, the lowest fission cross-section values were obtained by Lemley et al. [9] and the highest by De Saussure et al. [23].

The data of the other authors are distributed more or less evenly between these extreme values. From the nature of the differences it is clear that the data scatter depends mainly on systematic errors the values of which are not, as a rule, given by the authors (except Lemley et al., who gave a value of 8% for the systematic error, corresponding to the difference between their data and those of all the other authors). We therefore assumed that the systematic errors of all the above-mentioned works were of the same order of magnitude and in averaging the results we used the same weighting factor.

The results of our averaging are presented in Table 9 (we averaged linearly with respect to energy).

Table 9

Results obtained by averaging the cross-sections over intervals in the region 1-10 keV (in barn)

Δ E (keV)	Data from original studies						Average for these studies	Average over eval. curve	Mean-square scatter
	9	22	23	24	25	27			
I - 2	6,74I	7,445	7,60I	7,653	7,6I9	7,545	7,434	7,435	0,30
2 - 3	5,057	5,404	5,680	5,464	5,620	5,76I	5,498	5,528	0,22
3 - 4	4,5II	4,854	5,II7	4,72I	4,907	4,887	4,833	4,8I6	0,20
4 - 5	4,0I0	4,4I3	4,728	4,0I3	4,499	4,502	4,36I	4,346	0,20
5 - 6	-	3,948	3,9I0	3,459	3,83I	-	3,787	3,820	0,20
6 - 7	-	3,649	3,6I2	3,I49	3,457	-	3,422	3,470	0,I7
7 - 8	-	3,I93	3,93I	3,034	4,430	-	3,647	3,536	0,59
8 - 9	-	2,984	3,I22	3,030	3,227	-	3,090	3,I50	0,I0
9 -I0	-	3,074	3,I0I	3,248	3,340	-	3,087	3,090	0,I5
5 -I0	3,I05	3,334	3,535	3,I84	3,657	3,707	3,420	3,4I3	0,23

In the last column we present $\delta = \sqrt{\sum_{n=1}^{n} (\sigma_{fi} - \bar{\sigma}_{fi})/n}$, where n is the number of averaged data elements. The error in the evaluated curve is $\delta/\sqrt{n-1}$. Because of their systematic nature, the errors associated with the evaluated curve correlate strongly and are therefore not presented here (the question of the errors associated with the evaluated curve is discussed in greater detail below).

It should be noted that in drawing the smooth curve through the experimental points in this region we encountered difficulties caused by the appearance of structure in the fission cross-section in the interval 6-10 keV. It cannot be seen from the data presented in Fig. 1 that the presence of structure in this interval is established fairly reliably. However, examination of the more detailed data from the studies of De Saussure [23], Bowman [31] and Patrick et al. [18] shows that in the region 7-8 keV the fission cross-section has a pronounced peak possessing a complex structure.

There is also a less pronounced peak in the 10 keV region. We took these data into account qualitatively in drawing the recommended curve in such a way as to ensure that the mean cross-sections in the 1 keV-wide intervals were preserved. Moreover, in Fig. 1 a dash-dot line is used for the smooth curve which ensures correct (within the error limits) averaging of the fission cross-section in the region 5-10 keV.

Energy region 10-100 keV

This energy region was broken down into three intervals: 10-20 keV, 20-50 keV and 50-100 keV.

In the 50-100 keV interval we considered the data of Szabo et al. [1, 2], White [3], Knoll and Poenitz [7] and Lemley et al. [9].

In averaging the data of these authors we assigned the following errors: in the case of Refs [1], [2] and [3] we assigned the errors estimated by the authors as all this work is satisfactorily described and the authors were very conscientious in their approach to the question of estimating the errors associated with their results; for practical purposes, the errors assigned by Lemley et al. [9] and Knoll and Poenitz [7] to their results were retained (these errors are comparatively large and have only a slight effect on the result of averaging).

In the 20-50 keV interval we considered the data of Patrick et al. [18], Szabo et al. [1, 2], Knoll and Poenitz [7], Lemley et al. [9] and White [3].

In the case of Refs [1], [2] and [9] we assigned the errors given by the authors. The error given by Patrick et al. [18] was left virtually unchanged. The error given by Knoll and Poenitz was increased from 0.06 to 0.1 b in view of the fact that the authors did not discuss in detail the structure of the error and did not present information which might have thrown light on this structure. In particular, the neutron spectrum on the basis of which averaging was performed is not known exactly (it may have contained low-energy neutrons which escaped at backward angles in the centre-of-mass system); it is also not clear what the background value is or what possibility there is of an error in its determination.

A large error is assigned to the data of White [3] because it was necessary to introduce an 11% correction for neutron scattering in the fission chamber, the extent of this correction being estimated on the basis of data from another study (Szabo [1]).

The data obtained with photoneutron sources in Refs [8] and [6] were not taken into account owing to the uncertainties associated with the energy spectrum of the neutrons from the Sb + Be source and the strong structure in the fission cross-section in the 22-30 keV region.

In the 10-20 keV interval, we averaged the data of Szabo et al. [1, 2], Lemley et al. [9] and Blons et al. [22], the data of the last-mentioned authors being averaged over the energy resolution reported by Szabo et al. [1, 2]. The errors given in Refs [1], [2] and [9] were retained. The error assigned to the data of Ref. [22] was that given in Ref. [9].

In the 10-20 keV interval, where there are few experimental points and the cross-section changes very sharply, the curve was drawn in such a way as to ensure smooth matching with the evaluated curves below 10 keV and above 20 keV; the interval averages were not compared. The agreement between this curve and the data of various authors can be seen in Fig. 2.

In the regions 20-30 keV, 50-60 keV and ~ 100 keV the cross-section curve is observed to have a plateau. To verify the shape of the curve in this region we used the results of relative measurements by Bowman [31], which are represented in Figs 2 and 3 by broken lines. These results were renormalized to the evaluated curve at 70 keV.

It can be seen that these results confirm that there is a plateau in the regions 50-60 keV and 100 keV. In Table 10 we present the results of averaging (linearly with respect to lethargy) the results of various authors and the evaluated curve in the intervals 20-50 keV and 50-100 keV.

Table 10

Results of averaging cross-sections over intervals in the 20-100 keV region (in barn)

E (keV)	Ref.	Data from original studies **/		Aver. for these studies	Aver. over eval. curve	Mean-square scatter */
20-50	I	I,975±0,06	(0,06)	2,00	I,99	0,05
	2	I,996±0,06	(0,06)			
	7	2,I06±0,06	(0,I0)			
	9	I,975±0,I6	(0,I6)			
	3	2,036±0,I2	(0,I6)			
	I8	2,036+0,I8	(0,20)			
50-I00	I	I,757±0,05	(0,05)	I,762	I,762	0,0I7
	2	I,757±0,05	(0,05)			
	7	I,762±0,I3	(0,I5)			
	9	I,727±0,I4	(0,I5)			
	3	I,777±0,05	(0,05)			

*/ See comment on Table 7.

**/ The figures in brackets are the errors assumed for averaging purposes.

Energy region 100-1000 keV

The energy region 100-1000 keV was broken down into three intervals: 100-200 keV, 200-400 keV and 400-1000 keV.

In the 100-200 keV interval, we considered the results of Szabo et al. [1, 2] and White [3]. The results of Allen and Ferguson [12] and Gorlov et al. [4] were not considered in this energy interval as their measurements were really only relative and gave a curve with a shape which does not agree with the results of other, more precise measurements.

In averaging the data of the authors selected by us (Refs [1], [2] and [3]), we used the errors given by these authors.

In the 200-400 keV interval we considered the results of Szabo et al. [1], White [3], Diven [5], Dorofeev and Dobrynin [8] and Gorlov [4] (only at 270 keV, at which energy Gorlov measured the cross-section absolutely).

The results of Refs [1] and [3] were assigned the same errors as those given by the authors. The error given by Diven [5] was increased slightly because the extent of the error in extrapolating the proton spectrum to zeroth amplitude is not clear and because the study is a fairly old one.

The error given by Dorofeev and Dobrynin [8] was doubled to take into account the uncertainties of experimental geometry and source design referred to in section 2.

The error given by Gorlov et al. [4] at 270 keV was increased by a factor of 1.5 because it is not clear whether a correction was made for neutron scattering from the detector walls and the target and, if so, how large the correction was.

In the 400–1000 keV interval, we considered the results of Szabo et al. [1], White [3], Käppeler [10], Diven [5], Allen and Ferguson [12] (only at 550 keV), Poenitz [11] and Dorofeev and Dobrynin [8].

The results of Refs [1], [3] and [10] were assigned the errors given by the authors as these studies were satisfactorily described and carefully thought through.

The error given by Diven was increased by a factor of 1.5 for the same reasons as in the 200–400 keV interval. Allen and Ferguson [12] do not state any value for the systematic error of their measurements, giving only the statistical errors. We took into account only the result of their absolute measurements at 550 keV, assigning an error of 0.1 b.

In the case of Dorofeev and Dobrynin [8], the error was increased by a factor of 1.2 owing to the uncertainty associated with the source-detector geometry.

The error in the results obtained by Poenitz [11] was increased by a factor of 1.5 because no description was given of the procedure for normalizing the source and determining the amount of material in it; moreover, the structure of the error given by the author is not clear.

The experimental results for the 100–1000 keV region and the evaluated curve are presented in Fig. 3.

In Table 11 the results of various authors averaged over the above-mentioned intervals linearly with respect to lethargy are compared.

Energy region 1-15 MeV

The only reliable data for this energy region are the results of White [3], which are confirmed at 14 MeV by all the data of other authors. These data were also taken for reference purposes in drawing the recommended curve. Details of the behaviour of the cross-section as a function of energy were estimated mainly on the basis of the results of Smith, Henkel and Nobles [29] (with the correction of Hansen et al. [30]) and the data of Pankratov et al. [37]. In the 1-2 MeV region we also took into account the data of Allen and Ferguson [12] and Diven [5]. The data used and the curve recommended for this energy region are presented in Fig. 4.

4. ACCURACY OF THE EVALUATED CURVE AND COMPARISON WITH THE RESULTS OF EARLIER EVALUATIONS

An estimate of the accuracy of the evaluated fission cross-section in various energy intervals can be obtained from the values given in Tables 9-11 for the mean-square scatter of the data of various authors relative to the mean value. To obtain the error in the evaluated curve, it is necessary only to divide the value for this scatter by $\sqrt{n-1}$, where n is the number of experiments taken into account.

It should be noted, however, that the errors obtained in this way are by no means independent: as in many cases data in one and the same study contribute considerably to different averaging intervals, the errors in the mean values are strongly correlated. This correlation is strengthened further by the fact that in different experiments performed by more or less the same method the systematic errors associated with the measurement techniques are the same.

Allowance for correlations of the interval averages has a decisive effect on the result obtained when one estimates the accuracy with which reactor characteristics can be predicted on the basis of the accuracy of evaluated cross-sections; this must not be neglected. As we have not tried to estimate the correlation properties of errors in the evaluated curve, we think it essential to warn readers against carelessly using the errors in the interval averages which can be obtained from the data presented in Tables 9-11.

<u>Table 11</u>

Results of cross-section averaging over intervals in the energy region 100–1000 keV (in barn)

ΔE (keV)	Data from original studies**/									Aver. for all studies	Aver. over eval. curve	Mean-square scatter*/
	I	2	4	3	5	8	I0	II	I2			
I00÷200	I,474± 0,045 ±0,045	I,445± 0,040 ±0,045	-	I,5I5± 0,040 ±0,045	-	-	-	-	-	I,480	I,484	±0,035
200÷400	I,270± 0,04 ±0,04	-	I,295± 0,I0 ±0,I5	I,3II± 0,04 ±0,04	I,355± 0,08 ±0,I0	I,255± 0,08 ±0,I5	-	-	-	I,295	I,295	0,035
400÷I000	I,I57± 0,035 ±0,035	-	-	I,I68± 0,030 ±0,035	I,220± 0,07 ±0,I0	I,22± 0,08 ±0,I0	I,I56± 0,04 ±0,040	I,098 ± 0,04 ±0,060	I,23 ±0,I0	I,I64	I,I6I	0,045

*/ See comment on Table 7.

**/ Errors taken for averaging purposes.

In connection with the errors in the curve, we would emphasize that in the 1.5-2.5 MeV region the requirements as regards the accuracy of the ^{235}U fission cross-section are especially high (required accuracy 1.5-2%) because this cross-section is used as a standard in measuring the ^{238}U fission cross-section. It is precisely in this region that the accuracy of the evaluated curve is probably furthest from that is required, as the complex trend of the cross-section between White's points at 1 MeV, 2.25 MeV and 5.4 MeV had to be estimated on the basis of data from outdated and insufficiently reliable studies.

Careful measurements of the ^{235}U fission cross-section in the energy region above 1 MeV is, in our opinion, one of the most urgently required nuclear physics measurements for fast reactor design purposes.

In Fig. 5 the evaluated ^{235}U fission cross-section is compared with the results of evaluations by Davey [40], Hart [38] and Sowerby [47]. The numerical values of the evaluated ^{235}U fission cross-section are presented in Table 12.

In conclusion, we wish to thank V.N. Manokhin for his help with this work and G.N. Smirenkin, V.I. Nesterov and V.N. Kononov for their valuable advice.

Table 12

Evaluated ^{235}U fission cross-section in the 1 keV-15 MeV region

E (MeV)	$\sigma_f(^{235}U)$ (barns)	E (MeV)	$\sigma_f(^{235}U)$ (barns)	E (MeV)	$\sigma_f(^{235}U)$ (barns)
0,00I0	8,40	0,0060	3,56	0,0I5	2,38
0,00II	8,27	0,0062	3,46	0,0I6	2,32
0,00I2	8,I2	0,0064	3,36	0,0I7	2,27
0,00I3	7,95	0,0066	3,34	0,0I8	2,23
0,00I4	7,76	0,0068	3,39	0,0I9	2,20
0,00I5	7,52	0,0070	3,50	0,020	2,I8
0,00I6	7,33	0,007I	3,60	0,022	2,I5
0,00I7	7,02	0,0072	3,68	0,024	2,I35
0,00I8	6,70	0,0073	3,76	0,0265	2,II5
0,00I9	6,40	0,0074	3,80	0,0290	2,085
0,0020	6,I6	0,0075	3,78	0,03I7	2,0I5
0,0022	5,82	0,0076	3,74	0,0345	I,930
0,0024	5,58	0,0077	3,62	0,0380	I,865
0,0026	5,40	0,0078	3,50	0,04I7	I,825
0,0028	5,22	0,0079	3,40	0,0460	I,8I0
0,0030	5,08	0,0080	3,30	0,0500	I,805
0,0032	4,96	0,0082	3,I3	0,0525	I,800
0,0034	4,84	0,0084	3,08	0,0550	I,800
0,0036	4,76	0,0086	3,07	0,0575	I,795
0,0038	4,68	0,0088	3,08	0,0605	I,790
0,0040	4,60	0,0090	3,08	0,0630	I,785
0,0042	4,50	0,0092	3,09	0,0665	I,775
0,0044	4,40	0,0094	3,I0	0,0690	I,755
0,0046	4,30	0,0096	3,II	0,0722	I,735
0,0048	4,I9	0,0098	3,I0	0,0760	I,705
0,0050	4,08	0,0I00	3,08	0,0795	I,665
0,0052	3,97	0,0II	2,75	0,0830	I,635
0,0054	3,88	0,0I2	2,65	0,0865	I,600
0,0056	3,76	0,0I3	2,55	0,09I0	I,580
0,0058	3,64	0,0I4	2,45	0,0955	I,565

Table 12 (continued)

E (MeV)	$\sigma_f(^{235}U)$ (barns)	E (MeV)	$\sigma_f(^{235}U)$ (barns)	E (MeV)	$\sigma_f(^{235}U)$ (barns)
0,I000	I,550	2,2	I,320	I0,0	1,675
0,II5	I,540	2,4	I,280	I0,5	I,645
0,I33	I,5I5	2,6	I,245	II,0	I,645
0,I52	I,475	2,8	I,2I2	II,5	I,665
0,I73	I,425	3,0	I,I82	I2,0	I,705
0,200	I,380	3,2	I,I54	I2,5	I,780
0,230	I,345	3,4	I,I30	I3,0	I,890
0,265	I,3I0	3,6	I,I07	I3,5	2,0I5
0,305	I,275	3,8	I,087	I4,0	2,I50
0,345	I,245	4,0	I,068	I4,5	2,280
0,400	I,2I5	4,2	I,050	I5,0	2,400
0,440	I,I90	4,4	I,035		
0,480	I,I75	4,6	I,024		
0,530	I,I55	4,8	I,0I4		
0,580	I,I30	5,0	I,006		
0,635	I,I25	5,2	I,002		
0,700	I,I20	5,4	I,000		
0,760	I,I25	5,6	I,0I0		
0,840	I,I50	5,8	I,030		
0,920	I,I75	6,0	I,055		
I,000	I,2I0	6,95	I,I40		
I,I0	I,24I	6,50	I,250		
I,30	I,272	6,75	I,360		
I,30	I,296	7,0	I,445		
I,40	I,3I6	7,25	I,525		
I,50	I,33	7,5	I,592		
I,60	I,347	7,75	I,640		
I,70	I,360	8,00	I,666		
I,80	I,362	8,50	I,690		
I,90	I,360	9,00	I,700		
2,00	I,348	9,50	1,695		

REFERENCES

[1] SZABO, I., FILIPPI, G., HUET, T.L., LEROY, I.L. and MARQUETTE, J.P., Rapport DRP/SMPNF/70/21, October 1970, and paper presented to the EANDC Symposium on Neutron Standards and Flux Normalization, Argonne, USA, October 1970.

[2] SZABO, I. et al., Rapport DRP/SMPNF/71/06, March 1971, and Third Conf. on Neutron Cross Section Technology, Knoxville, March 1971.

[3] WHITE, P.H., J. Nucl. Energy, 19 (1965) 325.

[4] GORLOV, G.V. et al., J. Nucl. Energy 12 (1960) 79; Atomn. Energ. 6 (1959) 453.

[5] DIVEN, B.C., Phys. Rev. 105 (1957) 1350.

[6] PERKIN et al., J. Nucl. Energy 19 (1965) 423.

[7] KNOLL, G.F. and POENITZ, W.P., J. Nucl. Energy 21 (1967) 643.

[8] DOROFEEV, G.A. and DOBRYNIN, Yu.P., J. Nucl. Energy 5 (1957) 217.

[9] LEMLEY, J.R. et al., Nucl. Sci. Eng. 43 (1971) 281.

[10] KÄPPELER, F., EANDC Symposium on Neutron Standards and Flux Normalization, October 1970, Argonne, USA.

[11] POENITZ, W.P., EANDC Symposium on Neutron Standards and Flux Normalization, p. 281, October 1970, Argonne, USA.

[12] ALLEN, W.D. and FERGUSON, A.T.G., Proc. of the Phys. Soc. 70 (1957) 573.

[13] SZABO, I. et al., Conference on Nuclear Data for Reactors, Helsinki, 1 (1970) 229.

[14] WHITE, P.H., HODGKINSON, J.G. and WALL, G.J., 1965 IAEA Symposium on the Physics and Chemistry of Fission, Salzburg, 1 (1965) 219.

[15] SCHMITT, H.W., Nucl. Phys. 20 (1960) 220.

[16] RYVES, T.B. and BEALE, D.W., Intern. Journ. of Applied Radiation and Isotopes 18 (1967) 204.

[17] LALOVIC, M. and WERLE, H., Journ. of Nucl. Energy 24 (1970) 123.

[18] PATRIC, B.H., SOWERBY, M.G. and SCHOMBERG, M.G., J. Nucl. Energy 24 (1970) 269.

[19] PFLETSCHINGER, L. and KÄPPELER, F., Nucl. Sci. Eng. 40 (1970) 375.

[20] SCHWARTZ, S. et al., Nucl. Phys. 63 (1965) 593.

[21] UTTLEY, C.A. and DIMENT, K.M., EANDC Symposium on Neutron Standards and Flux Normalization, October 1970, Argonne, USA.

[22] BLONS, J., DEBRIL, G. et al., IAEA Conference on Nuclear Data for Reactors, Helsinki, 1 (1970) 469.

[23] DE SAUSSURE, G., GWIN, R., WESTON, L.W., INGLE, R.W., Report ORNL-TM-1804 (1967) and Intern. Conf. on Nuclear Data for Reactors, 2 (1966) 223.

[24] WILBURK et al., Proc. Conf. on Neutron Cross-section Technology, Washington, 2 (1966) 97.

[25] VAN-SHI-DI et al., IAEA Symposium on Physics and Chemistry of Fission, 1 (1965) 287.

[26] MICHAUDON, A. et al., Report CEA-1093 (1959).

[27] MICHAUDON, A. et al., Nucl. Phys. 69 (1965) 545.

[28] POENITZ, W.P., Conf. on Neutron Cross-section Technology, Washington, 1 (1968) 503.

[29] SMITH, R.K., HENKEL, R.L. and NOBLES, R.A., Bull. Am. Phys. Soc. 2 (1957) 196.

[30] HANSEN, G., McGUIRE, S. and SMITH, R.K., Revised data of R.K. Smith received from L. Stewart (1970).

[31] BOWMAN, C., IAEA Conference on Nuclear Data for Reactors, Helsinki, 1970.

[32] BENZI et al., IAEA Conference on Nuclear Data for Reactors, Helsinki, 1970.

[33] PANKRATOV, V., Atomn. Energ. 14 (1964) 167.

[34] NYER, W., LAMS-938, 1950.

[35] MOAT, A., 1958, unpublished data cited in 36.

[36] ADAMS, B. et al., J. Nucl. En. 14 (1961) 85.

[37] BEREZIN, A. et al., Atomn. Energ. (1959).

[38] HART, W., AHSB(S)R 169 (1969).

[39] UTTLEY, C.A., UKAEA Rep. AERE NP/R-1966 (1956).

[40] DAVEY, W.G., Nucl. Sci. and Eng. 32 (1968) 35.

[41] SOWERBY, M.G., Personal communication to V.A. Konshin, April 1971.

Figure Captions

Fig. 1 Cross-section for ^{235}U fission in the energy region 1-20 keV. The broken line smooths out fluctuations of the recommended curve while preserving the integral with respect to the 5-10 keV range.

Fig. 2 Cross-section for ^{235}U fission in the energy region 10-100 keV. The arrow indicates the result of White's correction for scattering in the fission chamber walls [3]. The broken line represents the data of Bowman et al. after smoothing.

Fig. 3 Cross-section for ^{235}U fission in the energy region 100 keV-1 MeV. The broken line represents the data of Bowman et al. after smoothing.

Fig. 4 Cross-section for ^{235}U fission in the energy region 1 MeV-15 MeV. Pankratov's data normalized to the recommended curve and used only for estimating its shape.

Fig. 5 Comparison of the result of our evaluation of the ^{235}U fission cross-section (thick continuous line) with the results of evaluations by Davey (thin continuous line), Hart (dash-dot line) and Sowerby (histogram and broken line).