International Atomic Energy Agency

INDC(CCP)-91/U

INDC INTERNATIONAL NUCLEAR DATA COMMITTEE

Evaluation of $\bar{\upsilon}$ (E_n) Data for ^{233}U, ^{235}U, ^{238}U and ^{239}Pu

L.I. Prokhorova, V.P. Platonov, G.N. Smirenkin

(Extract translation from INDC(CCP)-86/G,
Nuclear Constants, Vol.20 Part 1, 1975)

Translated by the IAEA
June 1976

IAEA NUCLEAR DATA SECTION, KÄRNTNER RING 11, A-1010 VIENNA

Reproduced by the IAEA in Austria
June 1976
76-4427

INDC(CCP)-91/U

Evaluation of $\bar{\upsilon}$ (E_n) Data for ^{233}U, ^{235}U, ^{238}U and ^{239}Pu

L.I. Prokhorova, V.P. Platonov, G.N. Smirenkin

(Extract translation from INDC(CCP)-86/G,
Nuclear Constants, Vol.20 Part 1, 1975)

Translated by the IAEA
June 1976

76-2687
Translated from Russian

EVALUATION OF $\bar{\nu}(E_n)$ DATA FOR ^{233}U, ^{235}U, ^{238}U AND ^{239}Pu

L.I. Prokhorova, V.P. Platonov, G.N. Smirenkin

ABSTRACT

This article gives an evaluation of data on the dependence of the number of prompt neutrons ν on incident neutron energy E_n for ^{233}U, ^{235}U, ^{238}U and ^{239}Pu. Recommended values of $\bar{\nu}(E_n)$ are given for all four isotopes over the range 0-5 MeV. The recommended values of $\bar{\nu}(E_n)$ are subjected to error analysis.

Introduction

The problem of measuring the mean yield of prompt neutrons per fission in isotopes used as reactor fuel arose at the beginning of nuclear power development and has lost none of its importance, a fact which can be explained by the difficulty of satisfying the exacting accuracy requirements of reactor technology in regard to the measurement of $\bar{\nu}$ (approx. 0.5-1%).

Thanks to the vast amount of data that has by now been compiled for the value of $\bar{\nu}$ and its dependence on incident neutron energy for such important reactor fuels as ^{233}U, ^{235}U, ^{238}U and ^{239}Pu, it is now possible to study the agreement between the data of different authors, to establish a unique curve for this function and to evaluate the error in it. Data on $\bar{\nu}(E_n)$ are doubtless more useful to reactor physicists in what has come to be called "evaluated" form.

The $\bar{\nu}(E_n)$ curve has been evaluated frequently over a period of many years, most often by experimenters on the basis of measured values [1-15]. Previously we evaluated the $\bar{\nu}(E_n)$ data for ^{235}U [12] and ^{239}Pu [15]. This article deals with a much wider data field, including work which appeared later on. We used the tables of experimental $\bar{\nu}(E_n)$ data prepared by Kon'shin and Manero [14], amplified or corrected by new information [16-18]. A complete compilation of all the $\bar{\nu}(E_n)$ data for ^{233}U, ^{235}U, ^{238}U and ^{239}Pu in the range up to 6 MeV is given in Figs 1-4. It is here that the information of prime interest for reactor construction is concentrated, so this compilation has been supplemented by new data.

Method of evaluation

In this work we tried to adopt a unified approach to the evaluation of $\bar{\nu}(E_n)$ for all four isotopes. The data were averaged for narrow intervals of neutron energy: between 0.05 and 1.45 MeV a step of $\Delta E_n = 0.1$ MeV was adopted and from 1.45 to 3-4 MeV a step of $\Delta E_n = 0.2$ MeV. The weights used in averaging were inversely proportional to the squares of the errors σ quoted by the authors. Table 1 gives the average value, $\langle\bar{\nu}\rangle$, for a given interval ΔE_n and two errors:

$$\sigma_I = \sqrt{\frac{\sum (\bar{\nu}_i - \langle\bar{\nu}\rangle)^2/\sigma_i^2}{(n-1)\sum 1/\sigma_i^2}} \quad \text{and} \quad \sigma_{II} = \frac{1}{\sqrt{\sum 1/\sigma_i^2}} \tag{1}$$

the first of which reflects the spread in the values $\bar{\nu}_i$ within the given interval ΔE_n and the second the accuracy of the general average, $\langle\bar{\nu}\rangle$. Agreement between these errors, $\sigma_I \simeq \sigma_{II}$, means that the spread in the data has an essentially random statistical character and there are no significant systematic discrepancies in the set of data. If such discrepancies exist, then $\sigma_I > \sigma_{II}$, and this inequality becomes the more pronounced the larger the scale of the systematic errors.

Figs 1 and 3 show the $\langle\bar{\nu}\rangle$ histograms for ^{233}U and ^{238}U beneath the initial experimental data; histograms for ^{235}U and ^{239}Pu, for which there is a plethora of data on $\bar{\nu}$, are presented separately in Figs 5 and 6. Figures from the British Data File [10-11] and from BNAB [8] are compared with the $\langle\bar{\nu}\rangle$ histogram. The BNAB group constants are given for average energy values

$$E_i = \frac{\int_{\Delta E_i} E\,N(E)\,dE}{\int_{\Delta E_i} N(E)\,dE} \tag{2}$$

where ΔE_i is the energy interval of the group, and N(E) is the fission neutron spectrum.

In addition, the least squares method was used to describe the aggregate $\bar{\nu}(E_n)$ data sets for each of the four isotopes by a smooth curve. The calculations were performed with the PREDA programme [20] in which the $\bar{\nu}(E_n)$ dependence is presented in the form of a series expansion in Chebyshev polynomials. The programme provides for:

(a) Selection of an optimum (statistically significant) number of terms in the series;

(b) Calculation of a confidence interval on the $\bar{\nu}(E_n)$ function for those neutron energies where experimental points are given; and

(c) The derivation of $\bar{\nu}(E_n)$ with any given step ΔE_n.

The values of $\bar{\nu}(E_n)$ obtained by polynomial description with a step of 0.1 MeV are compared with the $\langle\bar{\nu}\rangle$ histogram in Figs 1, 3, 5 and 6 and set out in Table 2. These values can be used as recommended curves.

We shall now comment briefly on the results of the quantitative analysis carried out, taking the isotopes in order of diminishing experimental point data in the arrays.

^{235}U. The amount of $\bar{\nu}(E_n)$ data for this isotope is so vast that the addition of new data [9, 16, 17] in the E_n range of interest had only a slight effect on the averaged $\langle\bar{\nu}\rangle$ values and on the relationship between the errors σ_I and σ_{II} obtained in Ref. [12]. The data of Savin and co-workers [17] supported the existence of previously observed singularities on the $\bar{\nu}(E_n)$ curve, involving both the broad stepped structure [12, 21] and the fine structure (E_n = 0.2-0.5 MeV) [22, 23]. The data of Boldeman [9] are not detailed enough to be used in considering the fine structure. In both descriptions of the $\bar{\nu}(E_n)$ dependence, the fine structure is shaded, but the stepped structure can be clearly seen, especially in the histogram.

^{239}Pu. The collection of $\bar{\nu}$ data for ^{239}Pu which we dealt with in Ref. [15] has been supplemented by the results of two other studies [18, 19]. Although the general accuracy of the data was thereby increased, the marked inequality $\sigma_I > \sigma_{II}$ for $E_n \sim$ 1.2-1.5 MeV not only persisted but even became stronger. This can be explained in two ways: by the possibility of a fine structure in $\bar{\nu}(E_n)$ in this range [15] or by a systematic discrepancy between the analyses. The results of our analysis - a histogram and a recommended curve - indicate the presence of a stepped structure, though not as pronounced as in the case of ^{235}U.

^{238}U. The $\bar{\nu}(E_n)$ data of the different authors for ^{238}U are in satisfactory agreement, to judge by the errors σ_I and σ_{II}. The values corresponding to the interval 2.3-2.5 MeV [24] have a small weight and do not affect the σ_I and σ_{II} relationship. The analysis reveals no stepped structure such as is seen in the case of even-even fissioning nuclei (compare ^{233}U below), but there is an obvious difference in the slopes of $\bar{\nu}(E_n)$ in the sections below and above $\approx$ 3 MeV.

^{233}U. There are very few data for this isotope: the $\bar{\nu}(E_n)$ curve is determined essentially by three analyses [18, 19, 24] which are in satisfactory agreement. The spread in the data in the 1 MeV range is surprising. A smooth curve corresponding to the polynomial description irons out the fluctuations in $\bar{\nu}(E_n)$ but preserves the stepped type structure which is typical of even-even nuclei.

We did not set ourselves the task of comparing our data with the numerous recommendations of other authors. This was done in the latest evaluations of the $\bar{\nu}(E_n)$ dependence with which we are familiar [10, 11, 14], and we therefore restricted ourselves to a comparison with the latter evaluations. Discrepancies compared with the evaluation of Kon'shin and Manero [14] are small, and in energy intervals where new data have appeared do not amount to more than 0.5%. In the energy range above 5 MeV, therefore - not considered in this article -, we adopt the recommendations of Ref. [14]. There is a systematic divergence from the British Data File [10, 11] in the high-energy range around 3 MeV (Figs 1, 3, 5, 6), where a large contribution is made by the data of Soleilhac [7]. This is explained by the fact that in Refs [10, 11] use was made of the original data of Ref. [7], while in our case and in Ref. [14] the values were revised by the authors - see Ref. [14].

What we found most interesting was the comparison with the BNAB data (reactor constants) in Ref. [8], since these are widely used for calculations and have not been revised for a long time. To supplement the qualitative comparison in Figs 1, 3, 5 and 6, Table 3 gives the BNAB group constants as well as the values calculated from the curves recommended here, together with the corresponding percentage deviations.

Evaluation of errors in the recommended curve

In conclusion let us consider the evaluation of errors in the recommended curve and in the group constants. The error in the curve, as determined by the least squares method, is 0.1-0.2% in the energy range of interest. This calculation relies on the assumption that the errors in the $\bar{\nu}$ measurements are not correlated, i.e. that the inner spread of the data has a purely random nature. In this case the error in the curve decreases, as $1/\sqrt{N}$ with increasing number of points in the data set. This is true for the statistical error but not for the total error in the curve, which is what we are interested in. The measurement error includes a systematic error which is strongly correlated and does not obey the $1/\sqrt{N}$ law. Whatever the method of evaluation used, this error must be added to the statistical error of the curve [26].

With the errors σ_I and σ_{II} for $\langle\bar{\nu}\rangle$ it is possible to reveal the presence of systematic errors in the data being averaged, but it is difficult to evaluate the magnitude of the systematic error in $\langle\bar{\nu}\rangle$ by comparing them because the contribution of the statistical error to σ_I and σ_{II} is very great for a narrow interval (with a small number of points). A more accurate evaluation can be made by considering a wider interval with an adequate number of points - for instance an energy group.

Table 4 gives the results of an analysis of mean group values $\langle\bar{\nu}\rangle_r$ calculated from the data of the authors whose contribution has been decisive. It is assumed that in the averaging of the data the statistical error was sufficiently reduced owing to the $1/\sqrt{N}$ factor for the discrepancies between the $\langle\bar{\nu}\rangle_r$ data of the different authors to be identical with the systematic errors. The error obtained from the spread in $\langle\bar{\nu}\rangle_r$ is then the upper evaluation of the systematic error $\delta\bar{\nu}_{syst}$. The figures in the appropriate columns show that this value does not exceed 0.4% in the groups considered. Since this value is approximately the same in all energy intervals, it can also be transposed to other groups where the data of one or two authors are predominant. Adding it to the statistical error of the curve, we conclude that the total error in the recommended curve for $\bar{\nu}(E_n)$ for ^{235}U and ^{239}Pu is not more than 0.5-0.7%.

The data for ^{238}U are not so abundant and we did not study them by this method; however, judging by the values of σ_I and σ_{II}, the error is unlikely to be more than 1.5 times the error for ^{235}U and ^{239}Pu.

The authors wish to thank L.N. Usachev for his advice and comments when the work was being carried out; V.N. Manokhin for his help in performing the calculations; N.E. Fedorova for her valuable assistance during the work; and Yu.N. Turchin and E.I. Shestoperova for their assistance in the presentation of the article.

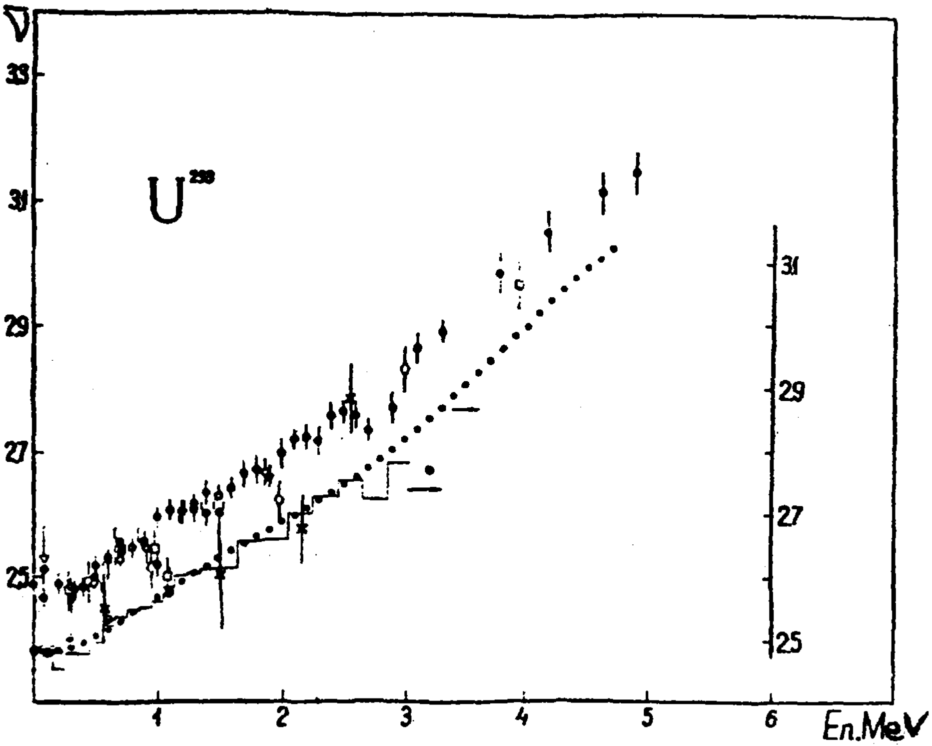

Fig. 1. Dependence of $\bar{\nu}$ on neutron energy E_n for ^{233}U

▽ - [27] , □ - [3] , ◊ - [3I] , ○ - [I9], ◑ - [25] ,
× - [39] , ◑ - [I8] .

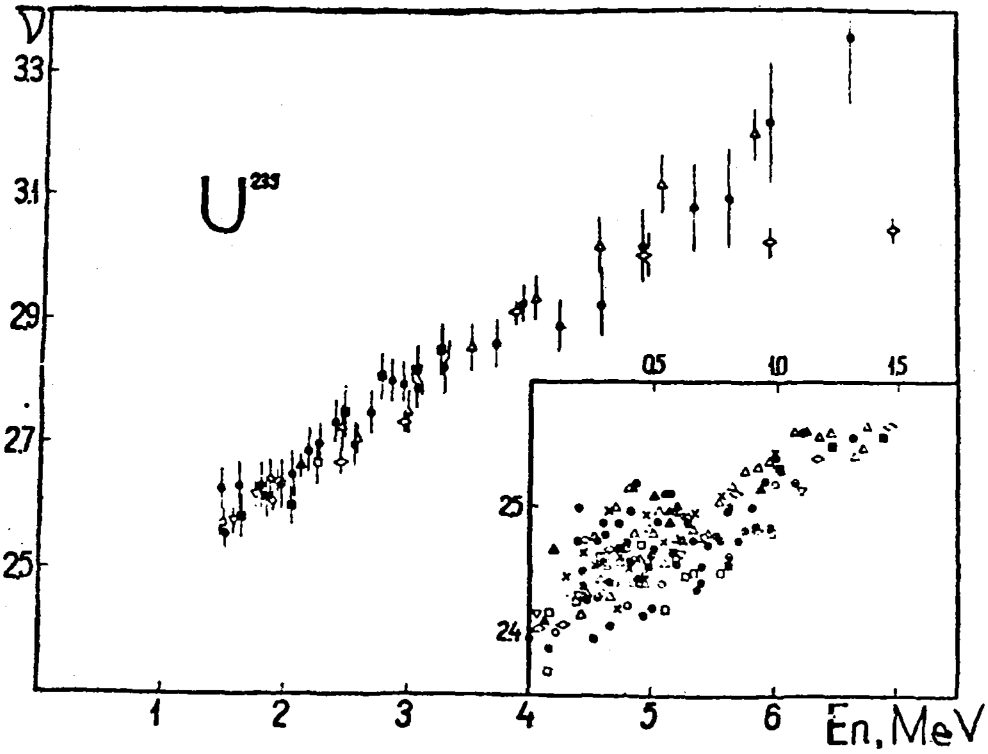

Fig. 2. Dependence of $\bar{\nu}$ on neutron energy E_n for ^{235}U

▲ - [32] , ▲ - [33] , × - [22] , □ - [34], ◇ - [4], ◊ - [3] ,
● - [28] , ▽ - [35], ○ - [9], △ - [I6,23] , ◐ - [I7,29] ,
■ - [30] , ● - [I2] .

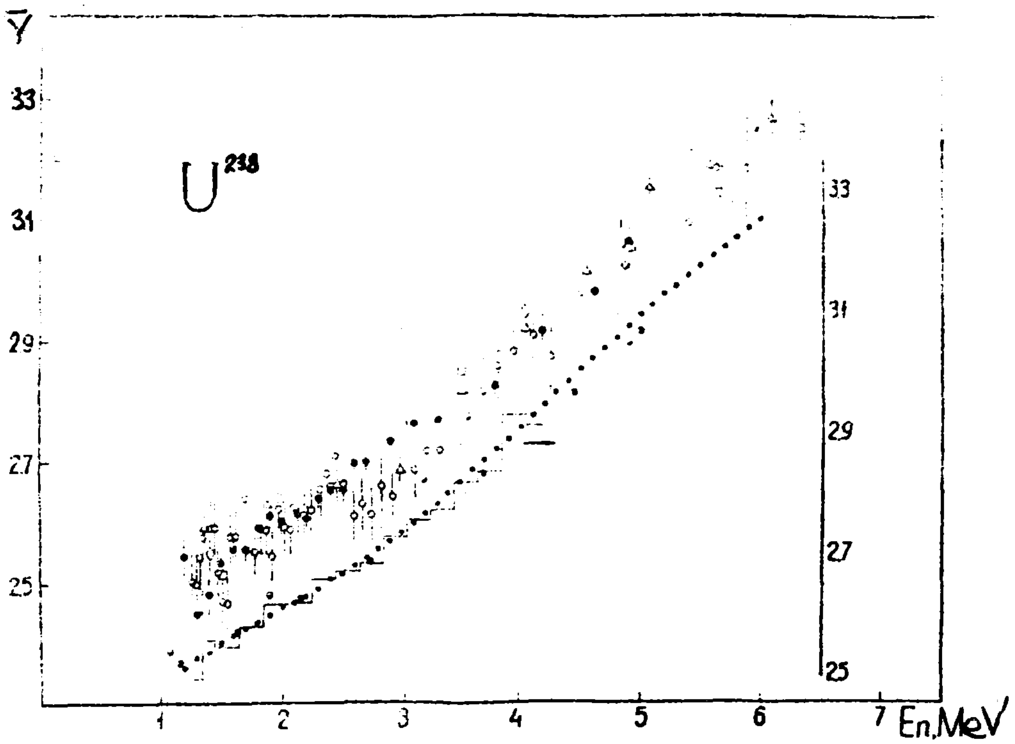

Fig. 3. Dependence of $\bar{\nu}$ on neutron energy E_n for ^{238}U
o - [24] , △ -[7] , ◊ -[31], □ -[14], ● -[18] ,
below; histogram, $\langle\bar{\nu}\rangle$, ⊖ - [8] , ⊕ - [10,11] .

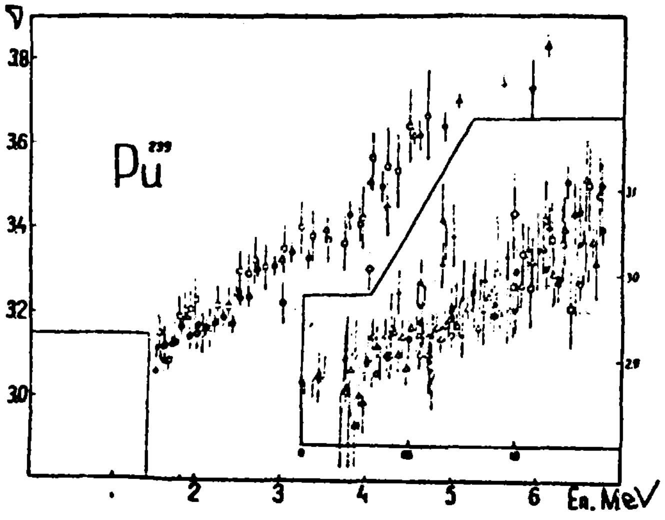

Fig. 4. Dependence of $\bar{\nu}$ on neutron energy E_n for ^{239}Pu
△' - [7,23] , ◊ -[3], O -[19], □ -[29] , + -[38],
◊ - [31] , ▽ - [37] , ⊕ -[15], ● -[18] .

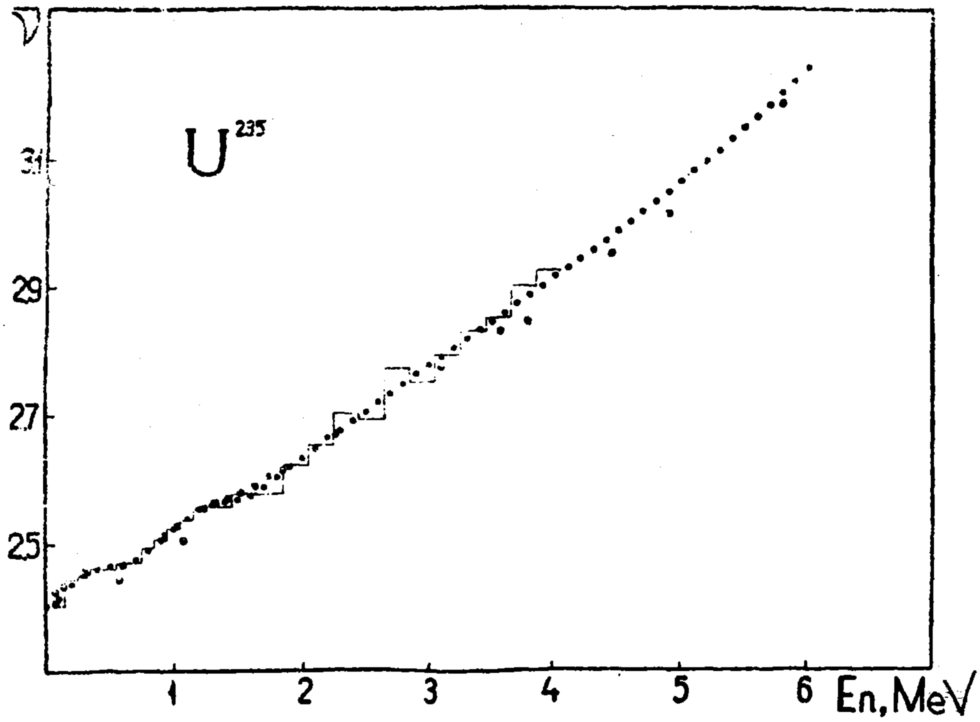

Fig. 5. Histogram of <ν̄> and recommended values of ν̄(E_n) for ^{235}U. ● – recommended values for ν̄ (E_n), ◒ - [8], ⊕ -[11] .

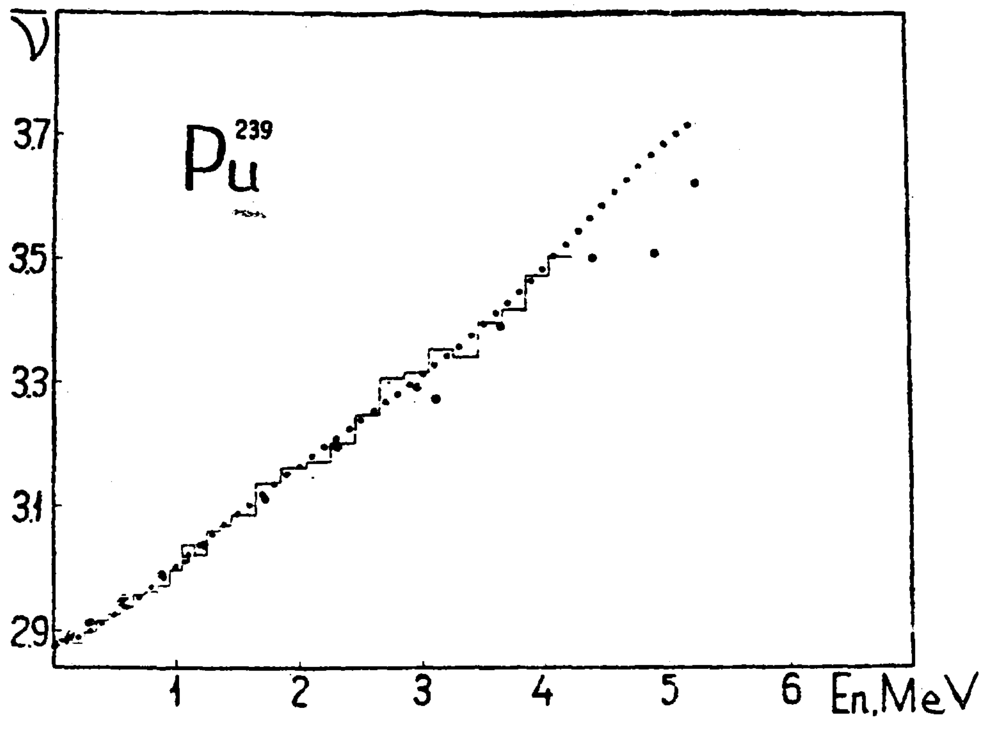

Fig. 6. Histogram of <ν̄>and recommended values of ν̄(E_n) for ^{239}Pu. ● – recommended values for ν̄ (E_n), ◒ - [8], ⊕ - [10] .

Table 1

Averaged values, $\langle\bar{\nu}\rangle$

№/№	$\bar{E}_n$	ΔE_n	^{233}U			^{235}U			^{238}U			^{239}Pu		
			$\langle\bar{\nu}\rangle$	σ_I	σ_{II}	$\langle\bar{\nu}\rangle$	σ_I	σ_{II}	$\langle\bar{\nu}\rangle$	σ_I	σ_{II}	$\langle\bar{\nu}\rangle$	σ_I	σ_{II}
I	0.I	0,050-0,I50	2,484	0,0I5	0,0I3	2,404	0,008	0,008				2,867	0,0I7	0,0I8
2	0,2	0,I5 - 0,25	2,429	-	0,025	2,445	0,007	0,007				2,880	0,009	0,0I2
3	0,3	0,25 - 0,35	2,475	0,004	0,009	2,453	0,005	0,005				2,876	0,0I6	0,0I5
4	0,4	0,35 - 0,45	2,485	0,008	0,0II	2,462	0,006	0,004				2,9I7	0,006	0,006
5	0,5	0,45 - 0,55	2,497	0,009	0,008	2,46I	0,005	0,004				2,927	0,0II	0,008
6	0,6	0,55 - 0,65	2,524	0,008	0,008	2,470	0,005	0,005				2,938	0,007	0,006
7	0,7	0,65 - 0,75	2,538	0,007	0,008	2,470	0,006	0,006				2,949	0,0I0	0,007
8	0,8	0,75 - 0,85	2,546	-	0,0I7	2,496	0,006	0,006				2,963	0,009	0,009
9	0,9	0,85 - 0,95	2,560	0,003	0,009	2,505	0,006	0,007				2,973	0,004	0,008
I0	I,0	0,95 - I,05	2,56I	0,02I	0,0I2	2,522	0,007	0,007				2,998	0,0I0	0,0II
II	I,I	I,05 - I,I5	2,582	0,044	0,0I4	2,536	0,0II	0,0II				3,007	0,006	0,0II
I2	I,2	I,I5 - I,25	2,600	0,00I	0,0I3	2,552	0,004	0,0I2				3,022	0,009	0,0I0
I3	I,3	I,25 - I,35	2,606	0,004	0,0I3	2,566	0,0I3	0,0I6	2,469	0,02I	0,023	3,060	0,0I7	0,009
I4	I,4	I,35 - I,45	2,6I5	0,0I7	0,0I4	2,555	0,008	0,009	2,562	0,023	0,0I6	3,068	0,0I3	0,007
I5	I,55	I,45 - I,65	2,62I	0,0II	0,0I0	2,574	0,007	0,008	2,540	0,0I0	0,009	3,085	0,0II	0,0I0
I6	I,75	I,65 - I,85	2,665	0,003	0,0I6	2,576	0,0I9	0,0I8	2,574	0,0I2	0,0II	3,I36	0,0I4	0,0I3
I7	I,95	I,85 - 2,05	2,664	0,0I2	0,0II	2,520	0,006	0,0I0	2,6II	0,009	0,0I0	3,I6I	0,0II	0,0I0
I8	2,I5	2,05 - 2,25	2,709	0,029	0,023	2,653	0,0I7	0,0I4	2,6I3	0,005	0,0I2	3,I70	0,008	0,0I4
I9	2,35	2,25 - 2,45	2,738	0,020	0,0I3	2,704	0,0I9	0,02I	2,653	0,007	0,0II	3,204	0,0I8	0,0I3
20	2,55	2,45 - 2,65	2,765	0,004	0,0I3	2,696	0,0I3	0,0I4	2,666	0,0I3	0,0I2	3,245	0,0I3	0,0I4
2I	2,75	2,65 - 2,85	2,736	-	0,0I9	2,775	0,008	0,025	2,678	0,0I9	0,0I5	3,305	0,005	0,0I8
22	2,95	2,85 - 3,05	2,793	0,029	0,02I	2,752	0,0I2	0,023	2,725	0,02I	0,0I2	3,3I4	0,0I5	0,0I3
23	3,I5	3,05 - 3,25				2,796	0,0I3	0,029	2,754	0,028	0,0I5	3,35I	0,02I	0,024
24	3,35	3,25 - 3,45				2,832	0,0I2	0,02I	2,77I	0,0I7	0,0I9	3,338	0,0I8	0,024
25	3,55	3,45 - 3,65				2,863	-	0,040	2,8I8	0,0I5	0,022	3,394	0,007	0,020
26	3,75	3,65 - 3,85				[illegible]	0,022	0,020	2,834	0,022	0,028	3,4I6	0,029	0,033
27	3,95	3,85 - 4,05				[illegible]	0,030	0,025	[illegible]	0,0I5	0,0I5	3,473	0,037	0,0I5
28	4,I5	4,05 - 4,25				[illegible]	-	0,044	2,8I0	0,0I2	0,026	3,506	0,0I8	0,029

Table 2

Recommended $\bar{\nu}$ values

№№ п/п	E_n	^{233}U	^{235}U	^{238}U	^{239}Pu
I	2	3	4	5	6
I	0,0	2,4800	2,407I		2,8738
2	0,I	2,4782	2,4I83		2,88I6
3	0,2	2,48I3	2,4383		2,8904
4	0,3	2,4872	2,4526		2,90I3
5	0,4	2,4955	2,4603		2,9I37
6	0,5	2,5053	2,4643		2,9274
7	0,6	2,5I64	2,4687		2,9420
8	0,7	2,5283	2,4765		2,9572
9	0,8	2,5407	2,4888		2,9728
I0	0,9	2,5535	2,5050		2,9887
II	I,0	2,5663	2,5228		3,0048
I2	1,10	2,5790	2,5394		3,0208
I3	I,20	2,59I6	2,5523	2,5080	3,0367
I4	I,30	2,6040	2,5602	2,5236	3,0526
I5	I,40	2,6I6I	2,5638	2,5374	3,0684
I6	I,50	2,628I	2,5660	2,5499	3,0840
I7'	I,60	2,6398	2,5708	2,56I4	3,0995
I8	I,70	2,65I4	2,5854	2,5723	3,II49
I9	I,80	2,6629	2,60I7	2,5829	3,I302
20	I,90	2,6743	2,6I76	2,5933	3,I455
2I	2,0	2,6858	2,6333	2,6038	3,I607
22	2,I0	2,6975	2,6487	2,6I45	3,I759
23	2,20	2,7094	2,6638	2,6255	3,I9II
24	2,30	2,72I7	2,6788	2,6370	3,2063
25	2,40	2,7343	2,6935	2,6489	3,22I7

Table 2 (continued)

1	2	3	4	5	6
26	2,50	2,7473	2,7081	2,6615	3,2372
27	2,60	2,7609	2,7224	2,6746	3,2528
28	2,70	2,7751	2,7367	2,6883	3,2685
29	2,80	2,7899	2,7508	2,7026	3,2845
30	2,90	2,8053	2,7648	2,7176	3,3006
31	3,00	2,8214	2,7787	2,7330	3,3169
32	3,10	2,8381	2,7925	2,7490	3,3333
33	3,20	2,8554	2,8063	2,7655	3,3501
34	3,30	2,8734	2,8200	2,7825	3,3669
35	3,40	2,8919	2,8337	2,7998	3,3840
36	3,50	2,9108	2,8475	2,8175	3,4012
37	3,60	2,9300	2,8612	2,8355	3,4186
38	3,70	2,9495	2,8750	2,8537	3,4361
39	3,80	2,9692	2,8888	2,8721	3,4538
40	3,90	2,9888	2,9027	2,8906	3,4715
41	4,00	3,0082	2,9168	2,9092	3,4892
42	4,20	3,0456	2,9453	2,9465	3,5248
43	4,40	3,0799	2,9742	2,9835	3,5604
44	4,60	3,1092	3,0040	3,0200	3,5957
45	4,80	3,1314	3,0347	3,0557	3,6305
46	5,00	3,1548	3,0664	3,0904	3,6646
47	5,20	3,1782	3,0994	3,1240	3,6979
48	5,40	3,2016	3,1337	3,1566	3,7303
49	5,60	3,2250	3,1695	3,1880	3,7616
50	5,80	3,2484	3,2070	3,2183	3,7919
51	6,0	3,2718	3,2463	3,2476	3,8212
52	6,2	3,2952	3,2875	3,2761	3,8496
53	6,4	3,3186	3,3309	3,3039	3,8770
54	6,6	3,3420	3,3765	3,3313	3,9038
55	6,8	3,3654	3,4285	3,3583	3,9300
56	7,0	3,3888	3,4552	3,3852	3,9559
57	7,2	3,4122	3,4819	3,4121	3,9815
58	7,4	3,4356	3,5086	3,4392	4,0073
59	7,6	3,4589	3,5353	3,4666	4,0332
60	7,8	3,4824	3,5620	3,4945	4,0596
61	8,0	3,5057	3,5885	3,5228	4,0865
62	8,2	3,5292	3,6154	3,5517	4,1140
63	8,4	3,5526	3,6421	3,5811	4,1423
64	8,6	3,5759	3,6689	3,6110	4,1714
65	8,8	3,5993	3,6955	3,6414	4,2013
66	9,0	3,6227	3,7223	3,6722	4,2319
67	9,2	3,6461	3,7490	3,7032	4,2631
68	9,4	3,6695	3,7757	3,7343	4,2948
69	9,6	3,6929	3,8024	3,7656	4,3267
70	9,8	3,7163	3,8291	3,7966	4,3588
71	10,0	3,7397	3,8588	3,8275	4,3907
72	10,2	3,7631	3,8825	3,8581	4,4222
73	10,4	3,7865	3,9092	3,8882	4,4531
74	10,6	3,8099	3,9359	3,9179	4,4832
75	10,8	3,8333	3,9626	3,9471	4,5124

Table 2 (continued)

I	2	3	4	5	6
76	II,0	3,8567	3,9893	3,9759	3,5405
77	II,2	3,880I	4,0160	4,0044	4,5675
78	II,4	3,9035	4,0427	4,0326	4,5934
79	II,6	3,9269	4,0694	4,0607	4,6184
80	II,8	3,9503	4,096I	4,0890	4,6428
8I	I2,0	3,9737	4,I228	4,II77	4,6668
82	I2,2	3,997I	4,I495	4,I469	4,6908
83	I2,4	4,0205	4,I762	4,I770	4,7I53
84	I2,6	4,0439	4,2029	4,208I	4,7407
85	I2,8	4,0673	4,2296	4,2404	4,7677
86	I3,0	4,0907	4,2563	4,2738	4,7964
87	I3,2	4,II4I	4,2830	4,308I	4,827I
88	I3,4	4,I375	4,3097	4,3432	4,8599
89	I3,6	4,I609	4,3364	4,3782	4,8942
90	I3,8	4,I843	4,363I	4,4I20	4,9290
9I	I4,0	4,2077	4,3898	4,4432	4,9626
92	I4,2	4,23II	4,4I65	4,4696	4,9922
93	I4,4	4,2545	4,4432	4,4886	5,0I37
94	I4,6	4,2778	4,4699	4,4964	5,02I8

Table 3

Group constants for $\bar{\nu}(E_n)$ from Ref. [8] and values calculated from the curves recommended in this article

E_n, MeV	^{233}U			^{235}U			^{238}U			^{239}Pu		
	[8]	This Article	Deviation %	[8]	This Article	Deviation %	[8]	This Article	Deviation %	[8]	This Article	Deviation %
0,I-0,2	2,493	2,480	+0.5	2,434	2,427	+0,3				2,884	2,886	-0,I
0,2-0,4	2,503	2,487	+0,6	2,454	2,449	+0,2				2,904	2,900	+0,I
0,4-0,8	2,533	2,5I4	+0,8	2,444	2,459	-I,0				2,944	2,940	+0,I
0,8-I,4	2,573	2,575	-0,I	2,504	2,53I	-I,I	2,536	2,507	+I,2	3,006	3,0I7	-0.4
I,4-2,5	2,623	2,674	-I,9	2,6I4	2,620	-0,2	2,626	2,602	+0,9	3,II4	3,I45	-I,0
2,5-4,0	2,773	2,846	-2,6	2,774	2,796	-0,8	2,826	2,758	+2,5	3,264	3,340	-2,3
4,0-6,5	3,0I3	3,I39	- 4,2	3,024	3,[illegible]I	-I,2	3,046	3,077	-I,0	3.476	3,645	-4,9
6,5-I0.5	3,363	3,469	-3,2	3,384	3,539	-4,6	3,436	3,480	-I,3	3,864	4.4I9	-I4,36

Table 4

Analysis of mean group values $\langle\bar{\nu}\rangle_r$ from the data of different authors

E_n Refs	0,1-0,2 MeV	0,2-0,4 MeV	0,4-0,8 MeV	0,8-1,4 MeV	1,4-2,5 MeV	2,5-4,0 MeV
			^{235}U			
35	2,424	2,436	2,460	2,5II		
4	2,42I	2,443	2,486	2,5I9	2,6I3	2,827
22	2,43I	2,450	2,490			
28	2,463	2,480	2,457			
30			2,483	2,5I9	2,629	
23		2,46I	2,475	2,543		
9	2,4I3	2,427	2,46I	2,526		
29'				2,523	2,659	2,822
I2	2,420	2,436	2,469	2,527		
I6						2,793
I7		2,450	2,474			
	2,429± ± 0,007	2,448± ±0,006	2,470± ±0,004	2,524± ± 0,004	2,634 ± 0,013	2,814± ± 0,0II
			^{239}Pu			
7					3,I83	3,347
29				3,029	3,I75	3,355
23		2,903	2,937	3,008		
38	2,897	2,9I9	2,963	3,039		
I9		2,89I	2,9I8	2,980		
I5	2,892	2,9I0	2,945			
I5		2,9I2	2,957	3,034		
I8				3,0I5	3,I35	3,334
	±2,894± 0,003	2,907± ±0,005	2,944± ±0,008	3,0I7± ± 0,009	3,I64± ±0,0I5	3,345± ±0,006

REFERENCES

1. R.B.Leachman. Proc.Intern.Conf. Peaceful Uses Atomic Energy, Geneva, 1955. N.Y., 1956, v.2, p.193.
2. I.I.Bondarenko, B.D.Kuzminov, L.S.Kutsaeva, L.I.Prokhorova, G.N.Smirenkin. Proc. of the Second United National International Conference on the Peaceful Uses of Atomic Energy, U.N. Geneva, 1958, v.15, p.353.
3. I.C.Hopkins, B.C.Diven. Nucl.Phys.1963, 48, 433.
4. D.C.Mather, P.Fieldhause, A.Moat. Phys.Rev. 1964, B1403, 133.
5. P.L.Filmore. Journ.Nucl.Energy 1968, 22, 73.
6. W.G.Davey. Nucl.Sci.Eng. 1971, 44, 345.
7. M.Soleilhac, I.Frehaut, I.I.Gaurian. Journ.Nucl.Energy, 1969, 23, 257.

[8] ABAGYAN, L.P., BAZAZYANTS, N.O., BONDARENKO, I.I., NIKOLAEV, N.N., Group constants for reactor calculations, Atomizdat (1964).

9. I.W.Boldeman, R.L.Walsh. Journ.Nucl.Energy, 1970, 24, 191.
10. D.S.Mather and P.F.Bampton AWRE 086/70, 1970.
11. D.S.Mather and P.F.Bampton. AWRE 055/71, 1971.

[12] PROKHOROVA, L.I., BOGDASAROV, R.E., KOTUKHOV, I.I., NESTEROV, V.G., NURPEISOV, B., SMIRENKIN, G.N., TURCHIN, Yu.M., Atomnaya Ehnergiya 30 (1971) 251.

13. R.I.Howerton. Nucl.Sci.Eng. 1971, 46, 42.
14. F.Manero, V.A.Konshin "Atomic Energy Review", 1972, v.10, No.4, p.637.

[15] VOLODIN, K.E., KUZNETSOV, V.F., NESTEROV, V.G., NURPEISOV, B., PROKHOROVA, L.I., TURCHIN, Yu.M., SMIRENKIN, G.N., Atomnaya Ehnergiya 33 (1972) 901.

[16] FREHAUT, I., SOLEILHAC, M., LOSINSKI, G., "Nejtronnaya Fizika" (Proc. Second All-Union Conference on Neutron Physics, Kiev, 1973) 3 (1974) 153.

[17] SAVIN, M.V., KHOKHLOV, Yu.A., LUDIN, V.N., "Nejtronnaya Fizika" (Proc. Second All-Union Conference on Neutron Physics, Kiev, 1973) 4 (1974) 63.

[18] NURPEISOV, B., VOLODIN, K.E., NESTEROV, V.G., PROKHOROVA, L.I., SMIRENKIN, G.N., TURCHIN, Yu.M., Preprint FEI-543.

19. R.L.Walsh, I.W.Boldeman. Nucl.Energy, 1971, 25, 321.

[20] CADWELL, I., HUDSON, D., CERN 7090 Programme Library. HUDSON, D., "Statiska dlya fizikov", "Mir" (1967).

[21] PROKHOROVA, L.I., SMIRENKIN, G.N., Yadernaya Fizika 13 (1971) 1170.

22. I.W.Medows, I.F.Whalen. Nucl.Eng. 1967, 21, 157.

23. M.Soleilhac, I.Frehaut, I.Gaurian, G.Mosinki. Nucl.Data for Reactors (Proc.Conf.Helsinki 1970). IAEA, Vienna, 1970, 2, 145.

[24] SAVIN, M.V., KHOKHLOV, Yu.A., PARAMONOVA, I.N., SMIRENKIN, G.N., Atomnaya Ehnergiya, 32 (1972) 403.

[25] NURPEISOV, B., NESTEROV, V.G., PROKHOROVA, L.I., SMIRENKIN, G.N., Atomnaya Ehnergiya, 34 (1973) 491.

[26] USACHEV, L.N., O edinom opredelenii pogreshnosti yadernykh dannykh (Unique determination of the errors in nuclear data), preprint FEI-537 (1974).

27. B.C.Diven, H.C.Martin, R.F.Tashek, I.Terrell. Phys. Rev., 1956, 101, 1012.

[28] KUZNETSOV, V.F., SMIRENKIN, G.N., Nuclear data for reactors (Proc. Conf., Paris, 1966) IAEA, Vienna, 2 (1967) 75.

[29] SAVIN, M.V., KHOKHLOV, Yu.A., ZAMYATNIN, Yu.S., PARAMONOVA, I.N., Nuclear data for reactors (Proc. Conf., Helsinki, 1970), IAEA, Vienna, 2 (1970) 157.

[30] PROKHOROVA, L.I., SMIRENKIN, G.N., "Yadernaya Fizika", 7 (1968) 961.

31. D.S.Mather, P.Fieldhause, A.Moat. Nucl.Phys., 1965, 66, 149.

32. H.Conde: Ark.Fys., 1965, 29, 293.

33. D.W.Colvin, H.G.Sowerby. Phys. and Chem. of Fission (Proc.Symp.Salzburg, 1965), IAEA, Vienna,1965, 2,25.

34. Y.A.Blymkina, I.I.Bondarenko, V.F.Kuznetsov, V.G.Nesterov, V.N.Okolovitch, G.N.Smirenkin, L.N.Usachev. Nucl. Phys. 1964, 52, 648.

35. I.W.Meadows, I.F.Whalen. Phys.Rev. 1962, 126, 197.

36. I.Asplund-Nilson, H.Conde, H.Starfelt. Nucl.Sci.Eng. 1964, 20, 527.

37. H.Conde, I.Hausen, M.Holmberg. Nucl.Energy, 1968,22, 53.