The Total Number of Delayed Neutrons and Average Half-Life of Their Precursors in the Neutron Induced Fission of U-235, U-238, Pu-239 (Summation Method)

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Abstract

In this work nuclear and physical characteristics of delayed neutrons have been calculated for thermal and fast neutron induced fission of ^{235}U, ^{238}U and ^{239}Pu within a summation method. Cumulative yields of fission products from last version of JEFF, ENDF/B, JENDL, ROSFOND libraries, and Wahl [1] data were used as basic data. Probabilities of delayed neutron emission were represented by the sets obtained by Pfeiffer-Kratz-Möller systematic [2], and the estimated experimental data. There were used 4 data sets of delayed neutron emission probabilities. As a result, for each set of cumulative yields of fission products it was obtained4values of the absolute delayed neutrons yield and 4 values of the average half-life of delayed neutron precursors. For each combination of data sets "a cumulative yield – probability of delayed neutron emission" model curves of neutron activity have been calculated. The analysis of the results based on comparison of obtained data with the appropriate evaluated data, allowed to reveal discrepancies in the fission product data relating to specified libraries – JEFF, ENDF/B, JENDL and ROSFOND.

Introduction

Traditionally summation method is used for calculation such physical characteristics as the absolute total delayed neutron yield, relative abundances and the energy spectra. This method is used for assessment of delayed neutrons parameters both for the nuclides, which are a part of nuclear fuel, and for nuclides, which were not studied in this regard. Method based on cumulative yields of fission products data and data on probabilities of delayed neutron emission of the separate delayed neutron precursors. These data were constantly specified with use, both experimental data, and theoretical approaches, including systematics development. Now accuracy of summation method at calculation of delayed neutron parameters is comparable with an accuracy of experimental methods. Discrepancies in results, most likely, are due to use of specific databases (libraries) on the cumulative yield of fission products and sets on probabilities of delayed neutron emission. Therefore, it is obvious that now the summation method can be used for determination of the most reliable data sets on the fission product~~s~~ yields, which are presented in ENDF/B, JEFF, JENDL, ROSFOND libraries. The objective of the this work is the comparative analysis of the delayed neutron characteristics for thermal and fast neutron induced fission of ^{235}U, ^{238}U and ^{239}Pu, obtained by a summation method on the basis of existing databases on the fission products yields (ENDF/B, JEFF, JENDL, ROSFOND) and various sets on probabilities of delayed neutrons emission *Pn* with the purpose to determine the most reliable data set of the fission products yields.

1. Calculation technique

1.1. Input data

Cumulative yields of 368 delayed neutron (further DN) precursors from JEFF-3.1.1, ENDF/B-VII.1, JENDL-4.0, ROSFOND-2010 libraries, and the estimated data of Wahl [1] were used as basic data. The probabilities of delayed neutron emission are represented by the sets obtained on the basis of Pfeiffer-Kratz-Möller (in text P-K-M, 2002) systematics [2], and also the estimated experimental data of England, Wilson (E-W, 2002) [2], Rudstam, Aleklett, Sihver (Rudstam, 1993) [3] and the IAEA data (IAEA, 2011) [4].

1.2. Calculation method of the absolute total delayed neutron yield

In this work for absolute total DN yield calculation the summation method is used $\bar{\nu}_d = \sum_i CY_i \cdot Pn_i$, where CY_i is cumulative yield of i-th precursor, P_i is probability of delayed neutron emission by i-th precursor. Obtained results are presented in tab. 1-5.

Table 1. Absolute total delayed neutron yields ^{235}U (thermal neutron induced fission)

P_n	CY, %					Data from literature	
	ENDF/B-VII.1	JENDL-4.0	JEFF-3.1.1	Wahl	ROSFOND-2010	PNE*)	Blachot**)
E-W	1.88	1.88	1.61	1.70	1.61	1.62	1.71±0.11
P-K-M	1.93	1.94	1.63	1.72	1.63		
Rudstam	1.84	1.84	1.61	1.69	1.61		
IAEA	1.90±0.10	1.91±0.10	1.63±0.08	1.71	1.63±0.08		

Table 2.Absolute total delayed neutron yields ^{235}U (fast neutron induced fission)

P_n	CY, %					Data from literature	
	ENDF/B-VII.1	JENDL-4.0	JEFF-3.1.1	Wahl	ROSFOND-2010	PNE	Blachot
E-W	1.79	1.81	1.82	-	1.82	1.63	1.91±0.13
P-K-M	1.82	1.93	1.82	-	1.82		
Rudstam	1.76	1.78	1.81	-	1.81		
IAEA	1.83±0.12	1.85±0.12	1.83±0.09	-	1.83±0.09		

Table 3.Absolute total delayed neutron yields ^{238}U (fast neutron induced fission)

P_n	CY, %					Data from literature	
	ENDF/B-VII.1	JENDL-4.0	JEFF-3.1.1	Wahl	ROSFOND-2010	PNE	Blachot
E-W	4.20	4.21	4.46	4.37	4.20	4.65	4.31±0.25
P-K-M	4.35	4.35	4.60	4.53	4.35		
Rudstam	4.02	4.03	4.24	4.12	4.02		
IAEA	4.17±0.28	4.18±0.28	4.43±0.15	4.36	4.17±0.28		

Table 4.Absolute total delayed neutron yields^{239}Pu (thermal neutron induced fission)

P_n	CY, %					Data from literature	
	ENDF/B-VII.1	JENDL-4.0	JEFF-3.1.1	Wahl	ROSFOND-2010	PNE	Blachot
E-W	0.74	0.76	0.66	0.70	0.74	0.65	0.62±0.06
P-K-M	0.75	0.77	0.65	0.71	0.75		
Rudstam	0.73	0.75	0.64	0.69	0.73		
IAEA	0.75±0.03	0.77±0.04	0.66±0.05	0.71	0.75±0.03		

Table 5.Absolute total delayed neutron yields^{239}Pu (fast neutron induced fission)

P_n	CY, %					Data from literature	
	ENDF/B-VII.1	JENDL-4.0	JEFF-3.1.1	Wahl	ROSFOND-2010	PNE	Blachot
E-W	0.65	0.68	0.73	-	0.65	0.651	0.69±0.06
P-K-M	0.65	0.68	0.72	-	0.66		
Rudstam	0.64	0.66	0.71	-	0.65		
IAEA	0.66±0.06	0.68±0.07	0.73±0.05	-	0.66±0.06		

*)recommended data [5]

**)data obtained by summation method in work [6].

1.3. Calculation method of the average half-life of delayed neutron precursors

On the basis of the obtained values of the DN relative yields a_i and half-lives T_i of each DN precursors, the average half-life was calculated

$$<T_{1/2}>=\frac{\sum_i a_i \cdot T_i}{\sum_i a_i}\text{, where } a_i = Pn_i \cdot CY_i\text{, therefore } <T_{1/2}>=\frac{\sum_i Pn_i \cdot CY_i \cdot T_i}{\sum_i Pn_i \cdot CY_i}.$$

Results of an average half-life of DN precursors are presented in tab. 6-10.

Table 6.Average half-lives of DN precursors ^{235}U (thermal neutron induced fission)

(P_n,$T_{1/2}$)	CY, %					Data from literature	
	ENDF/B-VII.1	JENDL-4.0	JEFF-3.1.1	Wahl	ROSFOND-2010	Keepin*)	Piksaikin**)
E-W	7.17	7.16	9.01	8.67	9.01	9.02±0.34	8.98±0.11
P-K-M	6.99	6.97	8.92	8.57	8.92		
Rudstam	7.48	7.46	9.19	8.85	9.19		
IAEA	7.30±0.42	7.27±0.41	9.16±0.60	8.83	9.16±0.60		

Table 7.Average half-lives of DN precursors ^{235}U (fast neutron induced fission)

(P_n,$T_{1/2}$)	CY, %					Data from literature	
	ENDF/B-VII.1	JENDL-4.0	JEFF-3.1.1	Wahl	ROSFOND-2010	Keepin	Piksaikin
E-W	7.4	7.32	8.15	-	8.15	8.83±0.25	8.96±0.06 (En= 0.81 МэВ)
P-K-M	7.27	6.88	8.12	-	8.12		
Rudstam	7.6	7.54	8.31	-	8.31		
IAEA	7.42±0.56	7.35±0.55	8.29±0.54	-	8.29±0.54		

Table 8.Average half-lives of DN precursors ^{238}U (fast neutron induced fission)

(P_n,$T_{1/2}$)	CY, %					Data from literature	
	ENDF/B-VII.1	JENDL-4.0	JEFF-3.1.1	Wahl	ROSFOND-2010	Keepin	Piksaikin
E-W	4.87	4.87	5.01	4.74	4.87	5.32±0.14	5.32±0.05
P-K-M	4.69	4.70	4.84	4.58	4.68		
Rudstam	5.12	5.13	5.30	5.07	5.12		
IAEA	4.99±0.42	5.00±0.42	5.14±0.21	4.87	4.99±0.42		

Table 9.Average half-lives of DN precursors ^{239}Pu (thermal neutron induced fission)

(P_n,$T_{1/2}$)	CY, %					Data from literature	
	ENDF/B-VII.1	JENDL-4.0	JEFF-3.1.1	Wahl	ROSFOND-2010	Keepin	Piksaikin
E-W	9.76	9.51	10.19	10.17	9.76	10.69±1.11	0.59±0.17
P-K-M	9.58	9.36	10.19	10.05	9.58		
Rudstam	10.01	9.80	10.62	10.47	10.01		
IAEA	9.81±0.51	9.59±0.57	10.43±1.20	10.31	9.81±0.51		

Table 10.Average half-lives of DN precursors ^{239}Pu (fast neutron induced fission)

(P_n,$T_{1/2}$)	CY, %					Data from literature	
	ENDF/B-VII.1	JENDL-4.0	JEFF-3.1.1	Wahl	ROSFOND-2010	Keepin	Piksaikin
E-W	10	9.74	8.81	-	10	10.09±1.26	10.27±0.13 (En= 0.86 MэВ)
P-K-M	9.91	9.68	8.85	-	9.90		
Rudstam	10.28	10.05	9.14	-	10.25		
IAEA	10.14±1.25	9.90±1.23	9.02±1.02	-	10.13±1.25		

*)recommended experimental data[7], **)[8]

1.4. Modeling of the time dependence of DN activity

Within the present work, the algorithm was developed and on its basis the program for carrying out a model assessment of time dependence of DN activity, which are emitted in the interaction of neutrons with nuclides ^{235}U, ^{238}Uand ^{239}Pu has been written.

Input data for calculation of model decay curves of neutron activity are half-life T_i of DN precursors, and the relative abundances a_i. Irradiation times were chosen 0.1 ms and 1000 s (such duration of irradiation is enough for establishment of the state, which rather close to a condition of saturation of DN precursors in the fissioning system).

For exclusion of the influence of DN absolute total yield value on the scale representation the decay curvesfor^{235}Uobtained in the modeling process, were normalized in the point of 50 s on the value of the curves presented in work [2]. It should be noted that ENDF/B-VI library results were used at calculation of the decay curves presented in work [2].

Half-lives values in Rudstamet. al. [3] are given not for all DN precursors therefore, for calculations T_i data from work [2] were used.

2. Results and discussion

2.1. Calculation results of DN absolute total yields

Values of DN absolute total yields calculated for all possible combinations of used *CY* and *Pn* are presented in tab. 1-5. Uncertainties are calculated only for a *Pn* taken from data of IAEA [4]. The obtained values of uncertainties are typical for a summation method and therefore they can be extended to all other cases presented in tables 1-5. The tables also present the recommended data and data obtained by summation method [6], using a set *Pn* libraries JEF-2.2, which is not represented in this paper.

The data presented in tab. 1-5 allow to estimate influence of separate sets of *Pn* on values ν_d, using the minimum and maximum value ν_d, received for *CY* data from one of considered fission reactions of separate library for all sets of *Pn* – $d\nu_d/\nu_d = (\nu_d max - \nu_d min)/\nu_d min$. The obtained results are presented in table 11.

Table 11.Estimation of influence of individual sets of *Pn* on ν_d values

	$d\nu_d(Pn)/\nu_d=(\nu_d max-\nu_d min)/\nu_d min$, %				
	^{235}U(T)	^{235}U(F)	^{238}U(F)	^{239}Pu(T)	^{239}Pu(F)
ENDF/B-VII.1	3.3	4.0	8.2	2.7	3.1
JENDL-4.0	3.8	8.4	7.9	2.7	3.0
JEFF-3.1.1	1.2	1.1	8.5	3.1	2.8
Wahl	1.2	-	9.9	2.9	-
ROSFOND-2010	1.2	1.1	8.2	2.7	1.5

On the example of JEFF library, it is visible that for a case of ^{235}U fission both thermal and fast neutrons influence of separate sets of *Pn* is insignificant ($d\nu_d/\nu_d$=1.1-1.2%). While for fast neutrons fissionof^{238}U the calculated value ν_d strongly depends on a used set of *Pn* ($d\nu_d/\nu_d$=8.5%). The assessment of most reliable sets of *Pn* and *CY*, apparently, can be obtained from comparison of calculated values ν_d with appropriate experimental data. Let us analyze each of considered fission reactions.

^{235}U(*n,f*)

From table 1 it is seen that for a case of the thermal neutron induced fission of ^{235}U the fission products' yields *CY* from JEFF and ROSFOND libraries give value ν_d which is the closest to the recommended one – 1.63±0.08 neutr./100 fiss. *CY* data from ENDF and JENDL libraries give the overestimated values of ν_d for all sets of *Pn* as compared with the recommended data ν_d. This allows to claim that yields from JEFF library for reaction ^{235}U(n_{th},*f*) are preferable. For reaction ^{235}U(n_{fast},*f*) (table 2) *CY* data from JEFF, ENDF/B, ROSFOND and JENDL libraries give ν_d values which are almost identical for all sets of *Pn*. This fact is the direct indication on identity of fission products yields of ^{235}U(n_{fast},*f*), presented in JEFF, ENDF, ROSFOND and JENDL libraries. However obtained data don't reproduce the energy dependence ν_d(*En*) recommended in work [9]. The calculated ν_d value for the fast neutron induced fission of ^{235}U varies in the range (1.76-1.83) neutr./100 fiss., that exceeds the recommended value to 8-10%. It should be noted that in experiment [10] madefor^{235}U fast neutron induced fission higher value of ν_d was obtained as compared with the recommended value ν_d (1,68 neutr./100 fiss.). In this work stronger energy dependence ν_d(*En*) was obtained.

^{238}U(*n,f*)

Until recently in many works the summation method gave strongly underestimated values ν_d for ^{238}U – up to 3.8 neutr./100 fiss. [11].The analysis of the reasons of strongly underestimated value ν_d wasn't carried out. It was considered that the reason is in the incorrect *Pn* values. Really, the present data on ν_d, calculated with *Pn* set from early work Rudstamet. al. [3], give strongly underestimated value in case of *CY* from ENDF/B – 4.02 neutr./100 fiss. Use of later data of *Pn* (P-K-M [2]) increases value ν_d to 4.35 neutr./100 fiss. in case of *CY* from ENDF/B, remaining, nevertheless, below the recommended values – 4.65 neutr./100 fiss. The combination of *CY* from JEFF and *Pn* set from P-K-M [2] gives the closest to the recommended ν_d value– 4.60 neutr./100 fiss. This circumstance indicates that products' yields of reaction ^{238}U(n_{fast},*f*) from JEFF library gives the most compatible to experiment results and, as well as in the case of reaction ^{235}U(n_{th},*f*) it is preferable. The fact is that *Pn* set from Rudstamet. al. [3] gives the comparable results obtained with other sets of *Pn* in case of reaction ^{235}U(n_{th},*f*) it is possible to explain by essential difference of products' yields of reaction ^{238}U(n_{fast},*f*) which leads to increase the yields of products insignificant in reaction ^{235}U(n_{th},*f*).Besides, based on the results obtained for reaction ^{238}U(n_{fast},*f*) it should be noted that *Pn* set from P-K-M [2] gives the values closest to experimental data ν_d using data of *CY* from JEFF.

It should be also noted, that the value ν_d for ^{238}U(n_{fast},*f*) underestimated as compared with experiment for *CY* data from ENDF, JENDL and ROSFOND (4,35 neutr./100 put), showing full correlation of the results obtained at use of specified data and data from JEFF at a variation of *Pn* sets, it is possible to explain with shift of the most probable charges in isobaric chains of fission fragments. This assumption requires an additional verification.

^{239}Pu(*n,f*)

In case of reaction ^{239}Pu(n_{th},*f*) influence of separate sets of *Pn* on final results is about 3% for all combinations of *CY* and *Pn*. Most likely difference in ν_d is due to discrepancies in *CY* data. The closest to the recommended values (0.65 neutr./100 fiss.) gives the data combination of *CY* from JEFF and *Pn* set from (P-K-M). Other sets of *Pn* give proximate ν_d values – (0.64-0.66) neutr./100 fiss. For reaction ^{239}Pu(n_{fast},*f*) all combinations of *CY* data from ENDF/B, ROSFOND and *Pn* sets give proximate to the recommended values (0,651 neutr./100 fiss.). Sets of *CY* from JENDL give proximate values ν_d – (0.66-0.68) neutr./100 fiss.

2.2. Calculation results of the average half-life of DN precursors

The values of an average half-life calculated in the present work for all possible combinations of sets ($Pn,T_{1/2}$) and *CY* are presented in tab. 6-10. Experimental data from work [7] are used as the recommended one.

The data presented in tab. 6-10, allow to estimate the influence of separate sets of *Pn* on the value $<T>$, using the minimum and maximum $<T>$ value received for *CY* data one of considered fission reactions of separate library for all sets of *Pn* – $d<T>(Pn)/<T>=(max<T>-min<T>)/<T>min$, %. Obtained results are presented in table 12.

The analysis of the data presented in table 12 shows that influence of separate sets ($Pn,T_{1/2}$) on value$<T>$ is almost identical for all sets of *CY* for each of considered fission reactions, except *CY* data from ENDF and JENDL libraries for a case of^{235}U thermal and fast neutron induced fission. It should be noted also high sensitivity of the$<T>$value to a separate set (*Pn*,$T_{1/2}$) in case of ^{238}U fast neutron induced fission for all considered *CY* sets. We will carry out the analysis each of considered fission reactions.

Table 12. Estimation of influence separate sets of *Pn* on <*T*> values

	d<*T*>*(Pn)*/<*T*>=(<*T*> *max*-<*T*> *min*)/ <*T*> *min*, %				
	^{235}U(T)	^{235}U(F)	^{238}U(F)	^{239}Pu(T)	^{239}Pu(F)
ENDF/B-VII.1	7.0	4.5	9.2	4.5	3.7
JENDL-4.0	7.0	9.6	9.1	4.7	3.2
JEFF-3.1.1	2.6	2.3	9.5	4.2	3.3
Wahl	3.3	-	10.7	4.5	-
ROSFOND-2010	2.6	2.3	9.2	4.5	3.5

^{235}U(*n*,*f*)

Discrepancies between the <*T*> values obtained with data sets from considered libraries reach up to 22% for ^{235}U thermal neutron induced fission and 15% for fast neutron induced fission of ^{235}U. *CY* data from JEFF and ROSFOND give the closest to the recommended (experimental) <*T*> values for all sets (*Pn*,$T_{1/2}$) – (8.92-9.19 s).The best agreement with the experiment is observed using sets (*Pn*,$T_{1/2}$) from E-W and P-K-M [2].*CY* data from ENDF and JENDL give <*T*> values in the range (6.99-7.48 s) depending on a used (*Pn*,$T_{1/2}$) set. It indicates strong distortion of time dependence of DN decay curves, caused by underestimation of a contribution of precursors with big $T_{1/2}$or, overestimation of the contribution short-living DN precursors. Thus, fission products yields *CY* for ^{235}U(n_{th},*f*) reaction presented in JEFF, ROSFOND and Wahl libraries from the stand point of reproduction of time dependence of DN activity are the most correct.

For ^{235}U(n_{fast},*f*) reaction the cumulative yields *CY* from JEFF and ROSFOND libraries – give the closest (8.31±0.54 s)to the recommended (experimental) data <*T*> (8.83±0.25 s and 8.96±0.06 s). 5% smaller value of <*T*> indicates an underestimation of a long-living DN precursor contribution in an integral curve of neutron activity recession. Bigger discrepancy with experimental data is observed for yields from JENDL and ENDF libraries – 14%.Therefore, it is possible to consider *CY* sets from JEFF and ROSFOND library as the best ones. However, it is necessary to carry out the analysis of the possible reasons of discrepancies with the experimental data. In this regard it should be noted that the set (*Pn*,$T_{1/2}$) from the work [3], obtained on the basis of an assessment of experimental data, always gives bigger value<*T*>in comparison with other sets. It indicates possible systematic errors in calculation of DN emission probability and a half-life of their precursors in case of the lack of experimental data. Most likely, it is related to short-living DN precursors.

^{238}U(n,f)

At the same relative discrepancies of the <*T*> value for *CY* from different libraries for the chosen (*Pn*,$T_{1/2}$) set the best agreement with experimental data was obtained for combination *CY* from JEFF and (*Pn*,$T_{1/2}$) from [3], indicating that systematic errors in an assessment of the *Pn* and $T_{1/2}$values for precursors not studied experimentally. Therefore, it is possible to consider that *CY* set from JEFF correctly predicts the time dependence of DN activity.

^{239}Pu(n,f)

For thermal neutron induced fission of ^{239}Pu the closest to experimental data $<T>$ values give *CY* yields from JEFF and Wahl when using sets (Pn, $T_{1/2}$) from [3, 4]. $<T>$ data obtained by yields from ENDF, JENDL and ROSFOND differ from experimental by 6-7%.In case of fast neutron induced fission of ^{239}Pu the $<T>$ values closest to experimental data were obtained for fission products yields from ROSFOND and ENDF libraries – 10.14±1.25 s with a ($Pn,T_{1/2}$) set from [4] and 10.28±1.27 s with a set [3]. The $<T>$ values obtained using fission yields from JEFF, differ from experimental by 10%. On the basis of the obtained results it is possible to consider that the most correct data from the stand point of time dependence of neutron activity on fission products yields for reaction ^{239}Pu(n_{th},f) are presented in JEFF library, and for reaction ^{239}Pu(n_{fast},f) – in ENDF library.

2.3. Model neutron activity decay curves

We will consider neutron activities decay curves obtained for ^{235}U at thermal neutron induced fission, because of the most prominent discrepancy in the average half-life values (22% for different *CY*). Fig. 1 shows neutron activity decay curves obtained by the simulation of irradiation ^{235}U by thermal neutrons for1000 s.

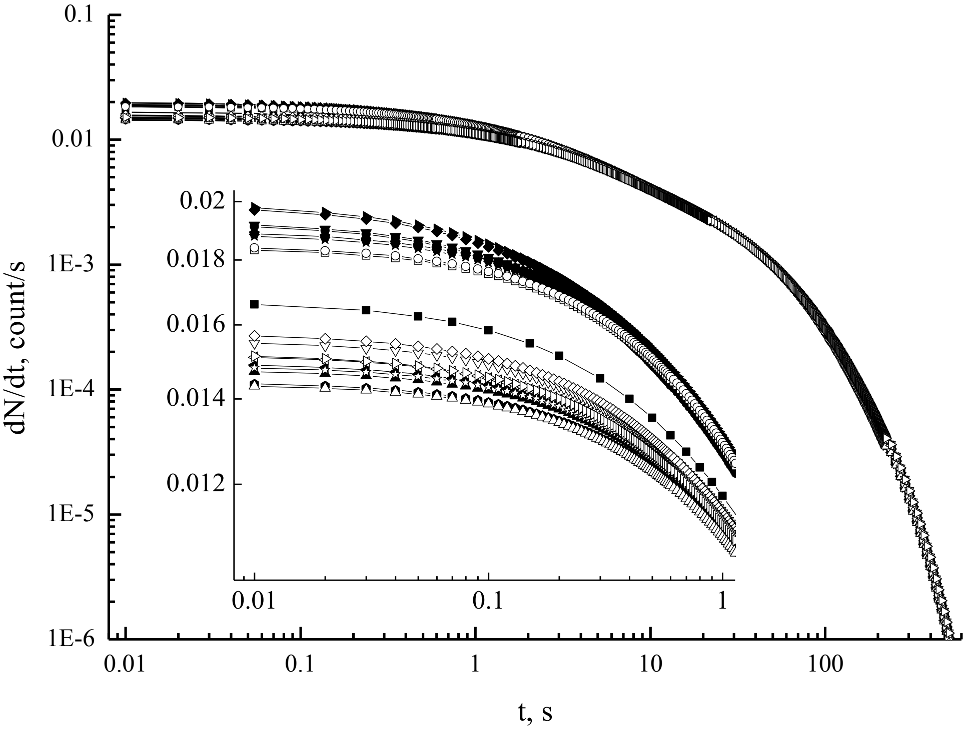

Figure 1. Activity decay curves obtained by simulation of irradiation ^{235}U by thermal neutrons, irradiation time 1000 s, on the insert shown the same data in the increased scale.

On the figure the following designations for data are accepted: squares – Ref E-W, circles – E-W+ENDF-B7.1, angle up triangles – E-W+JEFF 3.1.1, angle down triangles – E-W+JENDL 4.0, rhombuses – P-K-M+ENDF-B7.1, angle to the left triangles – P-K-M+JEFF 3.1.1, angle to the right triangles – P-K-M+JENDL 4.0, hexagons – IAEA+ENDF-B7.1, stars – IAEA+JEFF 3.1.1, pentagons – IAEA+JENDL 4.0, open squares – Rud+ENDF-B7.1, open circles – Rud+JENDL 4.0, open angle up triangles – Rud+JEFF 3.1.1, open angle down triangles – E-W+Wahl, open rhombuses – P-K-M+Wahl, open angle to the left triangles – Rud+Wahl, open angle to the right triangles – IAEA+Wahl, open stars – Keepin.

To get more visible discrepancies in decay curves for short-living components the simulation of neutron activity decay curves is carried out at short irradiation times. In fig. 2 activity decay curves are obtained by simulation of irradiation ^{235}U by thermal neutrons for 0.1 ms.

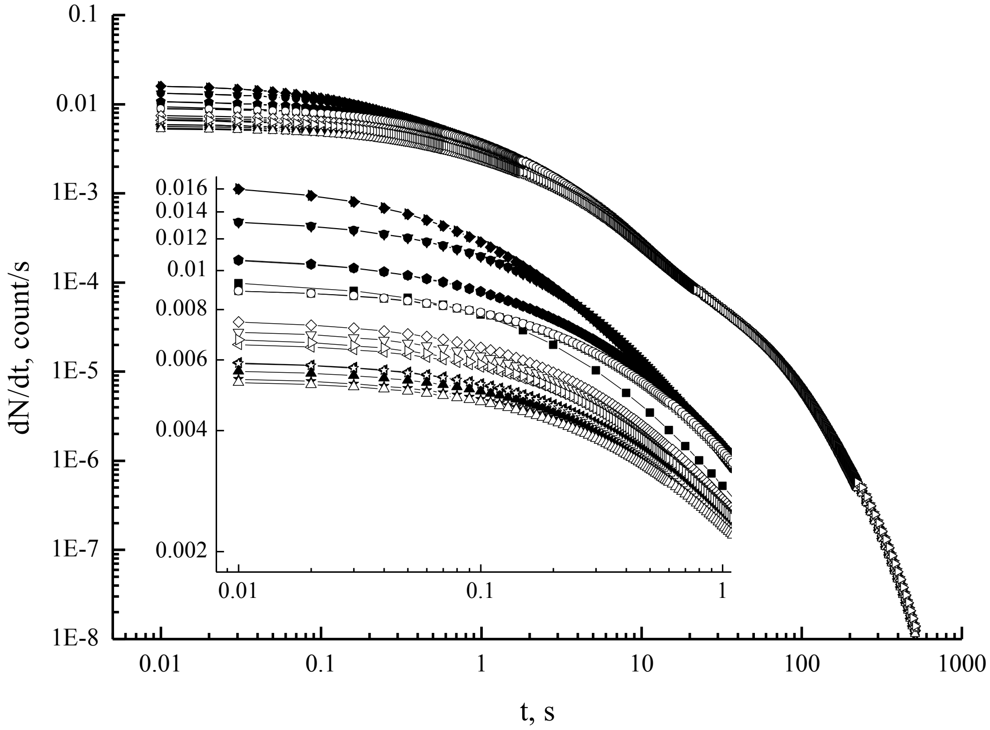

Figure 2. Activity decay curves obtained by simulation of irradiation ^{235}U by thermal neutrons, irradiation time 0.1 ms, on the insert shown the same data in the increased scale.

From fig. 2 it is seen that data of P-K-M+JEFF 3.1.1 coincide with Keepin's experimental values. Decay curves obtained by combinations of *Pn* from E-W, Rudstam, IAEA and JEFF*CY* data are below Keepin's activity decay curve. ENDF/B, JENDL, Wahl data are overestimated in the small times region relatively to an experimentally obtained decay curve.

Conclusion

In this work, the summation method is used for determination of the most reliable data sets of fission products' yields and probability of delayed neutron emission, which are presented in ENDF/B, JEFF, JENDL, ROSFOND libraries. Results are presented in table 13.

As a result of the carried-out analysis of DN nuclear characteristics calculated using various sets of ($Pn,T_{1/2}$), IAEA data is the most optimal ($Pn,T_{1/2}$) data for all of presented cases.

The most reliable cumulative yields are presented in JEFF library. However, the closest to recommended values ν_d and$<T_{1/2}>$ for fast neutron induced fission of ^{239}Pu is obtained using yields from ENDF/B library. This fact can be explained with shift of the most probable charges in isobaric chains of fission fragments. This assumption demands additional verification.

Table 13. The most reliable data sets of fission products' yields and probability of delayed neutron emission

Input data	Data sets for each nucleus				
	^{235}U(T)	^{235}U(F)	^{238}U(F)	^{239}Pu(T)	^{239}Pu(F)
CY	JEFF-3.1.1	JEFF-3.1.1	JEFF-3.1.1	JEFF-3.1.1	ENDF/B-VII.1
Pn	All	IAEA	IAEA	IAEA	IAEA, E-W, Rudstam

In the simulation activity decay curves it is observed that majority of the data are overestimated at short times after irradiation. It is also visible that JEFF data using ($Pn,T_{1/2}$) P-K-M coincide with Keepin's experimental values.

References

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