THE MATHEMATICAL MODEL FOR DECAY CURVE OF THE NUCLEI-DELAYED NEUTRON PRECURSORS IN EXPERIMENT AT A PULSED ELECTRON LINEAR ACCELERATOR

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On the basis of the notion about six groups of nuclei as delayed neutron precursors, radioactive decay laws and the pulsed mode of accelerator operation, a relationship has been derived to describe the decay curve of nuclei-delayed neutron precursors as a function of the pulse rate of the accelerator, the exposure time, the observation time, the time measurement interval and the number of measurement runs. A pilot experiment on thermal-neutron fission of ^{235}U has been conducted. The aim of the experiment was to check the hardware and the information readout computer program. Based on the expressions derived, an analysis was performed and relative yields of delayed neutrons were determined. The present results are compared to the data obtained by other authors. For further development of the analysis, a question is brought up about the influence of additional conditions on the determination of relative delayed-neutron yields. These additional conditions can be represented by certain expressions laid down when measuring delayed neutron yields directly between the accelerator pulses.

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1. INTRODUCTION

The importance of the use of delayed neutrons in applied nuclear physics is widely recognized [1]. Among the applications are the control and determination of small amounts of fissile elements (uranium and transuranium elements) in solid and liquid radioactive wastes, in spent fuel elements, and also the measurements of nuclear constants used in reactor engineering (relative yield and half-life period of certain groups of delayed neutrons). To determine the nuclear-physical constants, the world practice makes use of the fission processes of uranium, plutonium and other nuclei in neutron/gamma-ray beams. The beams may be both pulsed and continuous. The neutron/gamma-ray beams can be generated in different machines, including electron accelerators, through the use of targets-converters. Work [2] can serve an example of the use of a accelerator of continuous action . The electrostatic accelerator was used there to obtain some nuclear-physical constants necessary for the development of nuclear reactor engineering. The research techniques for investigating the composition of transuranium wastes with the use of pulsed reactors are well developed in France [3]. Though the pulse techniques are more complicated as compared to the continuous methods, yet they have certain advantages. In the pulse technique, delayed neutrons can be registered by two methods during one measuring run. In the first method, delayed neutrons are registered between the machine pulses in a certain time window chosen so as to reduce the background. In the second method, the sample is saturated with nuclei-delayed neutron precursors. Then the beam is switched off and the decay curve is measured. With machines of continuous action, only the measurement of the decay curve is possible. Since the delayed neutron yield registered between the pulses and the decay curve are described by the same parameters, the pulse technique is more informative, because it provides a joint analysis of the data obtained by the two measuring methods. In our papers [4-9], we have developed the methods for determining fissile elements with the use of the pulsed electron accelerator. These methods can find their application in different countries (e.g., France, Russia, etc.), where nuclear engineering is developing. Paper [8] was concerned with the first method of delayed neutron registration (between the accelerator pulses). The present work is devoted to the second method (decay curve measurement).

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2. DERIVATION OF ANALYTIC DEPENDENCE FOR THE DELAYED NEUTRON YIELD UNDER THE DECAY CURVE

2.1. Main assumptions and definitions

Let the accelerator pulse generate g_i nuclei-delayed neutron precursors of group $i = (1, 2, ..., 6)$; $g_i = const$ for all accelerator pulses; λ_i is the decay constant of the group i precursor; f is the accelerator pulse frequency ($\delta t = 1/f$ is the time between the pulses). We assume the machine pulse duration to be substantially shorter than the time between the pulses, therefore it will be neglected in our further considerations. The last assumption follows from the fact that the pulse duration is $\approx 1 \cdot 10^{-6} s$, while the interpulse interval at operating frequency of $50 Hz$ makes $0.02 s$. The computer program of information readout and management is characterized by the exposure time $t_{exp} = \mu\delta t$, μ being the number of pulses for the given time t_{exp}; the observation time t_{obs} (in the general case we assume $t_{exp} \neq t_{obs}$); the time measurement interval t_{int} (decay curve integration step or the time observation channel width), $t_{int} = const$; the time observation channel number-k; the number of measurement runs-n. The measurement procedure includes the alternating cycles of accumulation of nuclei-precursors for the time $t_{exp} = \mu\delta t$ and the cycles of observation of delayed neutrons for the time t_{obs}. The accumulation cycle begins from the moment of accelerator beam switching and ends as the time t_{exp} elapses with the beam switched off. As the beam is switched off, the observation cycle begins and lasts t_{obs} seconds. With the end of the observation cycle another accumulation cycle starts, and so on. Under the above-described assumptions, our task is to derive the expression, which describes the delayed neutron yield of all groups in the k-th time channel for n cycles. We divide the task into two stages. The first stage consists in the derivation of expression for the number of accumulated nuclei-precursors of the i-th group in a certain arbitrary l-th cycle; the second stage lies in the derivation of the final formula.

2.2. The number of accumulated nuclei-precursors of the i-th group in an arbitrary l-th cycle

We denote the unknown number of accumulated nuclei-precursors of the i-th group in an arbitrary l-th cycle as $N_i^{\mu l}$ (this symbol indicates that the accumulation took place during μ accelerator pulses). Let N_i^{μ} be the number of nuclei-precursors of the i-th group, which were accumulated for μ accelerator pulses in one cycle, and $N_i^{\mu} = const$ for all the cycles. Then the number of precursors of group i, which were accumulated in the first cycle is $N_i^{\mu 1} = N_i^{\mu}$. The number of precursors accumulated in the second cycle is equal to

$$N_i^{\mu 2} = N_i^{\mu} + N_i^{\mu} e^{-\lambda_i t_{obs}} = N_i^{\mu}(1 + e^{-\lambda_i t_{obs}}).$$

For the third cycle we have:

$$N_i^{\mu 3} = N_i^{\mu}(1 + e^{-\lambda_i t_{obs}} + e^{-\lambda_i 2 t_{obs}}).$$

Reasoning by induction, one can write down

$$N_i^{\mu l} = N_i^{\mu}(1 + e^{-\lambda_i t_{obs}} + e^{-\lambda_i 2 t_{obs}} + ... + e^{-\lambda_i (l-1) t_{obs}}).$$

After finding the sum of geometrical progression, we have:

$$N_i^{\mu l} = N_i^{\mu} \frac{1 - e^{-\lambda_i l t_{obs}}}{1 - e^{\lambda_i t_{obs}}}. \quad (1)$$

2.3. Derivation of the final formula

Using eq. (1), we find the number of i-th group delayed neutrons that came to the timing channel k in the cycle l:

$$\triangle N_{ik}^{\mu l} = N_i^{\mu} \frac{1 - e^{-\lambda_i l t_{obs}}}{1 - e^{\lambda_i t_{obs}}} (e^{-\lambda_i (k-1) t_{int}} - e^{-\lambda_i k t_{int}}). \quad (2)$$

Summing expression (2) over $l = (1, 2, \ldots, n)$, we obtain the number of i-th group delayed neutrons that came to the timing channel k during all the given n cycles:

$$\triangle N_{ikn}^{\mu} = N_i^{\mu} \frac{e^{-\lambda_i (k-1) t_{int}} - e^{-\lambda_i k t_{int}}}{1 - e^{-\lambda_i t_{obs}}} \times \left(n - \frac{e^{-\lambda_i t_{obs}} - e^{-\lambda_i (n+1) t_{obs}}}{1 - e^{-\lambda_i t_{obs}}}\right). \quad (3)$$

Summation of expression (3) over i gives the yield of all the groups of delayed neutrons in the arbitrary timing channel k for n measurement cycles

$$\triangle N_{kn}^{\mu} = \sum_{i=1}^{6} N_i^{\mu} \frac{e^{-\lambda_i (k-1) t_{int}} - e^{-\lambda_i k t_{int}}}{1 - e^{-\lambda_i t_{obs}}} \times \left(n - \frac{e^{-\lambda_i t_{obs}} - e^{-\lambda_i (n+1) t_{obs}}}{1 - e^{-\lambda_i t_{obs}}}\right). \quad (4)$$

It has been demonstrated in ref. [8] that N_i^{μ} can be represented as:

$$N_i^{\mu} = g_i \frac{e^{-\lambda_i / f}}{1 - e^{-\lambda_i / f}} (1 - e^{-\lambda_i \mu \delta t}). \quad (5)$$

In the following, formula (4) will be the basis for the analysis of our preliminary experiment. If $\lambda_i / f \ll 1$ for all neutron groups, then relation (5) can be represented in the following form:

$$N_i^{\mu} = g_i \frac{f}{\lambda_i} (1 - e^{-\lambda_i \mu \delta t}) = N_{0i}(1 - e^{-\lambda_i \mu \delta t}), \quad (6)$$

where $N_{0i} = lim_{t_{exp} \to \infty} N_i^{\mu}$ is the number of nuclei-precursors of group i accumulated in the sample at the cut-off time of the accelerator and at the start of measuring the decay curve at a sufficiently great t_{exp}. Practically, t_{exp} is approximately equal to $5T$, where T is the half-life period of the most long-lived group. In our experiment, $f = 50\, Hz$ and the condition $\lambda_i / f \ll 1$ can be fulfilled. So, in the analysis of our preliminary experiment by formula (4) the N_i^{μ} parameter was taken in the form of expression (6).

The aim of the analysis has been to estimate the relative yields of delayed neutrons under the decay curve $D_i = N_{0i}/\sum N_{0i}$ as well as the relative yields during fission $a_i = g_i/\sum g_i$, and to compare them with the available data. For further discussion we note that at $\lambda_i/f \ll 1$ these parameters can be represented as:

$$D_i = \frac{a_i T_i}{\sum a_i T_i}\,,$$

$$a_i = \frac{N_{0i}\lambda_i}{\sum N_{0i}\lambda_i}\,,$$

where T_i is the half-life period of the i-th group, the other quantities being defined above.

3. EXPERIMENTAL SETUP AND THE MEASURING TECHNIQUE

The experiment was performed at the NSC KIPT 300 MeV electron linear accelerator (LUE-300). The main units of the facility include: the linear accelerator, the neutron-producing target, the sample to be studied (a mixture of ^{238}U and ^{235}U with 2% of ^{235}U), a polyethylene warmer, the Mac-Kiben detector to register neutrons (see for its details in ref. [9]). A new element of the setup, as compared with the cited work, is represented by a computer control of both the process of information readout and the experimental conditions. The experiment on measuring the decay curve of nuclei-delayed neutron precursors was carried out at the energy of electrons incident on the neutron-producing target $E = 16\,MeV$, beam current $I = 34\,\mu A$, pulse frequency $f = 50 Hz$. In front of the sample there was placed a warmer, which represented a polyethylene unit, $8cm$ in thickness. To detect neutrons, the all-wave Mac-Kiben detector was used. The program-controlled experimental conditions were as follows: exposure time $t_{exp} = 300\,s$, the measurement interval $t_{int} = 1\,s$, the observation time $t_{obs} = 300\,s$, the number of cycles $n = 4$. Considering that the warmer was present in the experiment, in the treatment of the experimental data it was assumed that it was ^{235}U which mainly fissioned. Figure shows the results of decay curve measurements versus the time channel number (points with error bars).

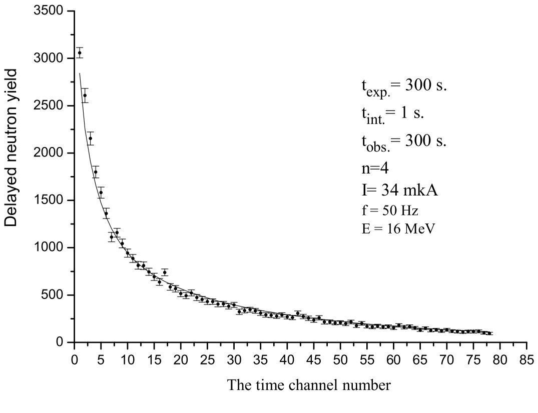

Fig. *The results of decay curve measurements versus the time channel number*

4. ANALYSIS OF THE EXPERIMENTAL DATA AND PROSPECTS FOR INVESTIGATIONS

Two analytic treatments have been performed. The first treatment made use of the parameters a_i taken from work [2]. The aim of the given analysis was to estimate N_{0i} and the relative contributions from different groups of delayed neutrons under the decay curve $D_i = N_{0i}/\Sigma N_{0i}$. The second direct determination of N_{0i} from the analysis of the decay curve made use of the least-squares method with a subsequent estimation of D_i and a_i. A question has been brought up about additional conditions that exert an influence on the determination of the sought-for parameters. These additional conditions can be formulated when registering delayed neutrons between the accelerator pulses.

1. Using the relation $a_i = g_i/\sum_1^6 g_i$ we write down the parameters g_i in terms of a_i and substitute the resuly into expression (6). Then formula (4) takes on the form:

$$\begin{aligned}\triangle N^{\mu}_{kn} &= \beta f \sum_{i=1}^{6} \frac{a_i}{\lambda_i}(1 - e^{-\lambda_i t_{exp}}) \times \\ &\frac{e^{-\lambda_i (k-1) t_{int}} - e^{-\lambda_i k t_{int}}}{1 - e^{-\lambda_i t_{obs}}} \times \\ &(n - \frac{e^{-\lambda_i t_{obs}} - e^{-\lambda_i (n+1) t_{obs}}}{1 - e^{-\lambda_i t_{obs}}}),\end{aligned} \qquad (7)$$

where $\beta = \sum_1^6 g_i$ With the a_i parameters for ^{235}U taken from ref. [2] and with the use of the least-squares method, the model dependence was brought into agreement with the experiment by varying the parameter β, which physically presents (to an accuracy of the proportionality factor) the number of nuclei-precursors of all six groups generated by one accelerator pulse. The fitting has resulted in $\beta = 16.71 \pm 0.12$, $\sum \chi^2_k/(N-1) = 1.57$, $N = 78$ being the number of points under the decay curve (see Fig.1, solid curve). Note that in this analysis only 78 experimental points were involved (we had 300 experimental values). This is explained by the fact that the supplementation of experimental points (more than 78) produces no essential effect on the definable parameter β. With an increase in the number of experimental points up to 300, the β value changes only by 0.1%. and an experimental error in it of 0.7%. The analysis under discussion well predicts the total number of events under the decay curve. The experiment gives the total number of events under the decay curve to be 43087 ± 208. The model value of this parameter can be estimated by the formula: $4 \cdot \sum_1^6 N_{0i}$, where N_{0i} is the second column of Tab.1 ($N_{0i} = f a_i \sum g_i/\lambda_i$, a_i, λ_i are taken from ref. [2], $\sum g_i$ - our analysis). The fourth column of Table1 gives the relative yields of delayed neutron groups under the decay curve: $D_i = N_{0i}/\sum N_{0i}$ (N_{0i} is the second column of Table 1).

Table. 1. *The number of nuclei-precursors of group i accumulated for one measurement cycle-*N_{0i}*, and the relative yield of the i-th group delayed neutrons under the decay curve-*D_i*. Here we used the following designations:* N_g*-Group number;* N^*_{0i}*-Calculated, using parameters from [2];* N^{**}_{0i}*-Our data;* D^*_i*-Calculated, using parameters from [2];* D^{**}_i*-Our data*

N_g	N^*_{0i}	N^{**}_{0i}	D^*_i	D^{**}_i
1	2476 ± 94	2469 ± 118	0.228 ± 0.09	0.246 ± 0.014
2	5685 ± 90	4941 ± 192	0.524 ± 0.010	0.492 ± 0.025
3	1523 ± 26	1561 ± 191	0.140 ± 0.003	0.155 ± 0.019
4	1078 ± 13	1007 ± 139	0.099 ± 0.002	0.100 ± 0.014
5	78 ± 2	68 ± 48	0.007 ± 0.0002	0.007 ± 0.005
6	6 ± 1	-3 ± 2.6		
		5 ± 4	0.0005 ± 0.0001	0.0005 ± 0.0004

2. For the analysis, formula (4) was taken in the following form:

$$\triangle N^{\mu}_{kn} = \sum_{i=1}^{6} N_{0i}\left(1 - e^{-\lambda_i t_{exp}}\right) \times \frac{e^{-\lambda_i (k-1) t_{int}} - e^{-\lambda_i k t_{int}}}{1 - e^{-\lambda_i t_{obs}}} \times \left(n - \frac{e^{-\lambda_i t_{obs}} - e^{-\lambda_i (n+1) t_{obs}}}{1 - e^{-\lambda_i t_{obs}}}\right), \qquad (8)$$

where N_{0i} represents the sought-for parameters. From the condition: $\partial\chi^2/\partial N_{0i} = 0$ a set of linear equations was formulated, and N_{0i} was determined with the least-squares method. This analysis has involved 240 experimental points. A further increase in the number of experimental points for the analysis does not change the N_{0i} values. For control, the set was solved in two ways using the Cramer and the Gauss method. In this case, it appeared that the quality of agreement between the analytic curve and the experiment is characterized as $\sum \chi^2_k/(N-P) = 1,1$, $(N = 240, P = 6)$. On finding N_{0i}, relative yields of delayed neutrons were determined both under the decay curve: $D_i = N_{0i}/\sum N_{0i}$ and under fission: $a_i = N_0\lambda_i/\sum N_0\lambda_i$. The N_{0i} values are listed in the third column of Table 1. It can be seen from the table that $N_{06} = -3 \pm 2.6$, this having, unfortunately, no physical meaning. The estimation of N_{06} with physical meaning was performed using the expression: $N_{06} = N_{05}\lambda_5 a_6/\lambda_6 a_5$, where N_{05} was taken from our analysis, while the other parameters were taken from ref. [2]. The D_i values are presented in the fifth column of Table 1. The comparison of the N_{0i} and D_i values obtained in this section with similar values of the previous section (see table 1) shows them to be coincident within the experimental error (the exception is the second group). A comparatively great error is caused by the fact that in the preliminary experiment there were only 4 measurement cycles. Table 2 gives the values of relative yields a_i. It is obvious from the table 2 that within the experimental error the ai values agree very closely with the results of ref. [2]. To conclude the analysis, we formulate below possible additional conditions for the search for the decay curve parameters.

Table 2. *Relative delayed neutron yields of six groups in thermal-neutron fission of* ^{235}U

N_g	$a_i - our\,data$	$a_i - from[2]$
1	0.041 ± 0.003	0.038 ± 0.001
2	0.197 ± 0.014	0.211 ± 0.004
3	0.217 ± 0.026	0.197 ± 0.004
4	0.397 ± 0.064	0.396 ± 0.005
5	0.123 ± 0.081	0.132 ± 0.004
6	0.025 ± 0.020	0.026 ± 0.001

5. ADDITIONAL CONDITIONS ON THE SEARCH FOR THE DECAY CURVE PARAMETERS

We now formulate additional conditions on the search for the decay curve parameters that can be obtained when registering neutrons between the accelerator pulses. In the preliminary experiment considered above, the measurements of delayed neutron yields between the pulses were not performed. Therefore, the conditions formulated below can be considered as a prospect for further investigations of the decay curve. At $\lambda_i/f \ll 1$, the following expressions are valid:$\sum N_{0i} = f\overline{T}\sum g_i/\ln 2$, where $\overline{T} = \sum a_i T_i$, a_i are the relative yields of delayed neutrons, T_i are the half-lives of nuclei-precursors. It has been demonstrated in paper [8] that if, at least, two measurements of delayed neutron yields are made with registration between the accelerator pulses with the times of exposure $t_1 >> 1/\lambda_i$ and $t_2 >> 1/\lambda_i$ (for definiteness, we assume that $t_2 > t_1$), then $\overline{T}$ and $\sum g_i$ can be determined from the following equations:

$$\frac{N(t_2)}{N(t_1)} = \frac{t_2 \ln 2 - \overline{T}}{t_1 \ln 2 - \overline{T},},$$

$$\sum g_i = \frac{(N(t_2) - N(t_1))\delta t}{(t_{end} - t_{in})(t_2 - t_1)f},$$

where $N(t_1)$ and $N(t_2)$ are the delayed neutron yields for the exposures t_1 and t_2, t_{end} - t_{in} is the time observation channel width, t_{in} is the start time, t_{end} is the end time point (the time is computed from the moment of the accelerator pulse), the remaining parameters are described above. So, performing the experiment between the pulses, we can formulate additional conditions on the search for the parameters of the decay curve in the following form:

$$\sum N_{0i} - f\overline{T}\sum g_i/\ln 2 = 0,.$$

Besides, the delayed neutron yield registered between the accelerator pulses for the time t_{exp} [8] can be an additional condition in the search of the decay curve parameters, because this yield and the decay curve are described by the same parameters:

$$N(t_{exp}) = \sum g_i \frac{e^{-\lambda_i t_{in}} - e^{-\lambda_i t_{end}}}{1 - e^{-\lambda_i/f}} \times \left(f \cdot t_{exp} - \frac{e^{-\lambda_i/f}}{1 - e^{-\lambda_i/f}}\left(1 - e^{\lambda_i t_{exp}}\right)\right). \qquad (9)$$

In finding the parameters by the least-squares method at additional conditions, the accuracy of the sought-for parameters often gets improved. In future, we expect to investigate the influence of the mentioned additional conditions obtained between the accelerator pulses on the accuracy of determination of decay curve parameters. Technically, the task is reduced to finding the constrained minimum of the χ^2 function and can be solved by the Lagrange method of undetermined coefficients.

6. CONCLUSIONS

1. An analytic representation of the decay curve has been obtained for the analysis and design of experiments.

2. A preliminary experiment has been performed to check the instrumentation and the computer information readout program.

3. The results of experimental data analysis are in agreement within the experimental error with the data of paper [2].

4. The question has been brought up about additional conditions that exert influence on the determination of decay curve parameters.

References

1. V.V. Frolov. *Nuclear techniques to control fissionable materials.* M: "Ehnergoatomizdat" 1989, 178p. (In Russian).
2. V.M. Piksaikin, L.E. Kazakov, G.G. Korolyov, S.G. Isayev, V.A. Roshchenko, M.Z. Tarasko. The relative yield and period of some delayed neutron groups at fission of ^{233}U, ^{235}U, ^{239}Pu by epithermal neutrons // *Atomnaya Ehnergiya.* 2000, v.92, p.135-143 (In Russian).
3. A. Lyoossi, J. Romeyer-Dherbey, F. Jallu, et al. Transuranic waste detection by photon interrogation and on-line delayed neutron counting // *Nuclear Instruments and Methods in Physics Research.* 2000, v.B160, p.280-289.
4. A.Yu. Buki, V.Y. Kasilov, V.V. Kirichenko, et al. Development of the industrial technique to determine the fissionable material concentration using the electron linac as the base // *Atomna Ehnergetika ta Promyslovist' Ukrainy.* 2000, N2, p.24-25 (In Ukrainian).
5. V.I. Kasilov, V.V. Kirichenko, L.A. Makhnenko, et al. About possible determination of the ^{238}U content in concrete samples by means of the electron linac. *Atomna Ehnergetika ta Promyslovist' Ukrainy.* 2000, N2, p.50-51 (In Russian).
6. R.P. Slabospitsky, S.S. Kochetov, V.V. Kirichenko. Rapid radioactive waste sorting system using the electron linac. Preprint KhFTI 2002-1. Kharkov, NSC KIPT , 2002, 19p.(In Russian).
7. S.S. Kochetov, R.P. Slabospitsky, V.V. Kirichenko. The use of the electron linac for determining fissionable materials in radioactive wastes // *Visnyk Kharkivs'kogo Universytetu, ser. fizychna "Yadra, chastynky, polya".* 2002, v.B.2(20), N.574, p.71-80 (In Russian).
8. A.A. Khomich, V.I. Kasilov, V.V. Kirichenko, et al. The model of delayed neutron yield in the experiment at the pulsed electron linac // *Visnyk Kharkivs'kogo Universytetu, ser. fizychna "Yadra, chastynky, polya".* 2006, v.B2(30), N732, p.87-95 (In Russian).
9. A.Yu. Buki , V.I.Kasilov , V.V. Kirichenko, et al. Method for defining the concentration of fissile materials in radioactive waste // *Voprosy Atomnoj Nauki i Tekhniki. Ser. "yaderno-fizicheskaya".* 2000, v. 2(36), p.64-65.

МАТЕМАТИЧЕСКАЯ МОДЕЛЬ КРИВОЙ РАСПАДА ЯДЕР, ПРЕДШЕСТВЕННИКОВ ЗАПАЗДЫВАЮЩИХ НЕЙТРОНОВ, В ЭКСПЕРИМЕНТЕ НА ИМПУЛЬСНОМ ЛИНЕЙНОМ УСКОРИТЕЛЕ ЭЛЕКТРОНОВ

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Исходя из представления о шести группах ядер-предшественников запаздывающих нейтронов, законов радиоактивного распада, и импульсного режима работы ускорителя, получено соотношение, описыва-

ющее кривую распада ядер предшественников запаздывающих нейтронов в зависимости от частоты посылок ускорителя, времени экспозиции, времени наблюдения, шага измерения по времени и количества циклов измерений. Проведен пробный эксперимент по делению ^{235}U тепловыми нейтронами. Цель эксперимента - проверка аппаратуры и компьютерной программы съема информации. На базе полученных выражений проведен анализ и определены относительные выходы запаздывающих нейтронов. Результаты сравниваются с другими работами. Как перспектива дальнейшего развития анализа, ставится вопрос о влиянии дополнительных условий на определение относительных выходов запаздывающих нейтронов. Такими дополнительными условиями могут быть некоторые выражения, сформулированные при измерении выходов запаздывающих нейтронов непосредственно между посылками ускорителя.

МАТЕМАТИЧНА МОДЕЛЬ КРИВОЇ РОЗПАДУ ЯДЕР, ПОПЕРЕДНИКІВ ЗАПІЗНІЛИХ НЕЙТРОНІВ, В ЕКСПЕРИМЕНТІ НА ІМПУЛЬСНОМУ ЛІНІЙНОМУ ПРИСКОРЮВАЧІ ЕЛЕКТРОНІВ

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Виходячи з представлення про шість груп ядер-попередників запізнілих нейтронів, законів радіоактивного розпаду, і імпульсного режиму роботи прискорювача, отримано співвідношення, що описує криву розпаду ядер-попередників запізнілих нейтронів у залежності від частоти посилок прискорювача, часу експозиції, часу спостереження, кроку виміру за часом і кількості циклів вимірів. Проведено пробний експеримент з поділу ^{235}U тепловими нейтронами. Мета експерименту - перевірка апаратури і комп'ютерної програми з'йому інформації. На базі отриманих виражень проведено аналіз і визначено відносні виходи запізнілих нейтронів. Результати порівнюються з іншими роботами. Як перспектива подальшого розвитку аналізу, ставиться питання про вплив додаткових умов на визначення відносних виходів запізнілих нейтронів. Такими додатковими умовами можуть бути деякі вирази, сформульовані при вимірі виходів запізнілих нейтронів безпосередньо між посилками прискорювача.