Periodic Phenomena in the Rate of Radioactive Decay Under the Action of an Electromagnetic Field

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We have determined a mode of treatment of a radioactive material (^{232}Th and daughter products in a colloid solution of monazite sand) with a sequence of short impulses of an electromagnetic field which results in a change in the intensity (counting rate) of gamma-radiation. The value of changes in the intensity as a general trend is approximately 1.8 % for a period of about 1 month. In addition to the changes in the intensity, we observed changes in the statistics of the radioactive decay. In the long-term signal of every-second regular measurements of the counting rate for daughter products of the decay of ^{232}Th obtained after the treatment of the specimen with an impulsive electromagnetic field, we have found the periodic components among which the periods of 0.5, 1, and 6.6 days are distinguished most clearly.

1 Statement of the problem

The regular periodic changes in the intensity of signals of the radioactive decay, as well as the sporadic splashes of the counting rate, were observed many times (see [1]). They include the seasonal changes with periods of 1 year, 1 month, and 1 day which can be obviously related to astronomical phenomena. While analyzing the periodicity of the 1-day radioactive decay, it is necessary to separate the studies of the changes in the intensity of signals from radon and beryllium in the near-Earth layer of the atmosphere, which are caused mainly by geophysical or meteorological factors and are omitted in the present work, from the studies of the radioactive decay under controlled conditions (see [2–4] and references therein), where the manifestations of the variability of a signal are assigned to changes namely in the rate of radioactive decay. The presence of changes in the rate of decay can be related, in our opinion, to such fundamental causes as cosmophysical factors. Separately, we mention the works by S. E. Shnoll [5], where the regular changes in the statistics of separate parts of the series of measured data on the rate of radioactive decay, namely, the changes in a form of the distribution function, were observed. It is worth to note the fundamental cycle of works executed by opponents of this idea [6–8], where the special studies of this question revealed no existence of seasonal changes in the half-life period.

But earlier, the existence of that or other regularities of the radioactive decay was discussed without any experimental interference at laboratories. Moreover, the possibility of the influence of external physical factors, being outside the nuclear scale of energies, on the rate of radioactive decay was considered impossible since Rutherford's times [1, 9, 10]. Hence, the studies in this direction have a fundamental meaning, because they would prejudice the basic assertions of the theory that, first, all events of a radioactive decay are mutually independent, and, second, the internal processes in a nucleus which define the processes of decay can be affected only by the fluxes of particles and quanta with energies of the order of those of nuclear transitions from kiloelectronvolts to megaelectronvolts. However, we mention a well-known exclusion, isotope ^{229}Th, whose excitation energy is about 1 eV.

In this work, we present the results of laboratory studies of the influence of an external electromagnetic field with sufficiently low intensity on the rate of counting of gamma-quanta from a radioactive specimen and will show that such influence is possible.

Especially, we note that, though the revealed changes in the intensity of a signal after the action of an external factor for the period of observations up to 40 days are rather small, the changes in the statistical properties of the obtained regular series of measurements are obvious and objective.

2 Materials and methods

The setup realizing the action on a specimen (for simplicity, we call it a driver) is a system of coils with special structure aimed at the creation of an impulsive electromagnetic field. The duration of impulses is 1–10 nsec. The treatment was carried on for 10–30 min. The power of the setup is about 25 W. The energy of impulses is at most 2.5 J.

The scheme of the experiment is as follows. First, we carried on the control measurements for some time. After the action of a driver, the specimen was returned to a counter, and we measured the radiation from the specimen for several days. Such procedure can be repeated several times. In this case, we studied the intensity of the summary gamma-radiation from a specimen of natural monazite sand (mineral with ^{232}Th) for the period from 20.12.2017 to 15.01.2018. The results are obtained in a laboratory, i.e. under controlled conditions. During the indicated period of measurements, the driver did not act on the specimen, i.e. the presented results are a manifestation of the aftereffect.

To gauge the counting rate, we used a counter of gamma-quanta such as a dosimeter "Pul's" for the remote radiation control. It was produced at the small joint-stock enterprise "Opyt" and includes a detector on the basis of NaI(Tl). The construction of the counter itself contains no lead-based protection. The counter can operate in the automatic mode and can write the result of measurements in the memory every second. During the measurements, the counter with a specimen have no special protection or can be placed inside a lead cylinder. The latter was open from one end, was about 30 cm in length, and has walls 10 cm in thickness. The measurements were carried out on different specimens, in different modes of action of a driver, many times, under the lead protection, and without it. On the whole, the results were invariable, i.e. the below-described effects did not disappear. The described conditions of measurements are given for the concreteness. The measurements were performed in heated premises. The changes on the temperature were in the interval 17–22 °C, but they were not regular with daily period.

In the room, where the measurements were performed, the background was much lower than the level of signals. For the indicated period, we have got a series of every-second measurements of the intensity of gamma-radiation with interruptions for the time, when the treatment of a specimen was executed.

Since the purpose of the present work is the search for the periodicity of a signal, we applied the wavelet-analysis using Gauss–Morlet wavelets [11, 12].

In Fig. 1, we show the signal from the untreated specimen in the form of a noisy path and its wavelet-expansion as a two-dimensional pattern of disordered spots. If some periodic regularities of the type of modulation by a sinusoid are present in the signal, the pattern of coefficients of the Gauss wavelet-expansion will contain the series of spots regularly arranged along the horizontal. The distance between such regular spots along the horizontal is equal to the half-period in units of the horizontal axis.

In view of the low rate of counting, while seeking the periodicities with a period of 1 h and more, we transformed the input series of data into a series of measurements for each 10 minutes (sum of sequential values for each 600 sec without the overlapping of intervals, where the number of counts is calculated).

3 Results

The analyzed signal itself after the action of a driver and the result of its wavelet-expansion are given in Fig. 2. The upper plot is the series of data which should be analyzed. Below, the two-dimensional pattern is the representation of coefficients of the wavelet-expansion (result of a wavelet-transformation of some series of data is the two-dimensional matrix of coefficients of the expansion). On the horizontal axis of the pattern, we indicate the number of a measurement which is proportional to the time from the start of measurements.

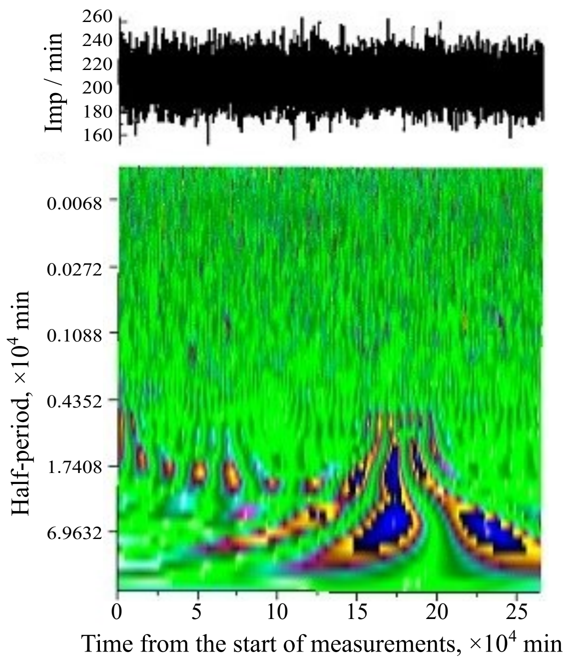


Fig. 1: Wavelet-expansion of a signal of the intensity of gamma-radiation from a specimen of monazite sand without the treatment with a driver. The upper plot is a signal; below, the two-dimensional pattern is the representation of the matrix of coefficients of the wavelet-expansion of this signal.

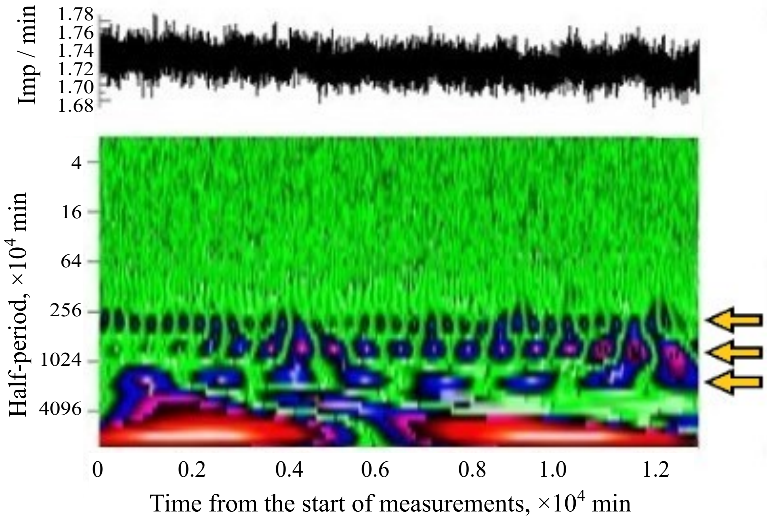
We note that the measurements are regular, and, in this case, each measurement corresponds to a time interval of 10 min. Therefore, for example, the number 1000 on the horizontal axis corresponds to a time moment of 10 000 min from the start of measurements. Along the vertical axis of the two-dimensional pattern, we give the half-period of a signal in units of the horizontal axis. We see clearly several horizontal rows of "spots," the distances between which are equal to the half-period (by assuming the modulation by a sinusoid).

In the table near the wavelet-expansion pattern, we show, as an example, several distances between spots for the rows indicated by arrows directly from the two-dimensional pattern in Fig. 2. This allows us to draw conclusion about the uncertainty of those estimates.

In addition to the appearance of a periodic daily modulation on the wavelet-expansion patterns, we observe that the signal itself looks as a uniform noisy path. We see also a tooth ripple of the daily variation and a small asymptotic decline.

4 Discussion of results and conclusions

The obtained array of results about the dynamics of the rate of counting of gamma-quanta after the treatment of a specimen with a driver testifies indisputably to the presence of the



Half-periods, day

0.27	0.48	3.60
0.27	0.55	3.60
0.24	0.53	3.34
0.26	0.50	3.17
0.24	0.53	3.00
0.24	0.49	2.99
0.26	0.54	3.34
0.25	**0.52**	**3.29**

Fig. 2: Wavelet-expansion of a signal of the intensity of gamma-radiation of a specimen with Th after the treatment with a driver. The upper plot is the signal; below, the two-dimensional pattern is the representation of the matrix of coefficients of the wavelet-expansion of this signal. Arrows indicate the periodic series. The signal is the number of impulses for 1 min. The table on the right shows some examples of the estimates of distances between spots. The lower row gives the mean values.

external influence on the process of radioactive decay. This fact cannot be a result of erroneous measurements or, especially, improper analysis: the effect is not observed prior to the treatment and is seen after it.

Because the described result, i.e. the appearance of a periodicity in the noisy signal, is reliably established experimentally, we may ask: why was no effect observed earlier? The possible causes are as follows:

1. The effect is reliably registered only in definite operational modes of a driver. To observe it, one needs to perform special long-term experiments, since the effect can reveal itself in several tens of days after the action of a driver.
2. In the whole array of experimental data, the effect of a variation of the trend of the rate of counting is not strong (several percents) and is variable in time. Therefore, without regular long-term measurements, the effect can be considered as a noise or the uncertainty of a procedure of measurements.

Thus, we showed experimentally the presence of many periodicities with noninteger ratios in measured sequences of the rates of counting. The logical consequence of these results and of the up-to-date model representations about the fractal dynamics of intranuclear clusters [13–15] and about the nuclear structure [13–18] is the conclusion that sufficiently weak electromagnetic signals can excite the dynamics of intranuclear clusters, and, hence, it is possible to observe a manifestation of this changed dynamics in the probabilities of nuclear processes.

Received on May 4, 2020

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