Observation of the influence of an electromagnetic field on a radioactive decay rate

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The influence of the electromagnetic field on the rate of gamma pulses counting from radioactive samples after the action of the driver in the form of pulses of the electromagnetic field was observed. Controlled radionuclide is ^{137}Cs. The sample was a sample of ordinary soil. At a certain time interval, there was an increase in the count rate, and then its decline. The magnitude of changes reached 3%. The observation lasted about one year.

Keywords: radioactive decay, electromagnetic field, decay rate, change in half-life.

Introduction

To date, the axiom is that a single nucleus has a probability to decay, and this probability does not depend on other nuclei, and the nuclear system as a whole decay with a characteristic half-life $T_{1/2}$, which not dependent on external influences [1, 2]. This statement is mitigated when considering the effects of atomic electronic shells. It is shown that small changes in the half-life are observed if the radioactive nucleus is embedded in the crystal lattice [3, 4], also during ionization of nuclei in accelerators very large changes in the half-life of ionized nuclei are observed. But these are very special situations, and under normal conditions, the effects were almost not observed. But today there are many reports of attempts to influence the rate of radioactive decay, see review in [5].

This paper presents the results of many experiments to find the effect of the influence of an external electromagnetic field on the rate of radioactive decay. The factor itself (in this case, the pulsed electromagnetic field), as well as the modes of its action, will be called the driver. In works [6-7] about the influence of an external factor on radioactive decay, it is noted that the effect of the influence of an external factor can be both an increase and a decrease in the count rate. Similar results were obtained in our laboratory too. But the peculiarity of the presented results is that a stable and reproducible effect of changing in the count rate under the action of the driver is achieved. This paper analyzes the situation when there was increasing and stable maintenance of the count rate at an elevated level for at least a year. Increasing the count rate means accelerating the process of radioactive decay. This process can be reformulated as an accelerated decrease in the number of radioactive nuclei in the sample.

Observations of the influence of the electromagnetic field on radioactive decay were reported in [8, 9], but the question of the nonstationarity of the radioactive decay process was investigated there, and the decay statistics were analyzed. The main task of this work is to demonstrate that under the action of an external pulsed electromagnetic field a change (increase) in the count rate is reliably observed, which means a change in the half-life, i.e., that $T_{1/2}$ ceases to be a constant.

Materials and methods

A sample with radioactive ^{137}Cs was investigated. Samples in the form of samples of ordinary soil were studied: after the Chornobyl accident, in the Kyiv region it is easy to find soil, the activity of which, although small, is sufficient for measurements. The sample was carefully packed in a special cell and it is believed that its properties do not change from moving it from the spectrometer to the safe and vice versa.

The driver is a coil of the special construction. The power consumption was about 80 Wt.

The scheme of experiments was as follows. After treatment by the driver, possibly repeatedly, the intensity of gamma radiation (count rate) from this sample was measured. The result is a table or graph of changes in count rate over a time. Measurements were not performed regularly, but in some cases over several years.

The measurements were performed on a scintillation NaI (Tl) gamma spectrometer "Inter-3M" produced by the research and production small joint venture "Opyt". The size of the crystal is Ø63x63 mm. The relative resolution of the ^{137}Cs gamma line (0.662 MeV) is not more than 8.5%. The energy range of gamma quanta is 0.05 ... 3.0 MeV; the number of channels is 1024.

As for the budget of result uncertainties, the uncertainty consists of the following components. 1. First of all, it should be noted that it is not the activity of the sample that is measured, but the count rate. Therefore, the uncertainty associated with the problem of converting count rate into activity does not affect the outcome. 2. Natural fluctuations of radioactive decay. They can be estimated by comparing the peak area or load of the spectrometer for the one-second spectra. In one hour, it will be 3600 spectra and the uncertainty of the average area of the line reaches less than 0.5%. 3. Because the measurements were performed during the year, the spectrometer was used to measure different samples. Although the samples were packed in special cuvettes, there is uncertainty due to the inaccurate placement of the sample in the spectrometer. This error cannot exceed the scatter of the results of multiple measurements, so it's conservative, i.e., the largest value is taken to be the scatter of the results on the experimental graph. 4. Instability of the spectrometer. This effect (shift of energy calibration to several channels) is really observed. This factor can lead to an error in determining the position and, consequently, the intensity of a single line, but in our case, when the controlled value is the total number of pulses (spectrometer statistical loading), this factor does not affect the result.

Results

The result for discussion is presented in Fig. 1. This figure shows the change in the count rate from this sample over time. Since the controlled signal belongs to ^{137}Cs (in the gamma spectrum we do not see any other lines), the graph also shows the theoretical dependence of the change in signal intensity over time for a half-life of 30.17 years. As can be seen, there is, albeit small (up to 3%), an increase in the count rate. This increase is markedly different from the expected decline (see the theoretical curve in Fig. 1) and is far beyond the scatter of values.

If we take some sample and measure the rate of counting (under the standard condition that the duration of measurements is much less than the half-life), the activity, that is the number of decays per second, for a particular sample will be related to the half-life by the dependence [10]

$$A_0 = const * m / T_{1/2}^{(0)} \tag{1}$$

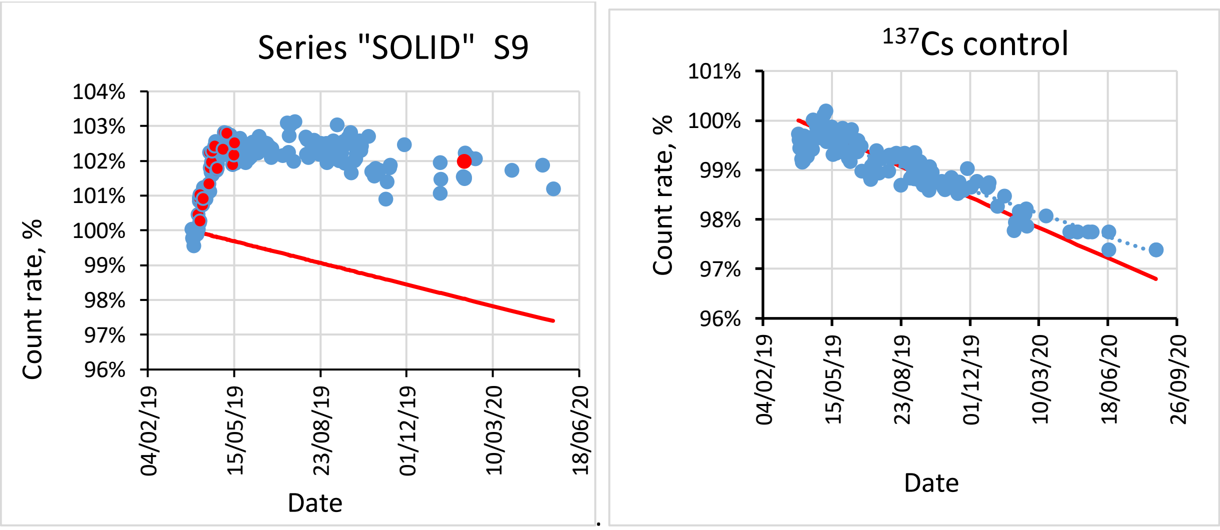
where **m** is the mass of the sample (assuming that the sample consists only of radioactive nuclei). It is also a constant and is mentioned only to emphasize that apart from the mass, which is proportional to the number of nuclei and the half-life, there are no other parameters of the sample in this expression. It can be seen that since **m** is a constant, the only way to increase the radiation intensity for this sample is to reduce its half-life. Only a decrease in the half-life leads to an increase in the number of decays, i.e., to an increase in signal intensity. Alternatively, an increase in the signal from radioactive nuclei as a result of the driver's action means an acceleration of decay, i.e., a decrease $T_{1/2}^{(0)}$ over time.

In the considered experiments the increasing rising in the intensity of gamma radiation after the action of the driver is observed. Such growth cannot be infinite, because with accelerated decay, sooner or later all nuclei will decay and the radiation intensity must decrease sharply. Therefore, with accelerated decay, the change in intensity over time should take the form of a curve with a maximum.

Discussion

From fig. 1 and formula (1) we draw the first conclusion: in the experiment, there was a decrease in the half-life.

Next, we show that the decay process has become non-stationary. Indeed, if nuclei with an increased decay rate (which will give an increased counting rate) have somehow appeared, then the number of decays should begin to decrease due to the decay process, although perhaps with a different half-life. The gradual increase in the count rate observed over some time (almost two months) means that more and more nuclei are involved in the process of accelerated decay at each subsequent point in time because as soon as the number of such nuclei stops growing, the counting rate must begin to decrease. The same logic is valid for the next zone of a more or less stable count rate. Therefore,



a

b

Fig.1. Dependence of gamma radiation intensity of controlled samples on time. ^{137}Cs. a) after the driver. The driver acted many times, but it seems that after reaching the maximum, the subsequent behavior was not affected, i.e., only the first actions of the driver were important. Red dots are the moments of the driver action. b) a control sample on which the driver did not act directly.

increasing or the raised value of the count rate compared to the theoretical curve means decay with acceleration compared to the theoretical exponential decay.

Further consideration requires some assumptions. We proceed from the above in Fig. 1 experimental fact: the driver accelerates the decay of radioactive nuclei (gamma spectrometric analysis shows that even after the driver, the observed radiation has an energy of 662 keV, that belongs to the original ^{137}Cs (^{137m}Ba). Then there are two possibilities. First: all nuclei of ^{137}Cs are exited, which begin to disintegrate rapidly but also accidentally. After some time, the excitation disappears and the last nuclei return to their original state. Second: only those nuclei are excited, the internal state of which has already been close to decay. That is, you can choose some of the nuclei, the decay rate of which has changed under the influence of the driver. Then, in the first stage, there is an increase in the intensity of decay, which, as the total number of radioactive nuclei excited by the driver decreases, will result in a decrease in the intensity of gamma radiation as a result of such accelerated decay. At the same time, the nuclei which are not excited by the driver, continue to disintegrate with the standard half-life. It seems that such results were obtained. Unfortunately, the typical times of such processes are months, if not years, so it is difficult to show this on repeated systematic measurements.

Then you can take the next logical step. The nucleus is a system of nucleons (droplet model of the nucleus). Radioactive nuclei (a system of nucleons, i.e., nuclei capable to radioactive decay)

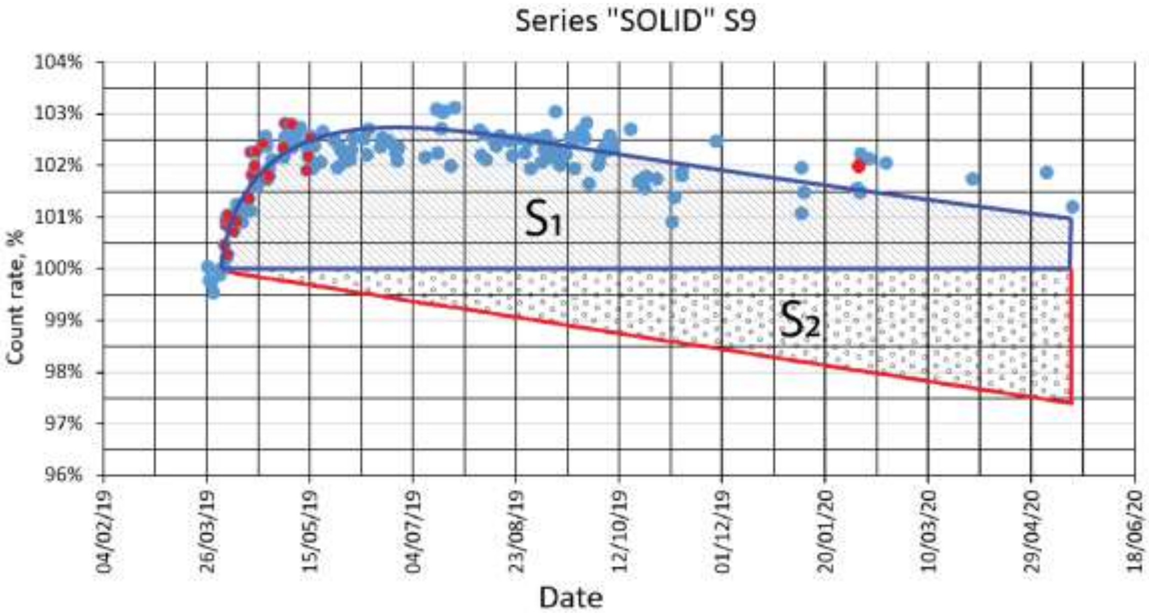


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Fig. 2. Data from fig.1 for analyzing driver effectivity. Shaded squares correspond to numbers of nuclei, which decayed both spontaneously and after driver’s action.

are in an excited state, and radiation in our case of beta or gamma particles leads to the removal of such excitation. It should be explicitly emphasized that under the action of the driver, the nucleus should go into a more excited state in terms of its internal dynamics. At the same time, relaxation times in months and years are observed in the experiment (on our experimental graph, decay with acceleration is observed for more than a year). It is impossible to imagine intranuclear processes with such a relaxation time within the framework of the droplet model. Therefore, the conclusion is that the nuclear system as a whole is involved in this process. The idea that radioactive decay takes place in a system of nuclei that are in the so-called "correlated states" was considered in the works of Adamenko and Vysotsky [11-14]. The state of such a system already depends on both intranuclear excitations and the interaction between excited nuclei and can last much longer.

It is now desirable to quantify changes in the decay rate under the influence of the driver. Let's do it graphically, using the graphs in Fig. 2. Denote S1 - the area that is proportional to the number of the nucleus that has disintegrated due to the influence of the driver; S2 is the area that is proportional to the number of nuclei that decayed due to standard decay; Sum = S1 + S2 - the total number of nuclei that decayed in a given period. The measure of a change (increasing the number of decays) will be Sum/S1. From Figure 2 we estimate the corresponding areas: S2 = 45.1, S1 = 63.4, Sum = 108.5. Then Sum/S1 = 2.4. That is, with the observed increase in the rate of counting by only 3%, the number of decays for almost a year was increased by about 2.4 times compared to the standard decay rate.

Conclusions

1. In the experiment, an increase in the decay rate under the action of an external factor – a pulsed electromagnetic field – was observed.
2. The relaxation rates of the decay rate observed in the experiment have a characteristic time from months to years.
3. The results obtained are best described in the assumption that only a limited number of nuclei are involved in the process. First, in our experiments, spikes in the rate of counting were repeatedly observed. Secondly, after that, the speed of counting somehow decreased to about "normal". (Such data are not given here due to poor reproducibility). This process can be described consistently, assuming that under the influence of external impact only part of the nuclei goes into a metastable (isomeric) state.
4. The increase in the count rate on the first stage (during the first months, Fig. 1,a) means that the process is accelerating. With standard radioactive decay, which proceeds at a

constant rate, the number of nuclei involved in this process decreases exponentially. In contrast, in this case, it is observed that the number of nuclei involved in the decay process is increasing or constant. From this at least it follows that the decay mechanism for these nuclei has fundamentally changed and ceased to be random (otherwise the exponential decline would have persisted). It is no longer determined by the constancy of the probability of decay, as before, but by the constancy of number of nuclei involved in this process.

5. The obtained results are generally consistent with the theory that radioactive nuclei are not independent, but are in the so-called correlated states [11-14], and the decay process is determined by the relationship between the nuclei. The model can be a sheet of paper, which is lit in the center. In the process of combustion, the burnt hole will first increase, and then, depending on the mode of combustion, with increasing diameter of the combustion zone will gradually fade.
6. The listed features should be present in any models, which will describe fig. 1a.
7. It is shown that for the specific case of ^{137}Cs (Fig. 2) for the interval of observations the decay rate was increased approximately three times compared to the "baseline" = 30.17 years.

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