

# Rhythmic and Sporadic Changes in the Rate of Beta Decays: Possible Reasons

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## Abstract

In a number of experiments, when detecting particles emitted in beta decays, periodic oscillations of count rate with an amplitude up to tenths of a percent and short bursts vastly exceeding the usual count rate are found. At the same time, several experiments did not detect any differences from the “normal” course of beta decays greater than 0.01%. The article shows that the inconsistency of the experimental results is due to different measurement technique. The assumption is made of the possible participation in the beta decay processes of cosmic slow neutrinos, which makes it possible to explain in a comprehensive manner not only periodic and sporadic changes in the beta decay rate, but also a number of other incomprehensible phenomena associated with beta radioactivity. On the basis of the experiments carried out, an estimate is made of the flux density of slow cosmic neutrinos.

## Keywords

Beta Radioactivity, Nuclear Decay Rate, Solar Neutrinos, Relic Neutrinos, Variations of Radioactivity, Rhythmic Oscillations

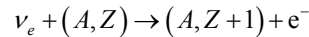
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## 1. Introduction

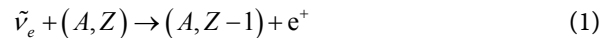
Until recently, the strictly exponential nature of radioactive nuclides decay rate was considered unquestionable. But recently many articles have been published with the results of measurements of radioactivity, which give rise to doubts about the inviolability of this property of radioactivity. Both periodic (first of all, with a period of 1 year) [1]-[17] and sporadic deviations [14]-[20] were detected. Attempts were made to explain these anomalies by the action of a flux of solar [6]-[12] or relic [13]-[17] neutrinos. At the same time, a number of articles show the results of measurements in which the anomalies in the rate of radioactive decay are invisible [21]-[28]. The results obtained during these careful mea-

surements, at first glance, refute reports of anomalies in the rate of radioactive decay, which calls into question the advisability of continuing research in this direction. We show that the absence of observed anomalies can be explained by an incorrect method of searching for variations.

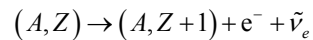
Let us assume that the anomalies in the beta decay rate are associated with the action of neutrinos or antineutrinos in accordance with nuclear reactions



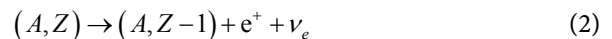
or



This occurs against the backdrop of spontaneous decays



or



The problem is to detect a small number of reaction acts (1) against the background of a large number of reaction acts (2). Solution of this problem is possible due to the fact that in the reactions (2) there are electrons or positrons with energies from zero to the upper boundary  $E_{\max}$ , characteristic for each nuclide. In the case of reaction (1), the emerging electrons or positrons have an energy exceeding  $E_{\max}$  on the energy of the absorbed neutrino or antineutrinos. If neutrinos (antineutrinos) appear in nuclear reactions, for example, in the interior of the Sun, the excess reaches several MeV. If relic neutrinos with very low energy are registered, the electrons have energy close to  $E_{\max}$ .

If the number of induced reactions is much less than the number of spontaneous decays, in order to detect effects associated with the action of neutrinos (antineutrinos), it is necessary to have detectors that can selectively register electrons (positrons) with an energy exceeding  $E_{\max}$ . Geiger counters, proportional counters, ionization chambers, semiconductor and scintillation detectors allow you to directly register beta particles. Moreover, these detectors allow partially to solve the problem of high-energy particles separation by placing a layer between the source and the detector of a substance that absorbs the bulk of the particles that arise during spontaneous beta decays and which transmits most of the particles of higher energy.

It is tempting to use gamma spectrometers to register beta decays. The use of such detectors is based on the fact that in most cases, as a result of beta decays, nuclei are formed in an excited state, which remove excitation by emitting gamma quanta. But the energy of the emerging gamma rays does not depend on the energy of the emerging electrons. Therefore, by detecting gamma quanta, it is practically impossible to isolate the events of interest related to the action of neutrinos (antineutrinos).

Thus, to detect variations in the rate of beta decays, if they are associated with the action of neutrinos (antineutrinos), it is necessary to use beta spectrometers

or beta particle detectors in combination with the optimum absorbers of particles formed during spontaneous decays. The registration of gamma quanta [21] [23] [27] cannot lead to success. There can be no success in the search for variations in decays not associated with weak interactions: in isomeric transitions with gamma-ray emission (e.g.,  $^{121}\text{Sn}^m$  [21]), and also in alpha decays [12] [16], [22] [25], if they are not members of a chain including beta active nuclides.

Some works, for example [26], refuting the presence of anomalies in the beta decay rate, are done very carefully, but they do not fulfill the conditions allowing to detect small changes associated with the desired effect on a high background of spontaneous beta decays. In this paper, just as in some others [21] [24], the ratio of the decay rates of various nuclides is investigated. But if the neutrino flux equally affects the decay rate of different nuclides, the absence of variations in the ratio of activities does not mean that there are no variations in the activities of individual radionuclides.

An attempt was made in [24] to explain the observed variations by seasonal temperature changes. There is no doubt that variability of environmental factors in one way or another affects the results of measurements. It is possible that in some studies, despite the measures taken, the influence of these factors appears. But it is important to pay attention to the fact that the instability of equipment, the impact of a changing temperature, pressure, air humidity, the background of ionizing radiations, power supplies, etc. very different in different laboratories. Nevertheless, if the effect can be detected, when measuring different radionuclides in different laboratories using different types of equipment, its period and phase are close [13] [14] [15] [16]. This indicates the existence of a non-trivial agent that equally affects the activity of various beta radionuclides. The neutrino flux coming from the Cosmos is the most suitable for the role of such an agent.

With a lot of experiments in which anomalies in the beta-decay process are discovered, one can get acquainted in [1]-[20]. This article will describe some of the results obtained by the author of this article.

## 2. Periodic Changes in the Beta Decay Rate

To detect anomalies in the course of radioactive decay, it was necessary to create a set of facilities that made it possible to obtain and continuously record, over the years, various information [15] [16]. The complex consists of sensors with power sources, thermostats and a device for continuous multichannel recording of information coming from sensors. Information is collected in more than 20 channels. In particular, data on the main parameters of the environment were collected. Comparison of this information with the results of measurements of radioactivity makes it possible to judge whether the detected effects are the result of effects on the equipment or changes in the environment.

The testing of various detectors has shown that the most suitable for long-term detection of beta particles are halogen Geiger counters, and for alpha particles—semiconductor detectors. To reduce the influence of temperature

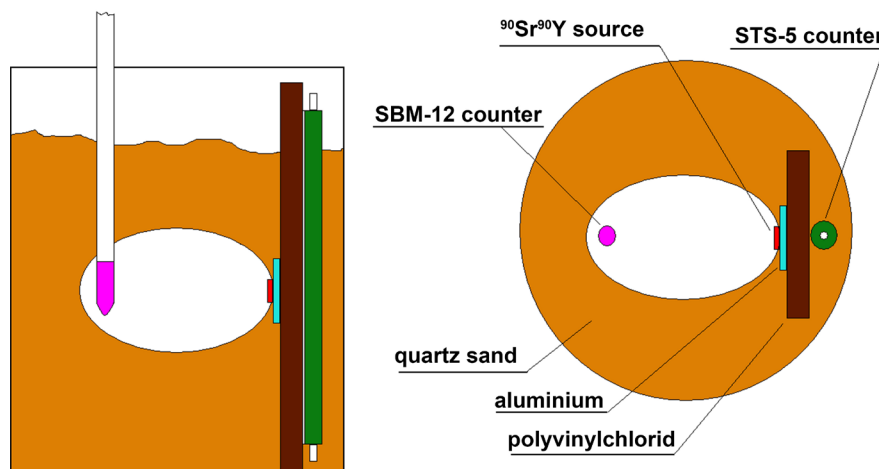
changes, not only detectors with signal amplifiers were thermostated, but also power supplies.

**Figure 1** shows the device of one of the installations on which the radiation of the beta source  $^{90}\text{Sr}^{90}\text{Y}$  was recorded. This source consists of two equilibrium radionuclides.  $^{90}\text{Sr}$  emits relatively soft beta particles with a maximum energy of 546 keV, and  $^{90}\text{Y}$  emits particles with energies up to 2.3 MeV. The first Geiger counter, type SBM-12, is located in the air cavity at a distance of 2 cm from the source. The second Geiger counter of the STS-5 type is separated from the source by a layer of aluminum and polyvinylchloride. Container with a source and detectors is filled with quartz sand to exclude the influence on the measurement results of beta particles reflected by external objects. The thermostabilization system maintains a temperature of  $31^\circ\text{C} \pm 0.1^\circ\text{C}$  in the installation. The power supply of the counters is also thermostatted.

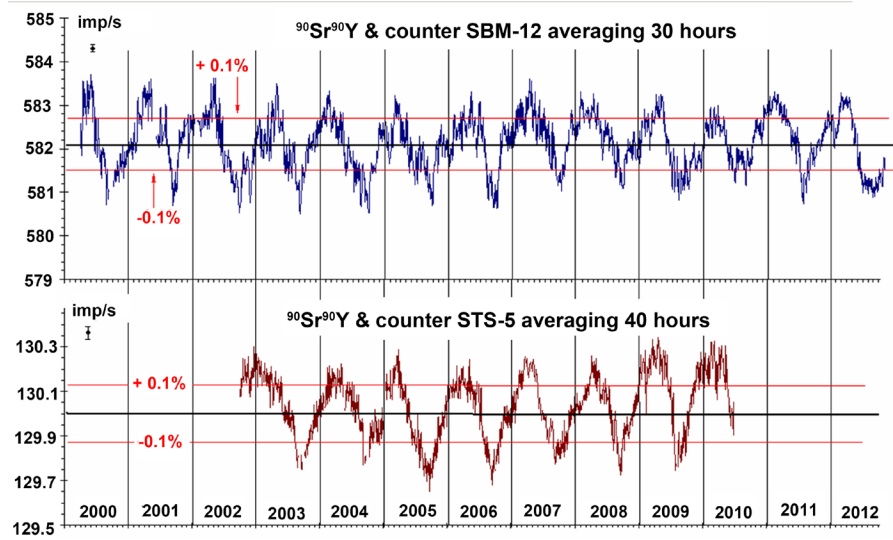
Counter located in the air cavity detects the radiation of both radionuclides, and the second, separated from the source by a layer of matter absorbing strontium radiation, registers radiation only of yttrium.

**Figure 2** shows what happened as a result of 12-year measurements with averaging covering more than 10 million pulses, corrected for the exponential decay of activity (half-life 28.6 years). Such averaging is required in order for the oscillations to become clearly visible against the background of statistical fluctuations. The magnitude of these fluctuations is shown near the vertical scale. The red lines show a deviation from the average by 0.1%. In spite of the fact that the measurements were made by counters of different types and the counters were in different conditions, they registered in-phase oscillations of the counting rate with amplitude of more than 0.1% of the mean value.

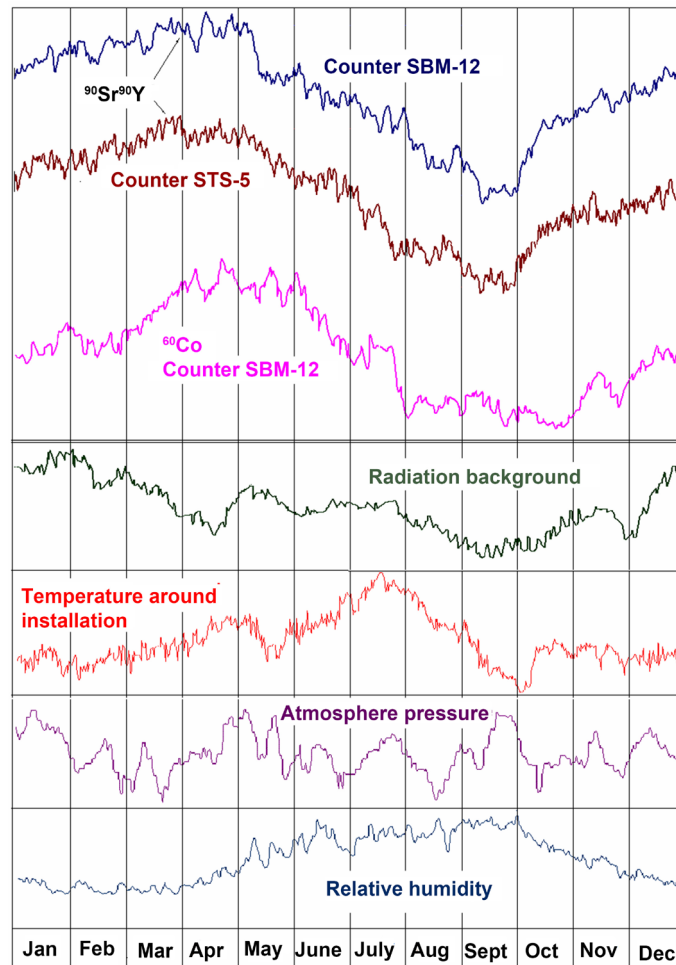
**Figure 3** at the top shows how the beta count rate on the average varies throughout the year. The results obtained on each calendar day of the year for 7 years are superimposed and averaged. It can be seen that the results obtained by



**Figure 1.** Scheme of installation for long-term measurement of beta source activity  $^{90}\text{Sr}^{90}\text{Y}$  by two counters. The thermostating system (temperature sensor, heater, thermal insulation) is not shown in the figure.



**Figure 2.** Results of beta source  $^{90}\text{Sr}^{90}\text{Y}$  activity measurements by two Geiger counters adjusted for a decrease in activity with a half-life of 28.6 years [16].



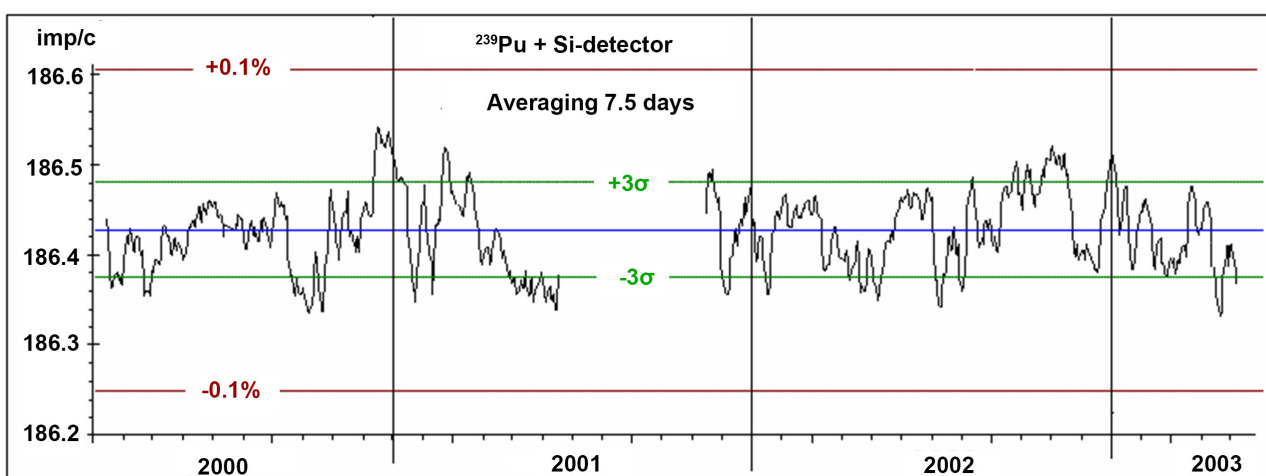
**Figure 3.** Beta particles count rate on the average throughout the year as well as the main environmental parameters for the annual period.

three different detectors from two different beta sources on average vary throughout the year almost identically. At the same time, the main environmental parameters that can be suspected as a source of instability of the recording equipment are radiation background, temperature, atmospheric pressure, humidity, behave differently. This indicates that there is a phenomenon associated with the beta sources, rather than the influence of variations in the parameters of the external environment.

In addition to beta radioactivity, long-term studies of the alpha decay process were carried out. To do this, the alpha source  $^{239}\text{Pu}$ , located near to the silicon detector, was placed with the amplifier in a thermostat at a temperature of  $18^\circ\text{C}$ . The results obtained for more than three years are shown in **Figure 4** [16]. The red lines show a deviation from the average by 0.1%. Green lines show a difference from the average for 3 standard Poisson deviations. It can be seen that the measurement results fluctuate chaotically. No rhythmicity at the level of hundredths of a percent is not visible.

A large amount of accumulated data makes it possible to apply frequency analysis, which allows us not only to clarify the parameters of the observed annual rhythms, but also to reveal other periodicity, imperceptible against the background of statistical fluctuations and interference acting at random times. For analysis of the results of  $^{90}\text{Sr}^{90}\text{Y}$  beta particle count rate measurements fast Fourier transformation was applied, followed by recalculation of the frequency in the periods [13] [14] [15] [16]. On the periodogram, a peak with a period of 1 year is allocated (amplitude 0.13%) and its harmonics (half, third, quarter of the year). In the region of near-monthly periods, peaks with amplitude of about 0.01% are visible.

The question arises, which of the known rhythms can be related to the observed near-monthly periodicity? With the period of the change of the lunar phases, the period of the Moon's rotation relative to the stars, the period of the change in the distance to the Moon, and perhaps with the period of solar activity



**Figure 4.** Long-term measurements of  $^{239}\text{Pu}$  alpha source activity.

change associated with the rotation of the Sun-which is also close to 1 month? Analysis [15] shows that the clearest correspondence exists with the synodic lunar month having an average period of 29.5 days. This clearly demonstrates the averaging of the results of radioactivity  $^{90}\text{Sr}$ - $^{90}\text{Y}$  measurements for 87 cycles of the synodic month. The count rate in the new moon is, on average, 0.02% higher than in the full moon. Without special analysis, such changes, unlike annual ones, are completely invisible. Only the imposition of epochs and averaging over a large number of cycles makes it possible to determine quite reliably the rhythms of such small amplitude.

In the range of shorter periods, the peak of the solar-diurnal period is clearly visible, near which peaks corresponding to the star-day and moon-diurnal periods are visible [13] [14] [15] [16]. The amplitude of the diurnal variations does not exceed thousandths of a percent of the mean value and, unlike the variations with the annual and monthly periods, it cannot be said with certainty that they are not caused entirely or partially by temperature influences on the measuring apparatus.

Summarizing the results of this section, taking into account the results obtained with the use of other detectors and radionuclides [1]-[18], the following conclusions can be drawn. Rhythmic changes are characteristic of beta decays and are invisible in alpha decays. When using equipment that selectively records particles with energy close to the maximum energy of the beta spectrum, there are oscillations in the count rate with a period of 1 year and amplitude of up to tenths of a percent of the average, maxima from January to March, and lows from July to September. Oscillations were detected in radionuclides with half-lives from 2.6 hours to 300,000 years. Experiments, in which almost the entire spectrum of beta particles emitted is detected, do not show an anomaly greater than 0.01% of the mean velocity. This indicates that the value of periodic oscillations do not exceed 1/10,000 of the average beta decay rate.

### 3. Short-Term Bursts of Beta Radioactive Nuclides Activity

Strong outbursts of beta particles count rate are detected with the continuous scanning of the celestial sphere by peculiar telescopes in which the beta source is located in the focus of the parabolic mirror. One of these types telescopes, with which the most striking results are obtained, has a steel mirror with a concave parabolic surface 22 cm in diameter with a focal length of 10 cm. A small beta  $^{60}\text{Co}$  source connected to a miniature Geiger counter is located in the focus. Like astronomical telescopes, the telescope has two axes of rotation. One is parallel to the Earth's axis. The other axis is perpendicular to the earth's axis. This design allows you to determine which area of the celestial sphere the telescope is pointing to. More detailed description of the methodology of these experiments and the results obtained can be found in [15] [16] and [20].

At the first stage of the researches, the telescope was oriented in a direction close to the east, with a fixed inclination above the horizon. Rotating with the

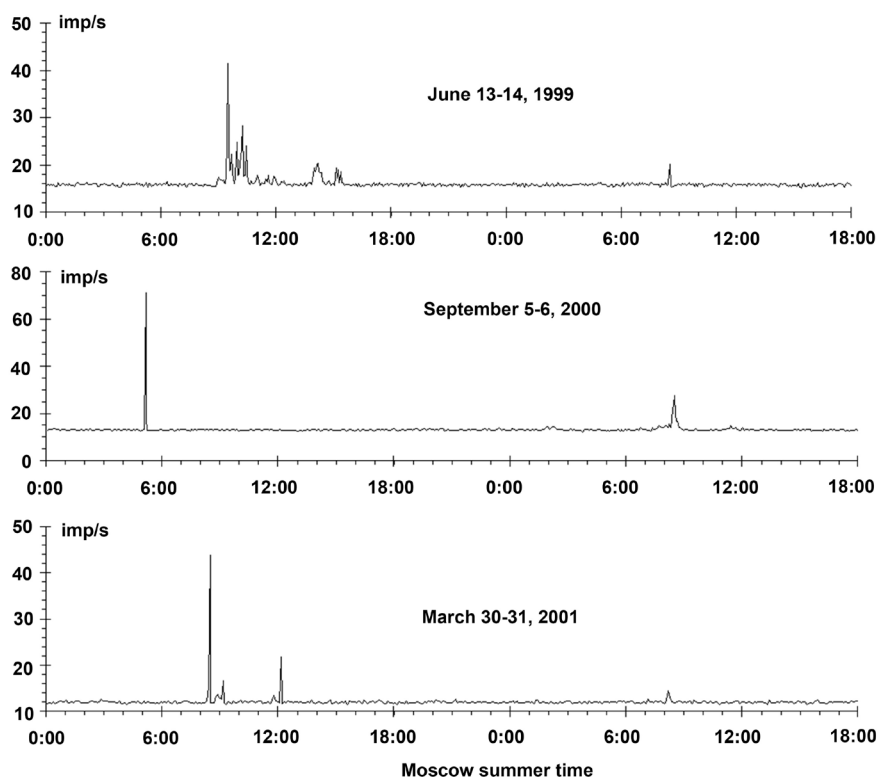
Earth, the telescope “viewed” a strip of the celestial sphere about  $1^\circ$  wide. The count rate was continuously recorded by the computer. The astronomical coordinates of the celestial sphere place, to which the telescope is currently directed (declination and right ascension), were determined with an error of about  $1^\circ$  on the basis of observations of the movement of the image of the Sun. Sometimes, at intervals of several months, bursts of counting counts from a few seconds to an hour were recorded, at which the count rate many times exceeded the background count (**Figure 5**). It was possible to detect these bursts only because of the long duration of almost continuous observations, since the total duration of recorded bursts did not exceed 1/1000 of the operating time of the installation.

The effectiveness of observations has increased to several bursts per day in the transition from one-dimensional scanning to two-dimensional. For this purpose, the telescope was given an oscillatory motion perpendicular to the scanning line associated with the daily rotation of the Earth. The amplitude of the oscillations is up to  $40^\circ$ , the “forward stroke” is about 10 minutes, the “reverse” is about 1 minute, the time of the beginning and the end of the backward movement was recorded by a computer with an exact time reference, which made it possible to determine to what points of the celestial sphere the telescope “looks” when the bursts are discovered.

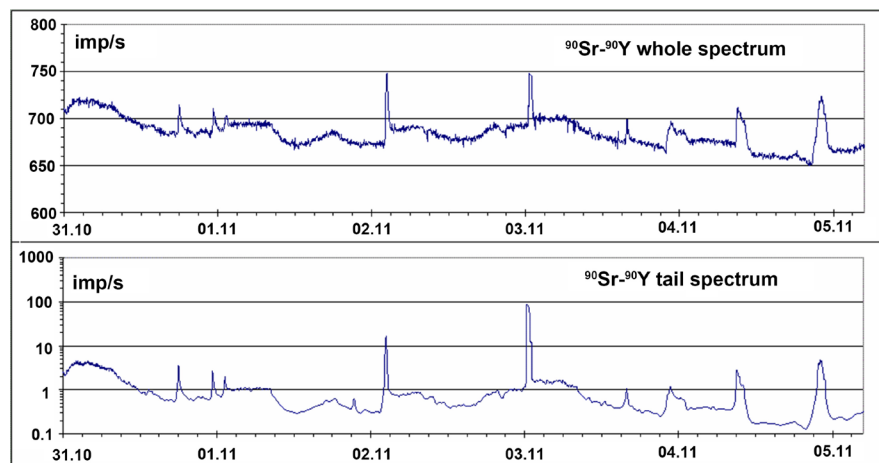
The conducted investigations give grounds for the following generalizations [15] [16] [20]. The dynamics of the bursts in time is diverse. The simplest form is single bursts lasting a few seconds. In this case, the increase in counting speed can exceed three orders of magnitude. Longer events (up to several hours) consist of short bursts of different amplitudes that are complexly distributed over time. The number of bursts per day and their connection with the orientation of the telescope are not clearly reproduced, although on the next days bursts are sometimes observed in nearby areas of the celestial sphere. The distribution of the telescope directions along the celestial sphere, at which bursts are recorded, is uneven. At different areas, the number of recorded events per square degree differs by more than 2 orders of magnitude.

Important results were obtained using detector that allows the extraction of beta particles with energy close to the maximum energy of the beta spectrum [16]. The  $^{90}\text{Sr}^{90}\text{Y}$  source was placed in the focus of the parabolic mirror. The emitted beta particles were detecting by a detector consisting of stilbene scintillator and silicon photomultiplier. Such detector makes it possible not only to count particles, but also to determine their energy. The electronic circuit allows registration by two channels. In the former, pulses from particles of almost all the beta spectrum were detected. The discrimination threshold in the second channel is raised to a value at which the count rate is three orders of magnitude smaller than the counting rate in the first channel, but much larger than the background count without the source. In this channel, beta particles with energy near the upper limit of the 2.3 MeV beta spectrum were detecting.

**Figure 6** shows fragment of signals recording in these two channels. In both channels, there are coincident bursts of count rate. Magnitudes of these bursts in



**Figure 5.** Examples of count rate recording of  $^{60}\text{Co}$ , located in focus of the telescope with a parabolic mirror [15].



**Figure 6.** Comparison of count rates of bursts at different discrimination levels. On the horizontal axis the dates of 2012 [16].

the channel, where particles with an energy close to the boundary value are recorded, is approximately equal to the magnitudes of the bursts in the channel, where the particles of the whole spectrum are recorded. This indicates that the emerging particles have energy close to the boundary energy, and not the “smeared out” spectrum inherent in the usual beta decay. Thus, during the outbursts, there is no intensification of the usual “direct” beta decay, but a nuclear reaction of the “reverse” beta decay occurs, as a result of which neutrinos and

nuclei interact with the same daughter nuclei as in “direct” beta decay, But the emerging electrons are not distributed over the spectrum, but have a fixed energy.

#### 4. Influence of Slow Neutrinos on Beta Radioactivity

The hypothesis of the connection between the variations of beta sources decay rate with neutrinos arising in nuclear processes on the Sun [6]-[12] is highly questionable in connection with the extreme weakness of interaction neutrino arising in nuclear reactions with matter. This was first pointed out by Bethe and Peierls shortly after the appearance of the neutrino hypothesis [29]. Assuming that the probabilities of direct and inverse processes are the same, they obtained the formula

$$\sigma = \lambda^3 / TV \quad (3)$$

where  $\sigma$  is the reaction cross section,  $\lambda$  is the de Broglie wavelength of the neutrino,  $T$  is the mean lifetime of radioactive nuclei, and  $V$  is the neutrino velocity.

In the case of relativistic neutrinos, which are dealt with in nuclear physics,  $\lambda = hc/E$  ( $h$  is the Planck constant,  $c$  is the speed of light,  $E$  is the neutrino energy), relation (3) goes over into formula

$$\sigma = h^3 c^2 / E^3 T \quad (4)$$

Substituting in Equation (4) typical for nuclear physics values  $E = 1$  MeV ( $1.6 \cdot 10^{-13}$  J),  $T = 1000$  s, we obtain the value of  $\sigma \sim 6 \cdot 10^{-48}$  m<sup>2</sup>, which is confirmed by experiments [30].

It follows from (4) that

$$n = N\phi\sigma = N\phi h^3 c^2 / E^3 T = A\phi h^3 c^2 / E^3 \quad (5)$$

where  $n$  is the number of acts of inverse beta decays per second,  $A = N/T$  is the number of direct beta decays per second (activity of the source),  $N$  is the total number of radioactive nuclei, and  $\phi$  is the neutrino flux density.

Let us find the ratio of the rate of reverse beta decays to the rate of spontaneous beta radioactivity  $K = n/A$ , using the relation (5):

$$K = \phi h^3 c^2 / E^3 \quad (6)$$

Substituting into (6) the flux density of solar neutrinos  $\phi \sim 6 \cdot 10^{14}$  m<sup>-2</sup>·s<sup>-1</sup> [30], we obtain  $K \sim 3 \cdot 10^{-30}$ . Such insignificant changes in activity cannot be measured.

In the case of neutrinos of very low energies (relic neutrinos)  $V \ll c$ ,  $\lambda = h/mV$  ( $m$  is the neutrino mass), the ratio (3) goes over into formula

$$\sigma = h^3 / m^3 V^4 T \quad (7)$$

Since neutrinos, which have very small kinetic energy and mass, cannot make a significant contribution to the energy of nuclear reactions, they can react only with nuclei that do not have an energy threshold. Such nuclei have beta radioactivity

It should be noted that the term “relic neutrinos” arose in connection with the fact that initially the presence in the universe of a huge number of neutrinos with very low energies was predicted by the “big bang” theory. But it cannot be ruled out that there may be other sources of such neutrinos. For us it is important that these particles have a rest mass and the speed of motion is so low that they are kept by the gravitational fields of the Galaxy, stars and other massive objects. Therefore, it is better to call such particles “slow neutrinos”. It cannot be ruled out that the anomalies in beta decays are associated not only with neutrinos, but also with other electrically neutral particles, capable of participate into weak interactions. But we are only considering neutrinos, since the initial assumption of equal probability of direct and inverse beta decays implies the identity of the decayed particles emitted from spontaneous decays and absorbed upon inverse beta decays.

It follows from (7) that in the case of neutrinos of very low energies

$$n = N\varphi\sigma = A\varphi h^3 / m^3 V^4 \quad (8)$$

Let us find the ratio of the rate of reverse beta decays to the rate of spontaneous beta radioactivity  $K = n/A$  using the relation (8):

$$K = \varphi h^3 / m^3 V^4 . \quad (9)$$

Taking into account that  $\varphi = \rho V / m$ , where  $\rho$  is the mass neutrino density, we obtain

$$K = \rho h^3 / m^4 V^3 \quad (10)$$

An important feature of relations (9) and (10) is independence from the half-life of the nuclei. Any beta radioactive sources, being in the same stream of slow neutrinos, acquire the same relative increase in activity. If during its motion the Earth passes regions with different velocities or neutrinos flux density, the same relative changes in the activity of different beta sources should occur.

These calculations do not pretend to be accurate, but clearly show that neutrino fluxes can be a tangible cosmic agent. In what follows we will assume that the agent that causes additional beta decays is neutrinos moving in the gravitational field of the Galaxy. In addition to galactic neutrinos, neutrino fluxes moving in near-solar and near-Earth gravitational fields can influence beta-radioactivity [15] [17] and [32]. But an assessment of their impact on radioactivity is problematic.

Combining the results of astronomical observations with relations (9, 10), we can estimate neutrino flux density, based on the strong dependence of the magnitude of the effect on velocity. Suppose that the main reason for variations in activity with a period of 1 year is that the velocity of the neutrino flux coming to the solar system is summed with the speed of the Earth’s orbital motion around the Sun.

According to [15] [32], near the solar system the fluxes of dark matter, including neutrinos, have a velocity of about  $3 \cdot 10^5$  m/s and are directed predominantly perpendicular to the motion of the Sun in the Galaxy at a velocity of

about  $2.5 \cdot 10^5$  m/s. The speed of the Earth's motion around the Sun is  $3 \cdot 10^4$  m/s. Based on these data, we can calculate that the speed of the Earth's encounter with the flux of galactic neutrinos varies throughout the year from  $V_{\min} = 3.7 \cdot 10^5$  to  $V_{\max} = 4.1 \cdot 10^5$  m/s. When the velocities vary from  $V_{\min}$  to  $V_{\max}$ , the activity increase due to the reverse beta decay changes on  $\Delta K = \frac{\rho h^3}{m^4} (V_{\min}^{-3} - V_{\max}^{-3}) = 2a$ , where  $a$  is the amplitude of the relative activity change,  $\rho$  is neutrino mass density, and  $m$  is neutrino mass. Therefore

$$\rho = \frac{2am^4}{h^3 (V_{\min}^{-3} - V_{\max}^{-3})}. \quad (11)$$

In [1]-[17], a change in the count rates of beta particle with an annual period up to 0.3% was found. These results prove the existence of variations, but they do not allow us to judge the value of  $a$ , since they were obtained with strong suppression of the beta particles of spontaneous decay. Precision measurements with the registering of all or most of the beta decays [21]-[28] revealed no variations with amplitude greater than 0.01%. Setting  $a = 0.0001$ , we can estimate the upper bound of  $\rho$ .

At present, there is no exact data on the mass of the electron neutrino (anti-neutrinos). A variety of experiments and astronomical observations indicate that it does not exceed 1 eV [30]. Relation (11), if we assume  $a = 0.0001$  and  $m = 1$  eV ( $1.78 \cdot 10^{-36}$  kg), gives  $\rho = 1.3 \cdot 10^{-31}$  kg/m<sup>3</sup> ( $\phi = 3 \cdot 10^{10}$  m<sup>-2</sup>·s<sup>-1</sup>).

Note that the de Broglie wavelength  $\lambda = h/mV$  of slow neutrinos with a mass of 1 eV moving in the Galaxy with a velocity of about  $4 \cdot 10^5$  m/s relative to the terrestrial observer has a value near 1 mm. This means that the interaction region of these particles covers an enormous number of atoms ( $\sim 10^{20}$  in a condensed matter), in contrast to relativistic neutrinos, which interact with only one particle. This is the main reason for a radical increase in the efficiency of neutrino interaction with matter at very low energies. Another reason is that the speed of movement is small, as a result of which the duration of neutrino contact with each particle of matter becomes much greater than in the case of "nuclear" neutrinos moving at a speed close to the speed of light. The interaction of slow neutrinos with matter is similar to the interaction of light with a transparent medium: refraction, reflection, and scattering on inhomogeneities occur practically without exchange of energy. Capture is possible only when interacting with beta radioactive nuclei. In addition, interference and diffraction are possible in slow neutrino fluxes.

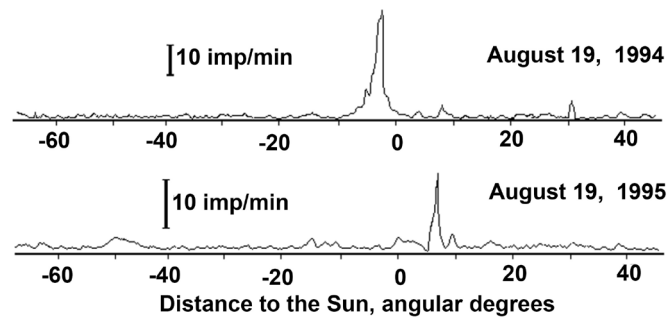
If surface is sufficiently smooth (unevenness is less than the wavelength), refraction and reflection occur according to the laws of geometric optics, which makes it possible to focus by means of lenses or mirrors. This circumstance makes it possible to create telescopes for slow neutrinos, using mirrors with a concave parabolic surface with a beta source located in the focus [15]. The advantage of mirrors in front of lenses is the same focus position for any focused agent. The reflection and refraction coefficients only affect the degree of ampli-

fication of the flux density at the focus.

For telescopes with a diameter  $D$  and a focal length  $f$  under the action of a monodirectional agent having wavelength  $\lambda$ , excess of the flux density in the focus above the unfocused flux density  $\chi = 0.14kD^4/f^2\lambda^2$ , where  $k$  is the coefficient that takes into account reflection losses from the mirrors or as a result of absorption in the lenses [15]. The telescope mentioned in the previous section has diameter of 22 cm and focal length of 10 cm. For such a telescope with  $\lambda = 1$  mm  $\chi = 3.3 \cdot 10^5 k$ . The quantity  $k$  is not known. But it is clear that the telescope gives a lot of amplification even with very weak reflection from the mirror. For example, for  $\chi = 0.01$ ,  $k = 3300$ .

Telescopes can only be used if the active agent is narrowly directed. The presence of narrowly directed beams in slow neutrino fluxes is associated with another important feature of them: the influence of gravitational fields on their motion. Slow neutrinos trajectories, as well as other objects of dark matter, is not different from any other space objects (stars, planets, asteroids, cosmic dust, etc.) and can be calculated by conventional methods of celestial mechanics [15] [32]. When neutrino flux passing them past the celestial bodies, on the streams associated with the orbital movements, phenomena associated with the gravitational focusing are superimposed. The essence of the gravitational focusing is that the trajectories of particles flying past a massive body, such as a star, bend to the axis connecting the center of the gravitating body and the observer. The magnitude of the bend depends on the distance of the trajectory to the center of gravity. There is such a distance at which the bent trajectory falls precisely into the observer. All particles passing at such a distance from the center of gravity are “collapsed” at the observation point, as a result of which the flux density increases sharply. This effect is analogous to light gravity lensing. But due to the fact that the speed of dark matter particles (including neutrinos) is much less than the speed of light, their focusing by the gravitational fields of celestial bodies is incomparably stronger [15] [32]. Since gravitational focusing occurs with a completely determined mutual position of the focusing celestial body and target, which are in motion, this effect must be observed in the form of bursts. It is this kind of signal that was observed when working with telescopes with parabolic mirrors, in particular, with the telescope described in the previous section of this article. Strong bursts, at which the counting rate of beta particles increased by 2 - 3 orders of magnitude, were recorded quite rarely (at best, several times a day) at unpredictable instants of time. But, in addition, events were recorded that occurred at the predicted time when the telescope was being directed to a given area of the celestial sphere.

Intent of this experiment was based on the idea of gravitational focusing of slow neutrino fluxes by a certain star and secondary focusing by the Sun. This effect can be observed if the star, the center of the Sun and the observer located on the Earth are on the same straight line. Close connections of the Sun with the near-by stars are rather rare events, the time of which is easy to determine using astronomical atlases. For example, on August 19 of each year the star  $\nu$  Leo



**Figure 7.** Count rate when scanning a near-solar region of the celestial sphere with a telescope with a focusing mirror 22 cm in diameter [15] [16].

passes at a distance of 5 angular minutes from the center of the Sun. On this day of 1994, the telescope was directed in such a way that the scanning path of the celestial sphere passed through the Sun. When the telescope was aimed at a region near the Sun, a strong burst of count rate was recorded. A similar burst was registered exactly one year later (Figure 7). Similar bursts were recorded on August 1 and 28, 1994, when there were close connections with the Sun of stars Cnc and 45 Leo, and also repeatedly on July 29 and 30, when the solar disk was projected onto the scattered star cluster M44 [15] [16]. On the other days of significant bursts of count rates were not found.

## 5. Conclusions

In a variety of experiments, periodic changes in beta particles count rate with amplitude up to tenths of percent were observed. However, such variations can be detected only with the predominant detection of particles with energies close to the maximum energy of the beta spectrum. This indicates that the observed oscillations in the count rate are associated with the action of neutrino fluxes. This is also indicated by the absence of such anomalies in alpha decays, in which the neutrino does not participate. Experiments in which most particles of beta spectrum are detected do not show periodic deviations from the usual beta decay process of more than 0.01%. This indicates that the periodic anomalies do not exceed 1/10,000 of the average beta decay rate.

Short-term irregular bursts of count rate of beta particles can be observed by placing a radioactive source in the focus of a concave parabolic mirror. These bursts can highly exceed the normal counting rate. The energy of the detected particles, as in the case of periodic anomalies, is close to the maximum energy of the spectrum of spontaneous beta decays.

In contrast to the hypothesis about the effects on beta radioactivity of solar neutrinos, the assumption of the possible involvement of space slow neutrinos in the process of beta decay allows, without departing from the scope of existing scientific knowledge, complex to explain not only the periodic and sporadic changes in the beta decay rate, but also a number of other phenomena associated with beta radioactivity, for example, inexplicable effects observed in the mea-

surement of the neutrino mass by tritium decay beta studies [15] [17] [31]. It is important to note that the hypothesis about the impact of slow neutrinos on the beta decays gives experimentally testable predictions, some of which have already been confirmed.

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