Experimental Investigations of Changes in $\beta$-Decay rate of $^{60}$Co and $^{137}$Cs.

Yu.A. Baurov, A.A. Konradov*, V.F. Kushniruk**, E.A. Kuznetsov**, Yu.V. Ryabov***, A.P. Senkevich***, Yu.G. Sobolev**, S.V. Zadorozhny***.

Central Research Institute of Machine Building, 141070, Korolyov, Moscow Region, Pionerskaya, 4. Russia.

* Institute of Biochemical Physics of Russian Academy of Sciences, 117977, Moscow, Kosygin-Street, 4, Russia.

** Flyorov Laboratory of Nuclear Reactions, Joined Institute for Nuclear Research (JINR), 141980, Dubna, Moscow Region, Russia.

*** Institute for Nuclear Research of Russian Academy of Sciences (INR RAS), B-312, Moscow, Prospect 60-letiya Oktyabrya, 7a, Russia.

Abstract

Results of simultaneous measurements of $\beta$-decay rate with the aid of Ge(Li)-detectors performed at two laboratories 140km apart (INR RAS, Troitsk, $^{60}$Co, and JINR, Dubna, $^{137}$Cs) during a period from 15.03.2000 till 10.04.2000, are presented. Regular deviations of the count rate of $\gamma$-quanta following the $\beta$-decay of $\sim 0.7\%$ (INR RAS, $^{60}$Co) and $\sim 0.2\%$ (JINR, $^{137}$Cs) from the statistical average, are observed. The analysis of extremum deviations of $\gamma$-quanta count rate shows that the set of directions of tangents to the Earth’s parallels of latitude at the extremum points of trajectories of motion in the space of each laboratory clearly forms three separate compact subsets of directions which agree, for two laboratories, to an accuracy of $\pm 10^\circ$. This phenomenon is shown not to be explained on the basis of traditional notion. A possible explanation is suggested basing on the hypothesis that there exists a new anisotropic interaction caused by the cosmological vectorial potential $A_g$, a new fundamental constant having, according to the experiments carried out, the coordinate of right ascension $\alpha \approx 285^\circ$ in the second equatorial system. This is in agreement with earlier experiments.

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1. Introduction.

In the Refs. [1-3], periodical variations in the β-decay rate of $^{60}$Co, $^{137}$Cs, and $^{90}$Sr were first found. An analysis of 24-hour period of these variations as well as diurnal rotation of the Earth in different seasons of the year has led to distinction of some spatial direction characterized by a change in the rate of the radioactive decay in the vicinity of the point of tangency of the tangent line to the parallel of latitude when that tangent line has an angle of $\sim 45^\circ$ with the above mentioned direction. The duration of uninterrupted measurements in those experiments was no more than two weeks.

In the experiments carried out at JINR (Dubna) from 9.12.1998 till 30.04.1999 with the aim of investigation of variations of the β-decay rate of $^{137}$Cs and $^{60}$Co, factors of experimental instability (for example, the temperature) and their influence on the final results were taken into account [4]. 24-hour and 27-day periods of β-decay rate variations were found. One confirmed also the existence of the above indicated separate direction in space. The refined spatial direction in the second equatorial system had the coordinate of right ascension $\alpha = 285^\circ$. The declination $\delta$ was not determined in those experiments.

An analysis of the work [5] in which periodical changes in flows of particles ($\sim24$ hours) during the $\alpha$ and $\beta$-decay of radioactive elements were observed, too, is also indicative of the existence of the above said anisotropic property of the physical space.

The main shortcoming of the works above listed is a high level of statistical and systematical instabilities and backgrounds masking the effect. For revealing it one used a special mathematical procedure of processing the experimental results [2-4]. In addition, the duration of measurements in some experiments with considerable changes in the β-decay rate (the deviation $\approx 7\sigma$ where $\sigma$ is the standard one), was not long ($\sim 3$ days [1]).

In the present paper, the results of new experimental investigations of the β-decay of $^{137}$Cs and $^{60}$Co with the aid of detectors allowing to minimize the statistical and systematical uncertainties and more clearly reveal the physical phenomenon, are presented. Briefly outlined are only preliminary results of an experiment being performed simultaneously in the course of several months at INR RAS (Troitsk) and at JINR (Dubna).

2. Measurement Procedure.

The aim of the experiment was to measure, for greater plausibility of its results, changes in the β-decay rate simultaneously at different points
on the Earth and uninterruptedly during a long period of time.

The town Dubna and Troitsk are nearly at the same (Moscow’s) meridian, the distance between them is $\sim 140\text{km}$. The experiment lasted from the middle of February till the middle of May, 2000.

The experimental technique (schematic diagram, electronic equipment, measurement of backgrounds) at Dubna was the same as in the experiment described in detail in Ref. [4], and differed from the latter only in that a Ge(Li)-detector was used. As before (when using a scintillation detector), the intensities of $\gamma$-transition from an excited level of a daughter nucleus with an energy of 0.661MeV in the course of the $\beta$-decay of $^{137}\text{Cs}$, was measured. The value of the integral of $\gamma$-quanta counts entered into the memory of a computer every 10s

As distinguished from the technique of long-term measurements of $\beta$-decay rate with an scintillation detectors [1-4], the $\gamma$- registration following the $\beta$-decay of the investigated radioactive nuclei with a Ge(Li)-detectors made it possible to substantially improve the stability and reliability of long-term measurements. At Troitsk, a Ge(Li)-detector with a volume of $100\text{cm}^3$ was used for measuring the $\gamma$- spectra with energies of 1.117MeV and 1.332MeV accompanying the $\beta$-decay of $^{60}\text{Co}$. A radioactive source was placed beyond of the vacuum volume at a distance of 7mm from the sensitive surface of the detector. To protect the detector and preamplifier from the possible influence of alternating high-frequency and magnetic fields, they were closed by covers from permalloy and electrolytic copper, and a 10cm layer of lead served as a shielding from the natural radioactive background. The signal time constant of the input signal was equal to $0.5\mu\text{s}$ at a gain factor of 10-20 which led the influence of amplitude overload of electronic paths to a minimum.

To record the amplitude spectra, a fast ADC with off-line storage built into a personal computer (PC), was used. A control program gave the time of measuring each spectrum (600s), start time, storage instruction, noted the time of transcription of a next spectrum to the PC memory, zeroed the off-line storage, and started a new measurement. The program worked in a cycle so that the information sequentially accumulated in the memory of PC through a long time. The final processing of information was made off-line by integration over the spectrum in various intervals of energy from the first channel to the maximum energy of photopeak (or only the peak itself) with the resulting formation of a sequence of numbers reflecting the time dependence of the $\beta$-decay rate. The statistic-average digital load of the detector was no more than $(2\div3)\cdot10^4\text{counts per second}$, i.e. corresponded to the optimum working conditions of the instrumentation. The statistical
accuracy obtained at a one point was 0.03% for the radioactive decay of $^{60}$Co.

Thus the measurements were made simultaneously by two identical Ge(Li)-detectors with two independent and different systems of information storage in natural conditions spaced 140km apart. One detector measured the decay of $^{137}$Cs, the other did that of $^{60}$Co.

3. Results and Discussion.

In Fig.1 and 2 the results of simultaneous measurement of the $\gamma$-counts rate of at Dubna ($^{137}$Cs) and at Troitsk ($^{60}$Co), respectively, at a period from 16$^{24}$ (Moscow time) of 15.03.2000 till 10.04.2000 inclusive. To correlate the results of two experiments, the values of flows from Dubna were averaged over 600s time intervals, like those at Troitsk, and additionally low-frequency filtration was made. The results from Troitsk did not processed altogether. As is seen from Fig.2, the change in the $\gamma$-count rate ranged in that experiment up to $\sim 0.7\%$ of the statistical average. At Dubna these changes were no more than 0.2%. It should be noted that the flow jump in the vicinity of 2180min (Fig.1) was caused by a technological change of the radioactive source relative to the Ge(Li)-detector in the process of refilling a Dewar flask with liquid nitrogen. The difference in the values of $\gamma$-count rate changes in the experiments at Dubna and Troitsk is probably connected with dissimilar measuring procedures: in the former case the $\gamma$-quanta were counted at a fixed energy threshold but at Troitsk one measured the total amplitude spectra and then determined the total $\gamma$-counts by integration over the spectrum. The difference of deviations can be explained also by that magnetic moments of the nuclei of $^{60}$Co and $^{137}$Cs. However that difference can be possibly associated with the different latitude position of the experimental setups.

The observed regular structure in the time dependence of the $\beta$-decay rate for nuclei $^{137}$Cs and $^{60}$Co can be, in general, explained by the following reasons:

a) temporal instabilities of the electronic recording paths;

b) outside influences and those connected with the human activity;

c) unknown physical processes in the Ge(Li)-detectors themselves in the course of long-term measurements;

d) a “cosmological” factor acting on the process of the $\beta$-decay of nuclei.

Consider each reason separately for the setup of Troitsk (that of Dubna, as was mentioned above, is considered in detail in Refs [3,4]).
a) The structure of changes in the count rate is such that it cannot be explained by the slow variations of the supply-line voltage (220V). Besides, the low-voltage supply of the electronic circuits was stabilized with an accuracy of 3% and did not vary when the supply-line voltage was changed within 15%. As is known, the spectrometric characteristics of Ge(Li)-detectors practically do not depend on insignificant variations of high-voltage supply.

b) As for the structural changes in the $\beta$-decay count rate due to variations of some external influences, daily variations of intensity of cosmic radiation, changes in the room temperature, etc, we can say that the detectors themselves as well as the channels of electronic paths were carefully protected against variable, alternating, and leakage electromagnetic and high-frequency fields. The natural background of the Ge(Li)-detector was as little as about 0.1% of the $\beta$-decay count rate of the radioactive sources investigated. That is, only a periodical 7-8 times increase of the background could explain the structure observed in the $\beta$-decay count rate. But the count rate of the background was constant in the limits of the statistical accuracy. To evaluate experimentally a possible influence of count overloads (idle time) of the electronic paths when measuring the background, one simultaneously fed to the input of the preamplifier a signal from a generator with an amplitude equal to that of the photopeak but with frequency 50-100 times more than under the operating conditions. For such spectra, there were no peculiarities in the time dependence of the count rate.

c) It is possible that in the material itself of the Ge(Li)-detector some yet unknown physical processes take place during the long-term exposure to radiation which lead to accumulation of charge in “internal” capacities, then to a break-down and relaxation of charge. This would correspond to the observable structure form in the time dependence if the “time constant” were close to 24 hours. In such a case the amplitude spectrum of $\gamma$-quanta would be perturbed, too, in those intervals of time but this was not observed in the experiments. As to an influence of capacitive coupling in the amplifying section itself, control measurements were carried out with the use of non-capacitive current amplifiers, and a similar structure with the same value was found in the time dependencies obtained.

d) Finally consider a possible influence of the cosmological factor on nuclear processes on Earth [1-4,6,7,9]. As was said [6,7,9], it can be associated with a new suggested interaction of objects in nature caused by the existence of the cosmological vectorial potential $A_g$, a new fundamen-
tal vectorial constant entering into the definition of byuons, discrete objects. According to the hypothesis advanced in Refs. [6-9], in the process of minimization of byuons’ potential energy in the one-dimensional space formed by them, the three-dimensional space $\mathbb{R}^3$ and the world of elementary particles appear together with all their quantum numbers and their quantum-mechanical behavior in $\mathbb{R}^3$.

In the model considered, the masses of particles are proportional to the modulus of the summary potential $A_Σ$. It comprises $A_g$ and the vectorial potentials of magnetic sources as of natural (from the Earth, the Sun, etc.) so of artificial origin (for example, the vectorial potentials $A$ of magnetic fields of plasma generators, solenoids etc.). The magnitude $|A_Σ|$ is always lesser than $|A_g| \approx 1.95 \cdot 10^{11}$ Gs-cm [6-9]. Practically the vector $A_Σ$ is collinear to $A_g$ due to the great value of the latter.

In the model [6,7], the process of formation of physical space and charge numbers of elementary particles is investigated. Therefore the values of potentials acquire a physical sense (as distinct from calibration theories, for example, the classical and quantum field theories) which is in tune with the known and experimentally tested Aharonov-Bohm effect [10-13] that is a special case of quantum properties of space described in Refs. [6,7].

According to the terrestrial experiments with high-current magnets [6,7,14-16], with a gravimeter and attached magnet [6,7,17], as well as in accordance with investigations of changes in $\beta$-decay rate of the radioactive elements under action of the new force [1-4,6,7,9] and astrophysical observations [6,7,18,19], the direction of the $A_g$ had the following rough coordinates: right ascension $α \approx 270^\circ$, declination $δ \approx 34^\circ$.

More accurate experiments with a stationary [20] and pulsed [21] plasma generators placed on rotatable bases for scanning the celestial sphere have given the coordinates $α = 293^\circ \pm 10^\circ$, $δ = 36^\circ \pm 10^\circ$.

The experiments listed have shown that if the vectorial potential of some current system is in opposition to the vector $A_Σ$ then the new force pushes any substance out of the region with weakened $|A_Σ|$ mainly to the side of $A_g$.

The new force predicted in Refs. [6,7,14-16] is of complex nonlinear and nonlocal character and can be represented in the form of some series in $ΔA_Σ$: a difference between changes in $A_Σ$ at the points of location of sensor and test body. The expansion of this series in terms of $ΔA_Σ$ gives as a first approximation

$$F \sim ΔA_Σ \frac{∂ΔA_Σ}{∂x}$$  \hspace{1cm} (1)
where $x$ is the spatial coordinate in $\mathbb{R}_3$.

The scaling estimation of magnitudes of potentials of Earth’s ($A_E$) and Sun’s ($A_\odot$) magnetic fields in the range of the Earth’s orbit show that they are equal to $\sim 10^8$Gs·cm and $\sim 5 \times 10^8$Gs·cm, respectively. Thus when rotating a setup for measuring the count rate of the $\beta$-decay, one can observe variations of the modulus of $A_\Sigma$ of $\sim |A_E + A_\odot| / |A_\Sigma| \approx 10^{-3}$ around the Earth and the Sun.

As the first approximation of the new force in terms of $\Delta A_\Sigma$ contains not only $\Delta A_\Sigma$ but $\frac{\partial \Delta A_\Sigma}{\partial x}$ , too, one can suggest that the change $\Delta W$ in the probability of the $\beta$-decay should be proportional to $\Delta A_\Sigma \frac{\partial \Delta A_\Sigma}{\partial x}$ [9] but not only to $\Delta A_\Sigma$ as was meant in Refs. [6,7]. Hence the new force can influence on the decay of the neutron.

Let us explain the aforesaid.

As is known [22], the neutron has a magnetic moment $M_n \approx 10^{23}$erg/Gs. In this connection and according to scaling estimations it is likely that there exists an enormous value of $\frac{\partial \Delta A_\Sigma}{\partial x} \approx 10^{16}$Gs in the vicinity of the neutron but therewith the magnitude $\Delta A_\Sigma$ from the magnetic field is not high and is equal to $10^3$Gs·cm. As during the rotation of radioactive sources together with the Earth around its axis and the Earth’s motion around the Sun the $\Delta A_\Sigma$ can vary within five order of magnitude at the places of their location by the action of potentials $A_E$ and $A_\odot$, so the joint action of two factors of $\Delta A_\Sigma$ from the Earth and the Sun as well as $\frac{\partial \Delta A_\Sigma}{\partial x}$ from the neutron’s magnetic field can create a value of the new force sufficient to influence on the period of decay of the neutron.

In Fig.3 and 4, the small circles denote places of observation of maximum flows of $\gamma$-quanta at the $\beta$-decay of $^{60}$Co at Troitsk as well as the maximum and minimum flows for the decay of $^{137}$Cs at Dubna, respectively. The numbered maxima and minima of flows of $\gamma$-quanta in Figs.1 and 2 correspond to number of arrows in Figs.3,4 drawn from place of observation of an extremum tangentially to the parallels of latitude (along which the vectorial potential of the magnetic field of the Earth’s dipole is directed).

As is seen from Figs.3,4 the total set of numbered arrows can be clearly divided, by their directions, into three subsets with an accuracy of $\pm 10^\circ$.

In Fig.4 we have the subsets $D_1$ (7, 9, 11, 13, 17, 19, 21, 23, 25, 33, 39a, 41, 43, 3.6, 10, 16a, 18, 20, 22, 24a, 42), $D_2$ (2b, 4, 14, 34, 1, 42, 44), $D_3$ (2a, 12, 16b, 24b, 39b, 5). In Fig.3 these are: $T_1$ (1, 2, 3, 4, 5, 6, 7, 10, 11, 15, 17, 18, 21), $T_2$ (8, 9, 19, 20), $T_3$ (13, 22, 12, 16). The subset $D_1$ is seen to be in correspondence with $T_1$, $D_2$ is with $T_2$, and $D_3$ is with $T_3$. Thus we see, in the same time interval and at the different experimental
setups being 140 km apart, a similar pattern of behaviour of the maxima and minima of the $\beta$-decay rate for the different radioactive elements $^{137}$Cs and $^{60}$Co.

The obtained subsets $D_1,T_1$ and $D_3,T_3$ clearly correspond (with an accuracy of $\pm 10^\circ$) to the directions of action of the new force fixed during scanning the celestial sphere by the stationary [20] and pulsed [21] plasma generators. These directions were found from dependences of heat release in the jet of the plasma generators on the angle.

The experiments with the pulsed plasma generator [21] have shown that at each point of space there exists a cone of directions of action of the new force with an opening $\sim 100^\circ$. Therewith the axial line of the cone is directed along the vector $A_g$ to which, according to the results obtained (see Figs.3,4), an angle $\alpha \approx 285^\circ$ corresponds that fall into the range of magnitudes of the coordinate $\alpha$ for the vector $A_g$ (on evidence of Refs. [21]) and is near to the earlier results [6,7,14-16]. Thus the sets of arrows $D_1,T_1$ and $D_3,T_3$ coincide with the directions of the cone generator to the precision indicated.

The emergence of the set $D_2$, $T_2$ is easily explicable on the basis of a hypothesis of equiprobable distribution of directions of neutron magnetic moments in the nuclei and total substance of radioactive source. That is, in any source always there are neutrons with the magnetic moments being perpendicular to the vector $A_g$ and hence the lines of the vectorial potential of magnetic field of the neutron will be always directed, in some region of space, under an efficient angle of $\sim 140^\circ$ to $A_g$ [20,21] corresponding to the maximum value of $\frac{\partial \Delta A_{\Sigma}}{\partial x}$ and hence of the new force.

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Fig. 1 The variation of the flow of $\gamma$-quanta accompanying the $\beta$-decay of $^{137}\text{Cs}$, with the time (JINR, Dubna).
Fig. 2. The variation of the flow of $\gamma$-quanta accompanying the $\beta$-decay of $^{60}$Co, with the time (INR, Troitsk).
Fig. 3. The spatial positions of sites where the clearly expressed extrema in the magnitude of the flow of $\gamma$-quanta in the experiment with the $\beta$-decay of $^{60}$Co, were observed (see Fig. 2).

$\bullet$ - the site of the maximum flow of $\gamma$-quanta with the indication of the direction of action of the new force drawn along the tangent line to the parallel of latitude;

a – the trajectory of motion of the radioactive source rotating together with the Earth;

b – the trajectory of motion of the Earth and the radioactive source around the Sun;

21.03 etc. – the point of the vernal equinox and other characteristic points of the trajectory “b”;

$\vec{A}_E$ – the direction of the vectorial potential of the magnetic field of the Earth’s dipole;

$\vec{A}_g$ – the direction of the cosmological vectorial potential.
Fig. 4. The same as in Fig. 3 but for minimum and maximum flows of γ-quanta during the β-decay of $^{137}$Cs (see Fig. 1).