Synchronous Changes of the Shape of Histograms Constructed from the Results of Measurements of ^{90}Sr β-Decay and ^{239}Pu α-Decay Observed in More than 3000 km Distant Laboratories

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It was discovered many years ago that histograms constructed from the results of measurements of various natural processes are not random. The histogram shape was demonstrated to be determined by the diurnal rotation and circumsolar movement of the Earth and to be independent of the nature of the process considered [1-17]. The results of those works change our basic views about stochasticity of natural processes. When the time series of physical measurements, which are traditionally considered stochastic, are transformed into the series of histograms constructed for an *optimally small number* of the results (i.e., *optimally short segment* of the time series), one can see regular changes in the histogram shape. The paper illustrates the main manifestations of this phenomenon by comparing the results of ^{90}Sr β-radioactivity and ^{239}Pu α-decay measurements, with the distance between the laboratories in which the data were collected being about 3000 km.

1 Introduction

The material for our research were results of long-term measurements of ^{239}Pu α-radioactivity in Pushchino (at the latitude of 54° north and longitude of 37°38' east) and ^{90}Sr β-radioactivity in Novosibirsk (at the latitude of 55°02'13" north and longitude of 82°54'05" east). The data were collected with a 1-second interval for many days. With the aid of Edwin Pozharsky's computer program GM [3], non-overlapping 60-point segments of 1-second time series were transformed into series of 1-minute histograms. The same program was used for a visual comparison of the histograms – after the procedures of smoothing, stretching, squeezing and mirror transformation, necessary to achieve the maximal similarity (for details, see [1]).

2 Experimental details

α-Radioactivity of a ^{239}Pu preparation was measured using low-voltage semiconductor detectors with collimators [10]. β-Radioactivity was measured using CTC-6 Geiger counters fixed in a metal case in a horizontal position, with their longitudinal axis directed along the azimuth of NN-SSW NNW-SSO (~320°). The source of β-radiation (^{90}Sr–^{90}Y, a flat disk of 20 mm diameter) was fixed 10 cm above the counter, with its radiating surface directed downwards to the counter.

3 Results

Fig. 1 shows a time series: the results of ^{90}Sr β-activity measurements. According to all fitting criteria, it is a purely stochastic process obeying the Poisson statistics.

As seen from Fig. 2, the results of measurements shown in Fig. 1 ideally correspond to the Poisson-Gauss statistics. That is why radioactive decay is considered an ideal example of the stochastic process. In Fig. 3, however, the same material of Fig. 1 is shown without smoothing, in the form of cumulative layers, where every next layer adds 3000 measurement points to the previous layer.

This figure demonstrates that contrary to the law of large numbers (the total number of measurements is 259200), the fine structure of the layered lines is not smoothed when the number of measurements is increased – it becomes even sharper. This paradox has a general character and can be observed in the measurements of any "stochastic" physical

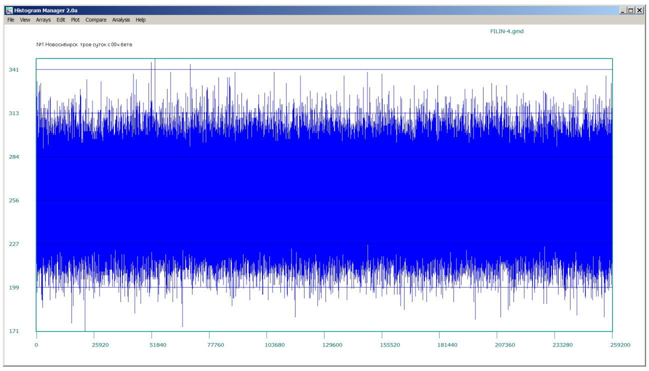

Fig. 1: A time series – the results of 1-second ^{90}Sr β-activity measurements for a period of 3 days (from 00:00 of June 19, 2013 to 23:59 of June 21, 2013). Novosibirsk local time (UTC + 7). X-axis: time, seconds. Y-axis: number of β-decays per second.

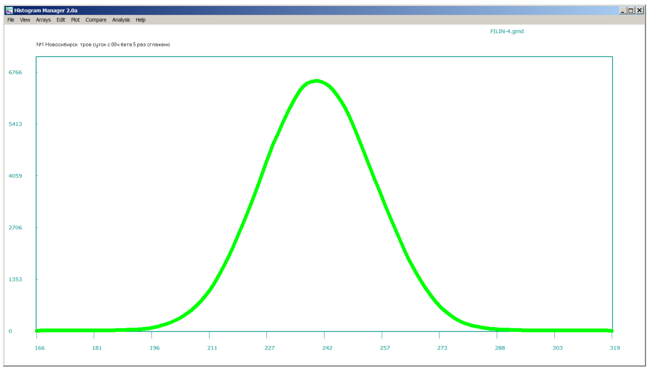

Fig. 2: Distribution of the results of measurements shown in Fig. 1. An ideal Poisson-Gauss distribution. X-axis: radioactivity, counts per second. Y-axis: number of results with the corresponding radioactivity value.

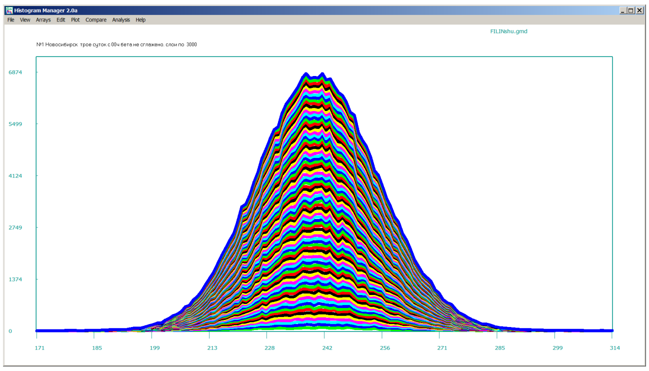

Fig. 3: Non-smoothed layered distribution of the results shown in Fig. 1. Every layer adds 3000 measurement points to the neighbor layer below. The axes are as in Fig. 2.

process [1].

In the paper, though, we consider histograms constructed for an *optimally small* number of measurements. It is transformation of time series into sequences of such *inconsistent* histograms, revealing well-reproducible cosmo-physical regularities, indicating nonrandomness of "stochastic" physical processes [1]. In the paper, this is demonstrated through synchronous measurements of ^{90}Sr β-radioactivity in Novosibirsk and ^{239}Pu α-radioactivity in Pushchino; the distance between these laboratories is about 3000 km.

The subject of this paper – as that of our previous works [1-17] – is the demonstration of regularities in the change of the shape of histograms constructed from an optimally small (30–60) number of results. Such a transformation of time series of the results of measurements into the sequences of histograms reveals the nonrandom character of these time series.

Fig. 4 shows some histograms constructed for the segments of the time series represented in Fig. 1. Each segment contains 60 ^{90}Sr β-radioactivity measurement points; the histograms were smoothed 5 times.

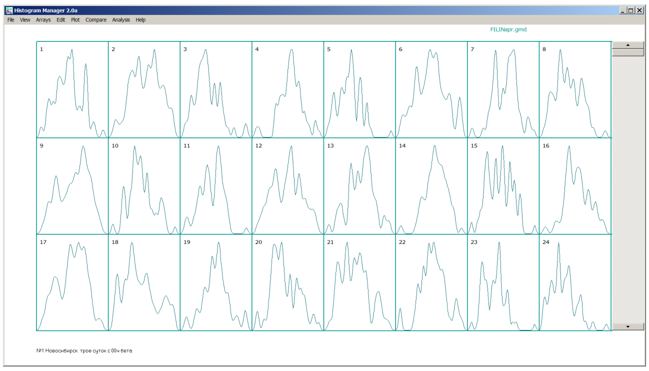

Fig. 4: Measurements of ^{90}Sr β-radioactivity. Transformation of a time series (Fig. 1) into a sequence of 60-point histograms smoothed 5 times. The figure shows the first 24 histograms from the total set of 4320 histograms.

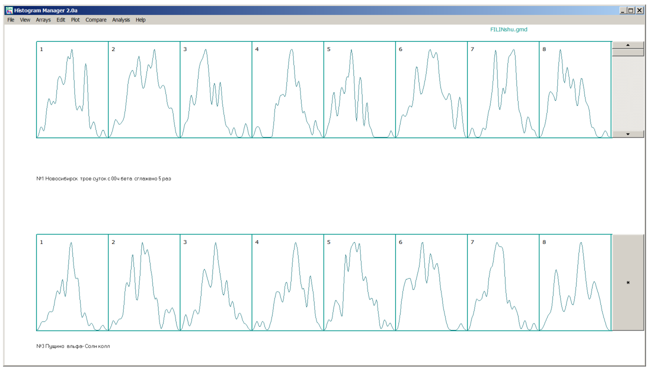

Fig. 5: A screenshot demonstrating comparison of two histogram sequences. Top band: measurements of ^{90}Sr β-radioactivity; bottom band: measurements of ^{239}Pu α-radioactivity. For each step, both bands shift forward by one number, and the new histograms, appearing at the right, are compared: the new top with all the bottom ones and the new bottom with all the top ones – this being repeated 360 times to build a distribution of the number of similar histogram pairs over the interval between these histograms (see Fig. 7 and hereinafter).

The fact that changes of the shape of such histograms in time are not random follows from a number of regularities found in our previous studies [1-17]. Even a careful examination of Fig. 4 would indicate this nonrandomness. It can, however, be estimated quantitatively. A quantitative measure of nonrandomness of the shape of inconsistent histograms is the results of their thorough comparison. The histograms can be compared either by a human expert, with the aid of Edwin Pozharsky's program, or by application of completely automated algorithms written by V. Gruzdev [19] and V.V. Strelkov et al. [18, 20–22].

Fig. 5 illustrates the procedure of pairwise histogram comparison, showing histograms constructed from the results of synchronous measurements of ^{90}Sr β-radioactivity in No-

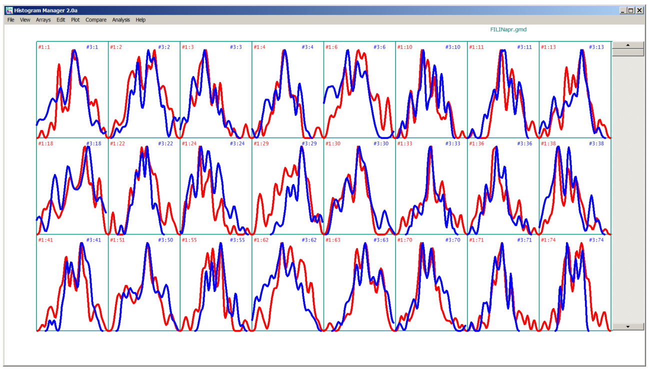

Fig. 6: A fragment of the computer journal (archive). Pairs of histograms considered similar by an expert.

vosibirsk (top band) and ^{239}Pu α-radioactivity in Pushchino (bottom band). Each band contained 360 numbers. In total, about 20,000 histogram pairs were compared, and the results are given in Figs. 6 and 7.

Fig. 6 shows an example of the histogram pairs that an expert deemed similar upon visual comparison.

Fig. 7 demonstrates the results of histogram comparison in the synchronous measurements of ^{90}Sr β-radioactivity in Novosibirsk and ^{239}Pu α-radioactivity in Pushchino in 3 variants of experimental setup: with the collimator aimed at the Polar star (no. 4); with the collimator constantly aimed at the Sun (no. 3) (on a rotating platform compensating for the diurnal rotation of the Earth); with the collimator directed west (no. 5). These results are represented as a dependence of the number of similar histogram pairs on the interval between the histograms.

As seen in Fig. 7, when the collimator in Pushchino is aimed at the Polar star, there is no synchronism in the change of histogram shape in Novosibirsk and Pushchino. When the collimator in Pushchino is directed west, synchronism is not very apparent but statistically significant ($P < 10^{-3}$). When the collimator is aimed at the Sun, synchronism is evident ($P < 10^{-7}$).

We shall not discuss now why the extent of synchronism depends on the direction of collimators in Pushchino (for details, see [1]). What is important is that with other conditions being equal, these differences in the experimental setup make the effects observed statistically significant. Therefore, the shape of histograms constructed from the results of measurements of β- and α-radioactivity at the distance between the laboratories ~3000 km does not depend on the nature of the process measured and the method of measurement. This agrees with the conclusion that the shape of histograms and its changes are determined by the orbital movement and diurnal rotation of the Earth and other cosmo-physical factors [1, 10–17].

This conclusion is confirmed by demonstration of the effects that are traditional for our works. The first effect is the "effect of near zone". It means that the neighbour histograms are much more probable to be similar, and Fig. 8 shows how it looks for the β-activity measurements.

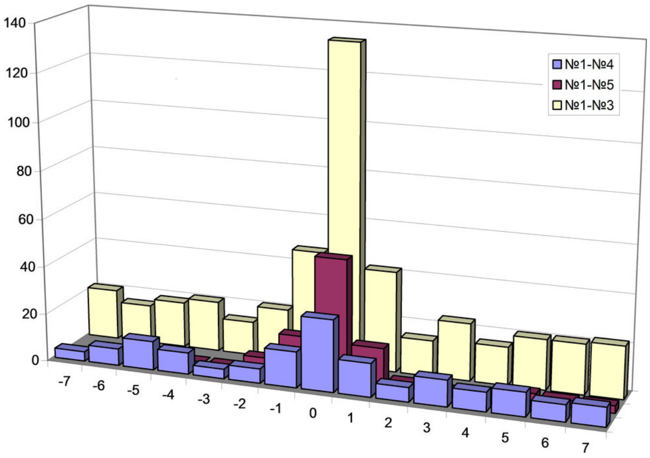

Fig. 7: Distribution of the number of pairs of similar histograms over the interval between them. Measurements of ^{90}Sr β-radioactivity in Novosibirsk and ^{239}Pu α-radioactivity in Pushchino with the collimators directed to the Sun (no. 3), Polar star (no. 4) or west (no. 5). Pairs no. 1-3; 1-4; 1-5. X-axis: intervals between similar histograms (min). Y-axis: number of similar histograms per 360 compared pairs.

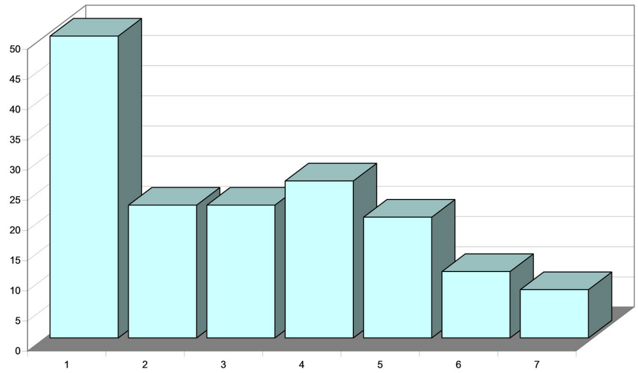

Fig. 8: Measurements of ^{90}Sr β-activity. The "effect of near zone", a higher probability of neighbor histograms (interval = 1) to be similar comparatively to the histograms separated by larger intervals. X-axis is time interval in minutes, Y-axis is number of similar histograms per 360 compared pairs.

Since histograms are constructed for non-overlapping segments of time series, the effect of near zone is the first sign of histogram shape to be determined by an external factor [1]. The second traditional effect, indicating cosmo-physical conditionality of the shape of histograms, is the existence of two clearly resolvable near-daily periods: sidereal and solar [1]. Fig. 9 shows these near-daily periods revealed in the measurements of ^{90}Sr β-activity in Novosibirsk (no. 1) and ^{239}Pu α-activity in Pushchino (no. 3–5)

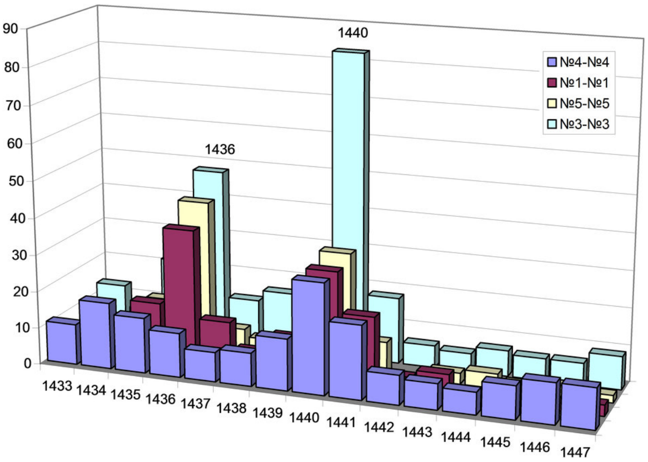

Fig. 9: Sidereal (1436 min) and solar (1440 min) daily periods in the appearance of similar histograms in the measurements of ^{90}Sr β-activity in Novosibirsk (no. 1) and ^{239}Pu α-activity in Pushchino (no. 3, 4, 5). Collimator is aimed at the Sun – no. 3; collimator is aimed at the Polar star – no. 4; collimator is directed west – no. 5. X-axis is time interval in minutes, Y-axis is number of similar histograms per 360 compared pairs.

The existence of well-resolvable sidereal and solar daily periods means a sharp anisotropy of the effects observed. The difference between the direction at the immobile stars (sidereal daily period) and the Sun (solar daily period) is about 1 degree. As seen in Fig. 9, these periods are 4 minutes apart, i.e., they are resolved with the accuracy of 15 angular minutes. We also observe spatial anisotropy in the effects of synchronism by the absolute and local time [1, 11].

One can see the effect of spatial anisotropy in Fig. 10, which demonstrates local-time synchronism in the change of the shape of histograms constructed for the measurements of ^{90}Sr β-activity in Novosibirsk (no. 1) and ^{239}Pu α-activity in Pushchino with a west-directed collimator. The calculated difference in local time is equal to 179–180 min. As seen in Fig. 10, there is a sharp extremum – evidence of the effect – at 178th minute (peak height, 134 similar pairs). Other extrema, corresponding to the moments of absolute-time synchronism (at 0th, 193rd and 209th minutes), are substantially lower (peak height, 16 similar pairs and less).

Thus, the measurements of ^{90}Sr β-activity performed in Novosibirsk give us another confirmation of universality of the effects described earlier.

As the last illustration, we shall consider the "effect of palindrome", which indicates a dependence of the histogram shape on the spatial relation between the directions of the Earth diurnal rotation and its movement along the circumsolar orbit [8, 9]. The effect consists in the reverse change of the histogram sequences at the moments when the relation between the directions alternates its sign. According to the previously published works, it occurs at 6:00 and 18:00 by accurate (longitudinal) local time. In the course of its diurnal rotation, the Earth starts moving against its orbital translocation at 6:00. At 18:00, the directions of both movements become the same. The effect manifests itself in a dramatic difference in the similarity of consecutive histograms when a "daytime" histogram sequence (from 6:00 to 18:00) is compared to either inverse or non-inverse "nighttime" sequence (from 18:00 to 6:00 of the next day). This effect is illustrated in Fig. 11.

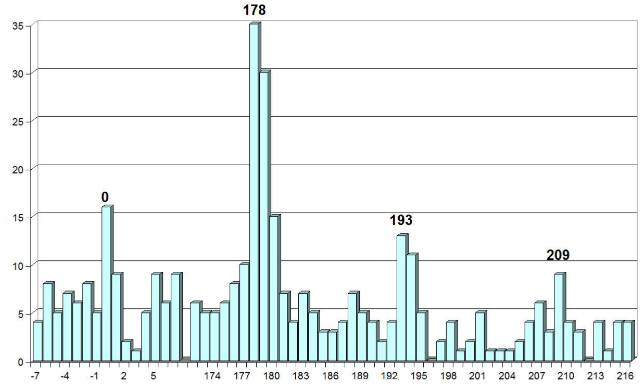

Fig. 10: Effect of synchronism by local time revealed upon comparison of the histograms constructed for the measurements of ^{90}Sr β-activity in Novosibirsk and ^{239}Pu α-activity in Pushchino with a collimator directed west. X-axis is time interval in minutes, Y-axis is number of similar histograms per 360 compared pairs.

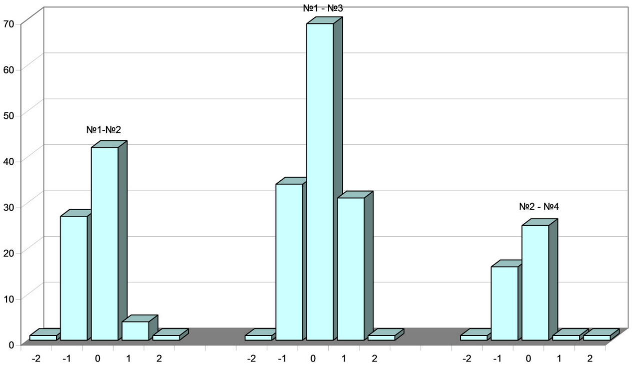

Fig. 11: Measurements of ^{90}Sr β-activity. The "palindrome effect" revealed upon comparison of a daytime histogram sequence (no. 1; from 6:00 to 18:00 by accurate local time) to the non-inverse (no. 2) and inverse (no. 3) nighttime sequences (from 18:00 to 6:00 of the next day) and the next daytime sequence (no. 4). X-axis is time interval in minutes, Y-axis is number of similar histograms per 360 compared pairs.

The effect of palindrome is clearly seen in Fig. 11. After inversion of one half of a day (in the points of palindrome), the number of similar histogram pairs doubles.

4 Discussion

The objective of this paper was to check if the results of ^{90}Sr β-activity measurements conducted by E.Y. Filin can be compared with the results of other measurements obtained within the research on "cosmo-physical fluctuations". As follows from the presented data, all the expected effects were reproduced with these experiments. Since β-particles run a distance of a few meters in the air (in contrast to α-particles, which run only a few centimeters), these measurements can be a valuable tool for a study of the spatial anisotropy of the observed effects.

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