"The Arrow of Time" in the Experiments in which Alpha-Activity was Measured Using Collimators Directed at East and West

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In our previous paper (Shnoll and Rubinstein, Progress in Physics, 2009, v. 2, 83–95), we briefly reported about a phenomenon, which can be called the "arrow of time": when we compared histograms constructed from the results of 239-Pu alpha-activity measurements that were obtained using West- and East-directed collimators, daytime series of the "eastern" histograms were similar to the inverted series of the following night, whereas daytime series of the "western" histograms resembled the inverted series of the preceding night. Here we consider this phenomenon in more detail.

1 Introduction

As follows from all our past results, the fine structure of the spectrum of amplitude fluctuations (the shape of the corresponding histograms) is determined by the motion (orientation) of the object studied (the laboratory) in relation to spatial inhomogeneities [2]. The spatial pattern (arrangement in space) of these inhomogeneities is stable: as the Earth rotates about its axis and moves along the circumsolar orbit, similar histogram shapes are realized repeatedly with the corresponding periods (daily, near-monthly, yearly) [3, 4]. The inhomogeneities themselves are analogous to the "numerals on the dial of the celestial sphere", which determine one or another shape of histograms. In the experiments with rotating collimators, beams of α-particles periodically go in the direction of the same inhomogeneities, and similar histograms appear with the corresponding periods [5]. Earlier, when the collimator-equipped devices were immobile (with one collimator directed West and another East), we showed that histograms from either of the collimators would have their analogs (similar shapes) from the other collimator lagging behind by half a day [6] (i.e., by the time needed for the collimators, rotating with the Earth, to face the same spatial inhomogeneities). In the experiments with "daily palindromes", however, this periodicity turned out to be asymmetrical. Asymmetry manifested itself in the daytime series of the "eastern" histograms being similar to the inverted series of the *following* night and the daytime series of the "western" histograms being similar to the inverted series of the *preceding* night [1]. Below we describe this phenomenon in more detail and discuss its possible nature.

2 Materials and methods

The material for this study was series of histograms constructed from the results of long-term measurements of α-activity registered from two ^{239}Pu preparations using two independent collimator-equipped devices. The collimators were used to isolate beams of α-particles flying at certain directions. In this study, one collimator was directed East and another was directed West. The technical information on the devices, which were constructed by I. A. Rubinstein and N. N. Vedenkin, can be found in [2]. The analysis of histogram series consists in the estimation of histogram similarity depending on the interval between them. A detailed description of the methodology for constructing and comparing histograms, as well as for obtaining distributions of the number of similar pairs over the length of the interval between the histograms compared, is given in [2]. To characterize correlations in

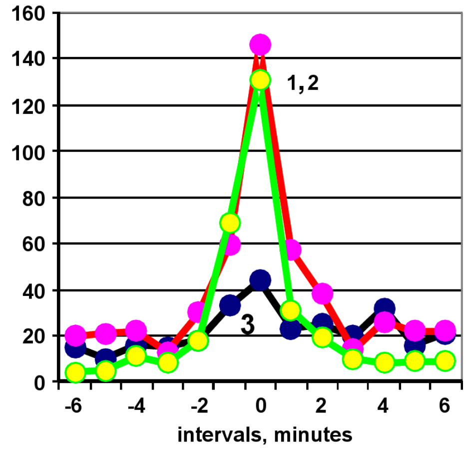

Fig. 1: Illustration of the "palindrome phenomenon". A high probability of histograms of the same order numbers to be similar in the direct daytime/inverse nighttime sequences (line 1) and the direct nighttime/inverse daytime ones (line 2). A low probability of histograms to be similar at comparing the direct daytime and nighttime sequences (line 3). The counter did not contain a collimator. Date of measurements, September 23, 2005. Every line sums up the results of approximately 10000 pairwise comparisons. X axis, interval between the histograms compared (min); Y axis, the number of similar pairs.

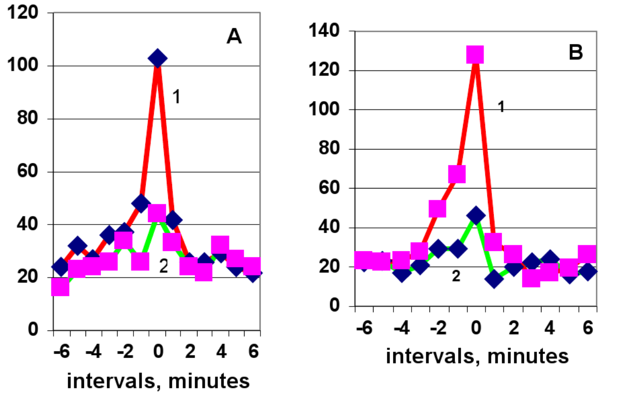

Fig. 2: Palindrome effects in the simultaneous measurements of ^{239}Pu α-activity with two independent collimator-equipped devices directed East (A) and West (B). Date of measurements, September 22–23, 2003. The axes as in Fig. 1. (A) "East": (1) "day" versus the *following* inverse "night"; (2) "day" versus the *preceding* inverse "night". (B) "West": (1) "day" versus the *preceding* inverse "night"; (2) "day" versus the *following* inverse "night".

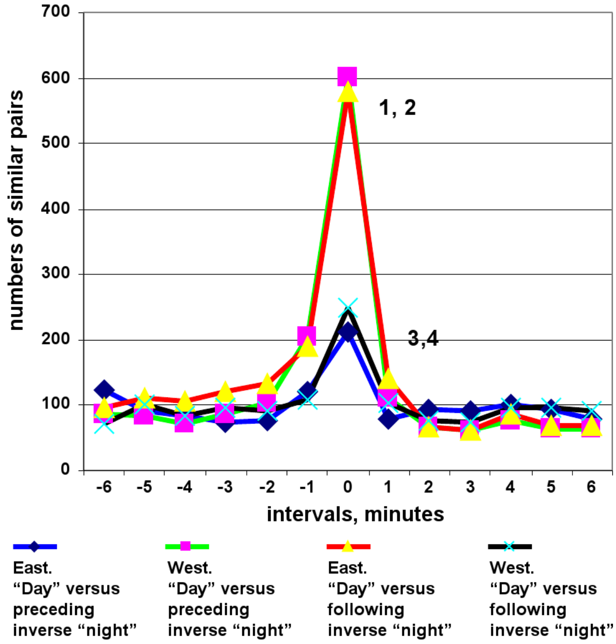

Fig. 3: In the measurements of ^{239}Pu α-activity with the West-directed collimator, a direct sequence of daytime histograms is similar to the reverse histogram sequence of the *preceding* night; in the measurements of ^{239}Pu α-activity with the East-directed collimator, a direct sequence of daytime histograms is similar to the reverse histogram sequence of the *following* night. A sum of four experiments.

the change of the histogram shape over time, we used the "palindrome phenomenon" [7] — the high probability of a sequence of histograms constructed from the results of daytime measurements (from 6:00 to 18:00, by local longitude time) to be similar to the *inverse* sequence of histograms constructed from the results of nighttime measurements (from 18:00 to 6:00 of the next day). Fig. 1 demonstrates this phenomenon. The source material is series of ^{239}Pu α-activity measurements registered with a counter without collimator (frequency of measurement, 1 point per second). From these data, 1-min histogram sequences were constructed (60 points per histogram), with the histograms smoothed 7-fold by the moving summation method (for visual convenience). Two histogram sequences were compared: (1) from 6:00 to 18:00 by accurate local time ("daytime" sequence) and (2) from 18:00 to 6:00 of the next day ("nighttime" series), each sequence consisting of 720 histograms. The sequences could be direct (from no. 1 to 720) or inverse (from no. 720 to 1).

As seen in Fig. 1, if compared are the direct daytime and nighttime sequences, the similarity (the probability to be similar) of histograms of the same order numbers is low (line 3). In contrast, the direct daytime/inverse nighttime (line 1) or inverse daytime/direct nighttime (line 2) comparisons reveal a high similarity of the same histogram numbers — the "effect of palindrome" [7].

3 Results

The phenomenon of palindrome was easily reproduced in the analysis of measurements performed in different seasons without a collimator. However, the analysis of data obtained in the experiments with collimators (western and eastern) showed varying results; the phenomenon became irregular. In the experiments with the western collimator, palindromes were reproduced regularly when a direct daytime sequence was compared with the inverse sequence of the preceding night; with the eastern collimator, it must have been a direct daytime sequence versus the inverse sequence of the following night. This phenomenon is illustrated in Fig. 2.

Fig. 2 shows that in the measurements with the eastern collimator, a clear palindrome can be seen when the direct sequence of histograms obtained from 6:00 to 18:00 on September 22 ("day") is compared with the inverse sequence of histograms obtained from 18:00 on September 22 to 6:00 on September 23 ("night"). At the same time, comparing the direct sequence of nighttime histograms (measurements from 18:00 on September 22 to 6:00 on September 23) with the inverse sequence of the following daytime histograms (measurements from 6:00 to 18:00 on September 23) shows no palindromes.

In the experiments with the "western" collimator, the situation is opposite. A clear palindrome is seen when the direct sequence of histograms obtained from 6:00 to 18:00 on September 22 ("day") is compared with the inverse sequence of histograms obtained from 18:00 on September 21 to 6:00 on September 22 ("night"). No palindromes is revealed when the direct sequence of histograms obtained from 6:00 to 18:00 on September 22 ("day") is compared with the inverse sequence of histograms obtained from 18:00 on September 22 to 6:00 on September 23 ("night"). To put it briefly: the eastern collimator will give palindromes upon the direct-day-to-*following*-inverse-night comparing; the western collima-

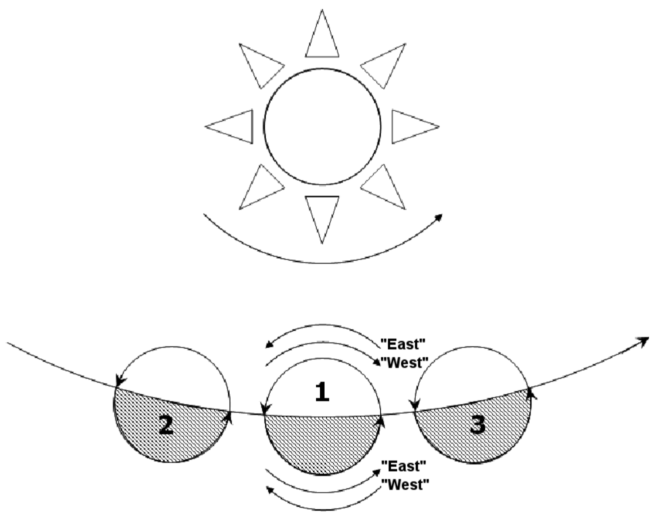

Fig. 4: The relation between the directions of motion during the daily rotation of the Earth, its translocation along the circumsolar orbit, the rotation of the Sun about its axis and the directions of α-particles flying through the "western" and "eastern" collimators.

tor will show palindromes upon the direct-day-to-*preceding*-inverse-night comparing. Since the regularities found were of principle importance, we conducted more than 25 analogous experiments. The regularities were reproduced well and did not depend on the season. This can be seen in Fig. 3, which represents a summary result of four independent experiments.

4 Discusion

The phenomenon under discussion concerns regularities revealed in the experiments, in which ^{239}Pu α-activity was measured with collimator-equipped devices. The collimator were directed either West or East, and the sequence of histograms obtained with the western collimator from 6:00 to 18:00 by local time ("day") turned out to be similar to the inverse sequence of the preceding night (from 18:00 to 6:00), whereas the sequence of daytime histograms obtained with the eastern collimator were similar to the inverse sequence of the following night.

Here we would remind the reader that the matter does not concern any "effects on α-decay"; it concerns changes of the fine structure of amplitude fluctuation spectra (the shape of the corresponding histograms). The intensity of α-decay, a mean number of decay acts per time unit, does not depend on the direction of the collimator; it will fluctuate according to the Poisson statistics — proportionally to $\pm\sqrt{N}$, where N is the decay intensity.

Earlier we established that the changes of the histogram shape would depend on the orientation of collimators in space [8]. It seems that certain histogram shapes correspond to certain directions, possibly, to the spatial locations of gravitational inhomogeneities. Changes of the histogram shape are determined by the motion of our objects in relation to these quite long-living (for more than a year) stable inhomogeneities. Now we see that apart from the dependence on the spatial vector, there is also a dependence on the vector of time.

Fig. 4 schematically illustrates spatial relations in the experiments described above. There are two devices in the laboratory (on the Earth), which differ only by the orientation of the collimators: one isolates a beam of α-particles flying West (i.e., against the direction that the Earth rotates in) and the other is directed East (i.e., along the Earth rotation). The Earth rotates about its axis and moves along the circumsolar orbit. Both these motions, as well as rotation of the Sun, have the same direction: they are directed counterclockwise. However, combining the first two motions results in the rotation of the Earth to be counter-directed to its translocation along the orbit in the daytime and co-directed in the nighttime [9]. Accordingly, α-particles from the "eastern" collimator would fly *against* the orbital Earth motion in the daytime and *along* this motion in the nighttime, this being the opposite for the "western" collimator. Hence, the collimators alternatively (one during the day- and the other during the nighttime) take the same orientation — either "along" or "against" the orbital motion of the Earth. Therefore, the phenomenon discussed cannot be explained by the change of the collimator orientation towards the Earth motion along the circumsolar orbit.

> Thus, the "arrow of time" in our experiments is determined only by the difference in the orientation of the collimators in relation to the direction of the Earth rotation about its axis.

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