Synchronous Measurements of Alpha-Decay of ^{239}Pu Carried out at North Pole, Antarctic, and in Puschino Confirm that the Shapes of the Respective Histograms Depend on the Diurnal Rotation of the Earth and on the Direction of the Alpha-Particle Beam

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Dependence of histogram shapes from Earth diurnal rotation, and from direction of alpha-particles issue at ^{239}Pu radioactive decay is confirmed by simultaneous measurements of fluctuation amplitude spectra — shapes of corresponding histograms. The measurements were made with various methods and in different places: at the North Pole, in Antarctic (Novolazarevskaya station), and in Puschino.

1 Introduction

Fine structure of an amplitude fluctuation spectrum (i.e., that of "data spread") can be determined during measurements of different nature changes with the Earth rotation around its axis and its movement along its orbit.

This follows from the regular changes in the shape of the respective histograms with diurnal and annual periods. Well-defined periods are observed: those of "stellar" (1,436 minutes) and "solar" (1,440 minutes) days, "calendar" (365 average solar days), "tropical" (365 solar days 5 hours 48 minutes) and "sidereal" (365 days 6 hours 9 minutes) years [1].

Experiments with collimators that allow studies of alpha-particle beams with definite directions indicate that this regularity is related to non-uniformity (anisotropy) of space [1, 6].

Dependence on the diurnal Earth rotation shows in high probability of shape similarity of histograms obtained during measurements in different locations at the same local time, as well as in the disappearance of diurnal periods near the North Pole [2]. However, together with synchronous changes in histogram shapes according to the local time, some experiments show changes in histogram changes simultaneously according to an absolute time [2]. It was discovered that synchronism with regard to absolute time (e.g. during measurements in Antarctic and in Puschino, Moscow Region) observed during measurements of alpha-decay of ^{239}Pu, depends on the spatial orientation of the collimators [1, 3, 5].

In order to study dependences of the absolute synchronism phenomenon, experiments carried out near the North Pole, which would minimize effects of the Earth's diurnal rotation, were required,.

The first such attempt was undertaken in 2001 by joint efforts of Inst. Theor. & Experim. Biophysics of Russ. Acad. Sciences (ITEB RAS) and Arctic & Antarctic Res. Inst. (AARI), when twenty-four-hour measurements of ^{239}Pu alpha-decay with a counter without collimator were carried out continuously during several days in a North Pole expedition on the "Akademik Fedorov" research vessel.

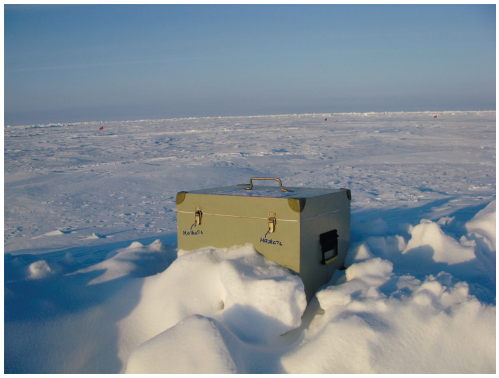

Fig. 1: Measuring device at North Pole.

However, the ship was not able to come closer than latitude 82° North to the North Pole. But even this incomplete approaching to the North pole has shown almost complete disappearance of diurnal changes in the histogram shapes that were observed during the same period of time in Puschino (latitude 54° North) [2].

In 2003, we found out that diurnal changes in histogram shapes also disappear when alpha-radioactivity is measured with collimators that issue alpha-particle beams directed towards the Pole star. This indicated that histogram shapes depend on a space direction of a process[1, 6].

This conclusion was later repeatedly confirmed by experiments with collimators directed westward, eastward, northward, or rotated in the horizontal plane counterclockwise with

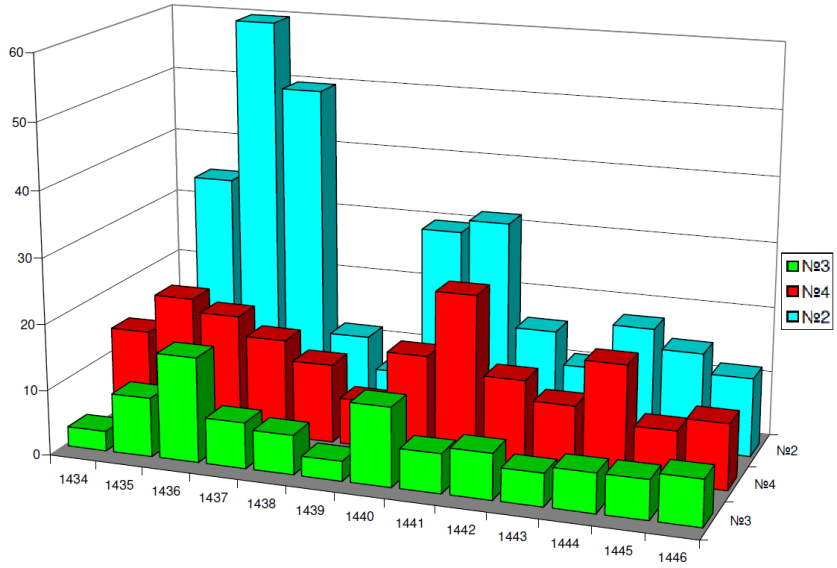

Fig. 2: During the ^{239}Pu alpha-decay measurements at the North Pole, the effect of the daily period disappearance is more pronounced for the vertical detector (device no. 3) than for the horizontal one (device no. 4). For comparison, daily period is shown for synchronous measurements in Puschino with a westward-directed collimator (device no. 2). The abscissa axis shows minutes. The ordinate axis shows the number of the similar pairs obtained during this period with a total number of the compared rows of 360.

periods of 1, 2, 3, 4, 5, 6, 12 hours. The histogram shape changed with the respective periods.

In 2011, we were able to carry out synchronous experiments on ^{239}Pu alpha-decay using nine different devices, two of which were located at the North Pole during the period of work at the Pan-Arctic ice drifting station (latitude 89° 01 — 89° 13 North, longitude 121° 34 —140° 20 East), one in Antarctic (the Novolazarevskaia station, latitude 70° South, longitude 11° East), and six more having different collimators in Puschino (latitude 54° North, longitude 37° East).

As a result of this project, we were able to confirm the conclusion that histogram shapes depend on the diurnal rotation of the Earth, and to show that, when alpha-particle beam is directed along the meridian, the histogram shape changes synchronously from the North Pole to the Antarctic.

2 Materials and methods

The device was installed on the surface of drifting ice near the geographic North Pole (Fig. 1) and worked continuously since April 5, 11 till April 12, 11, until its accumulators were out of charge.

The measurement results obtained at the North Pole since April 5, 11 till April 12, 11 were analyzed in the ITEB RAS in Puschino. The analysis was, as usual, comparison of histogram shapes for measurements made with different devices. A detailed description of the methods of histogram construction and shape comparison can be found in [1].

This paper is based on the results obtained from the simultaneous measurements of alpha-activity of the ^{239}Pu samples with the activity of 100–300 registered decay events per second using 9 different devices with semiconductor alpha-particle detectors constructed by one of the authors (I. A. Rubinshtein) with and without collimators [6] and registration system constructed by M. E. Astashev (see [7]).

The main characteristics of the devices used in this study are given in Table 1.

Because of special complications presented by the conditions at the North Pole (no sources of electricity, significant temperature variations) a special experimental system with autonomous electricity source, thermostat, and time recording was created by M. E. Astashev. This device contained two independent alpha-particle counters (I. A. Rubinshtein), one directed upwards and another one directed sidewards, which were combined with a special recording system.

A system based on the computing module Arduino Nano V.5 [7–1] was used for registering the signals from the alpha-particle counter. The software provided all service functions for impulse registration, formation of the text data for the flash card, obtaining the time data, regulation of the heater, obtaining the temperature and the battery charge data. The data were recorded onto a 1 Gb microSD card, and the function library Fat16.h, real time clock were implemented using the DS1302 chip [7–2] with a lithium battery CR2032 independent power supply [7–3]. Power supply of the registering system and alpha-particle counters was provided by four waterproof unattended geleous lead batteries of 336 W× h total capacity [7–3]. To provide working conditions for the batteries and stability of the system, a 12 W electric heater with pulse-duration control and temperature detector AD22100 was added [7–4]. Pulse counters were implemented by processing external hardware interruptions of the computing module. The data were recorded onto the card as plain text.

Number	Device type	Coordinates	The expected purpose, i.e. registration of the histogram shape changes caused by:
1	Collimator, directed eastward	Puschino, lat. 54° North, long. 37° East	diurnal Earth rotation
2	Collimator, directed westward	Puschino, lat. 54° North, long. 37° East	diurnal Earth rotation
3	Flat detector without collimator, directed "upwards"	North Pole	Earth circumsolar rotation
4	Flat detector without collimator, directed "sidewards"	North Pole	combined, diurnal and circumsolar, Earth rotation
5	Collimator, directed towards the Polar Star	Puschino, lat. 54° North, long. 37° East	circumsolar Earth rotation
6	Polar Star directed collimator-free flat detector	Puschino, lat. 54° North, long. 37° East	combined, diurnal and circumsolar, Earth rotation
7	Sun directed collimator, clockwise rotation	Puschino, lat. 54° North, long. 37° East	circumsolar Earth rotation
8	Collimator-free flat detector, directed "upwards"	Puschino, lat. 54° North, long. 37° East	combined, diurnal and circumsolar, Earth rotation
9	Horizontal collimator, directed northward	Puschino, lat. 54° North, long. 37° East	combined, diurnal and circumsolar, Earth rotation

Table 1: The devices for the measurements of ^{239}Pu alpha-decay used in this study.

3 Results

3.1 Daily periods of the histogram shape changes depend on the detector orientation

Fig. 2 shows that measurement of ^{239}Pu alpha-activity in Puschino with a westward-directed collimator (device no. 2) leads to appearance of similar histograms with two clearly distinguished periods, which are equal to a sidereal day (1,436 min) and a solar day (1,440 min). During measurements at the North Pole with flat detectors, daily periods almost disappear. It can be noticed, however, that daily periods are slightly more pronounced for the flat detector directed sidewards (horizontally; device no. 4). The periods disappear for measurements at the North Pole with a detector directed upwards (vertically; device no 3).

Dependence of the effects observed at the North Pole on the detector orientations, which was revealed while looking for the diurnal periods, indicates that these effects were not caused by any influence by some "geophysic" impacts on the studied processes or on the measurement system. Not location of the device but rather orientation of the detector determines the outcome. A similar result was observed for two other Pole Star-directed detectors in Puschino, one of which was flat and another had a collimator (data not shown). The main effect, disappearance of the daily period, was significantly more pronounce with a collimator-equipped detector.

3.2 The absolute time synchronism of the changes in the histogram shapes, in the ^{239}Pu alpha-activity measurements in Antarctic, at the North Pole and in Puschino depends on the orientation of the detectors

The main role of the spatial orientation rather than geographical localization in the studied phenomena is clearly seen from the high probability of the histogram similarity if they are measured simultaneously at the same absolute time using a vertical detector at the North Pole and a Pole Star-directed detector with a collimator in Puschino (Fig. 3A, B)

Dependence of the synchronism with regard to the absolute time on the spatial orientation of the detectors was particularly clearly revealed during comparison of the histograms constructed on the basis of ^{239}Pu alpha-activity measurements in Antarctic, at the North Pole, and in Puschino.

In Fig. 4 A and B, we can see high probability of absolute synchronism for measurements performed on April 8, 2011 and on April 9, 2011 in Antarctic (no. 8) with a vertical detector located at the North Pole (no. 3), and in Puschino with a collimator directed at the Sun (no. 7). There is no synchronism for experiments with a horizontal detector at the North Pole (no.4) and detector in Antarctic (no. 8).

Therefore, during measurements at the North Pole with a vertical detector, or with collimator-equipped detectors aimed at the Sun or at the Pole Star in Puschino, that is both detectors cannot depend upon Earth diurnal rotation, there was an absolute synchronism of the histogram shape change with histogram shape changes in Antarctic.

Another illustration of the role of detector orientation for the measurements at the North Pole is given in Fig.5. Absolute synchronism of the histogram shape change is more pronounced for comparison of the ^{239}Pu alpha-activity measurements in Puschino with a collimator constantly directed at the Sun and at the North Pole with a vertically-directed collimator.

4 Discussion

The results of the present study confirm that the changes in the histogram shape depend on the diurnal rotation of the

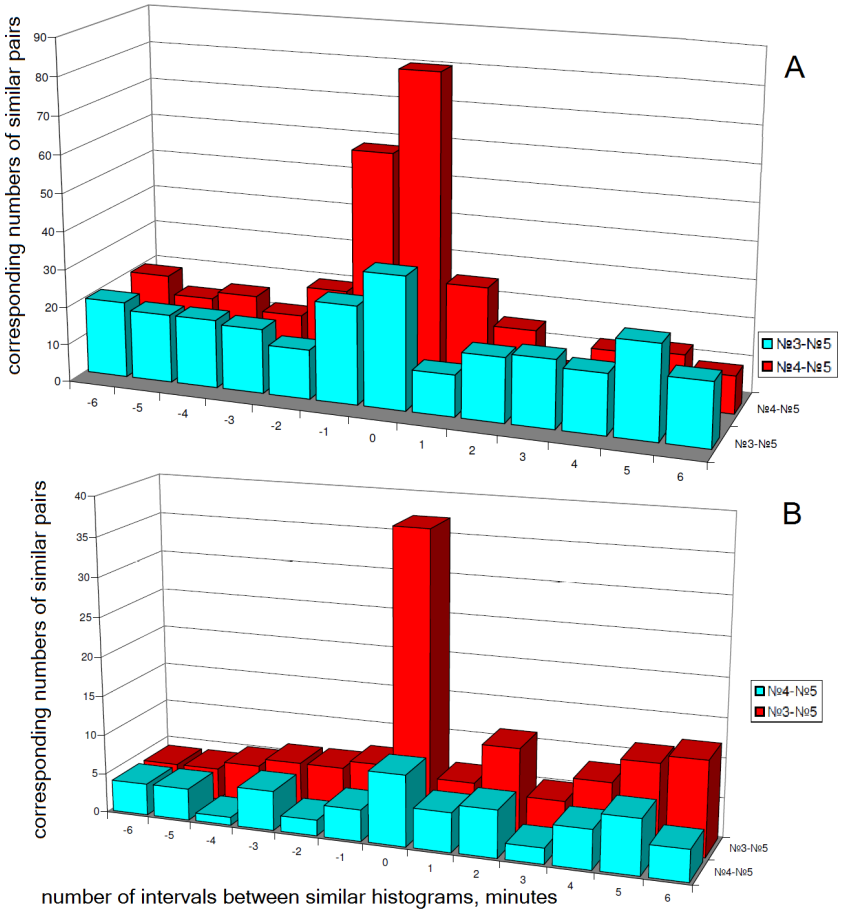

Fig. 3: Two experiments were performed on April 8, 2011(A) and April 9, 2011(B). High probability of the histogram shape similarity at the same absolute time is observed for measurements in Puschino using Pole Star-directed detector with a collimator (device no. 5) and at the North Pole with a vertical detector (device no. 3). There is no similarity during similar measurements in Puschino (the same device no. 5) and at the North Pole with a horizontal detector (device no. 4). X-axis is numbers of intervals between similar histograms, min.; Y-axis is correspondent numbers of similar pairs.

Earth and that this dependence is caused by anisotropy of our space. Daily periods of the changes in the histogram shapes are not observed when alpha-particle beams are parallel to the Earth axis.

Absolute synchronism of the changes in the histogram shapes is observed in experiments with collimators directed at the Pole Star and at the Sun in Puschino (latitude 54° North) (no. 5). and for measurements at the North Pole (latitude 90° North) with a "vertical" detector only (no. 3). There is no absolute synchronism with the "horizontal" counter (no. 4). By analogy, absolute synchronism of the changes in the histogram shapes for measurements in Antarctic is observed only for measurements at the North Pole with a "vertical" detector and a Sun-directed detector in Puschino.

Comparison of these data with the "local time effect", i.e. synchronous changes in the histogram shape in different geographical locations at the same local time, allows to suggest that changes in the histogram shapes, which are synchronous in different geographical locations with regard to the absolute time, are caused by the movement of the laboratory with the Earth along the solar orbit, and synchronism with regard to the absolute time is caused by Earth rotations. This conclusion should be a subject of additional studies.

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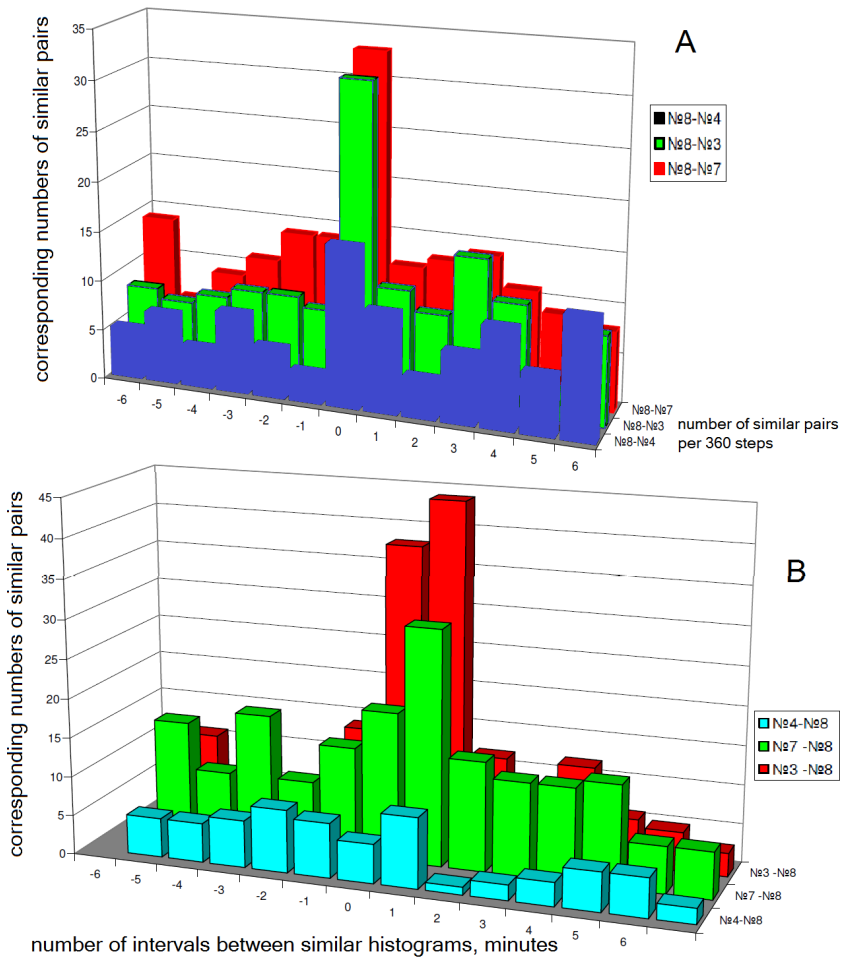

Fig. 4: The experiments, A and B. The shapes of the histograms change synchronously with regard to the absolute time during measurements of the ^{239}Pu alpha-activity in Antarctic and at the North Pole with a vertical detector (no. 8 — no. 3) and in Puschino with a collimator directed at the Sun (no. 8 — no. 7). During measurements at the North Pole with a horisontally-directed collimator, there is no synchronism with Antarctic (no. 8 — no. 4).

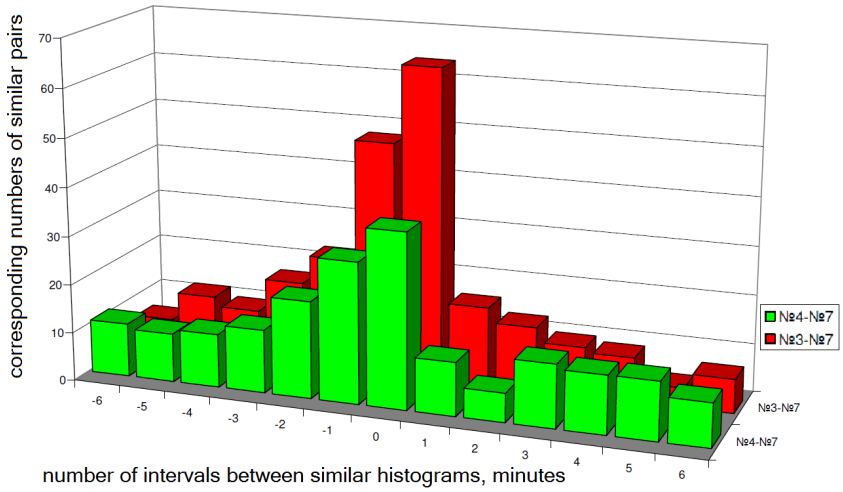

Fig. 5: Absolute synchronism of the changes in the historgram shapes for measurements of ^{239}Pu alpha-activity in Puschino with a collimator directed at the Sun (no. 7) and measurements at the North Pole with a vertical (no. 3) and a horizontal (no. 4) detectors. Absolute synchronism is more pronounced for measurements with a vertical detector.

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