On the Dependence of a Local-Time Effect on Spatial Direction

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This paper addresses further investigations of local-time effects on the laboratory scale. We study dependence of the effect on spatial directions defined by a pair of sources of fluctuations. The results show that the effect appears in the neighborhood of directions North-South and East-West. Only for these directions are the experimental results in excellent agreement with theoretically predicted local-time values. The results reveal the character of near-Earth space heterogeneity and lead to the conclusion that at the laboratory scale, local-time effects cannot be caused by some axial-symmetric structure, which has permanent properties along an Earth meridian. Appearance of the effect along an Earth parallel is linked to rotational motion of the Earth. Observed properties of local-time effects in the direction of an Earth meridian can be linked to motion of the Earth in this direction.

1 Introduction

The results of many years of investigation of macroscopic fluctuation phenomena can be considered as evidence of an essential heterogeneity and anisotropy of space-time. This statement is based upon the results of studies of α-decay-rate fluctuations of ^{239}Pu sources measured by plane semiconductor detectors and detectors with collimators cutting α-particle beams, carried out in the years 1985–2005 [1–6]. For reasons of methodology, the time resolution reached in those years was about one minute, and the studied spatial scale about a hundred kilometers. This work presents results of further investigations of macroscopic fluctuations phenomena with time resolution to 0.5 milliseconds.

Such resolution allows studies of local time effects for distances down to one metre between sources of fluctuations [7, 8]. On the one hand, this result has an independent importance as a lower scale end for the existence of macroscopic fluctuations phenomena, but on the other hand, it has great methodological importance due to the possibility of systematic laboratory investigations, which were previously unavailable because of very large spatial distances between places of measurement. One such investigation is the dependence of local-time effects as function of spatial directions, which is the main subject of this paper.

2 Experiment description and results

A functional diagram of the experimental setup is presented in Fig. 1b). It consists of two sources of fluctuations, which are fixed to a wooden base. The distance between the sources was 1.36 m. The base, with the sources of fluctuations, can revolve on its axis and can be positioned in any desired direction. A two-channel LeCroy WJ322 digital storage oscilloscope (DSO in Fig. 1b) was used for data acquisition.

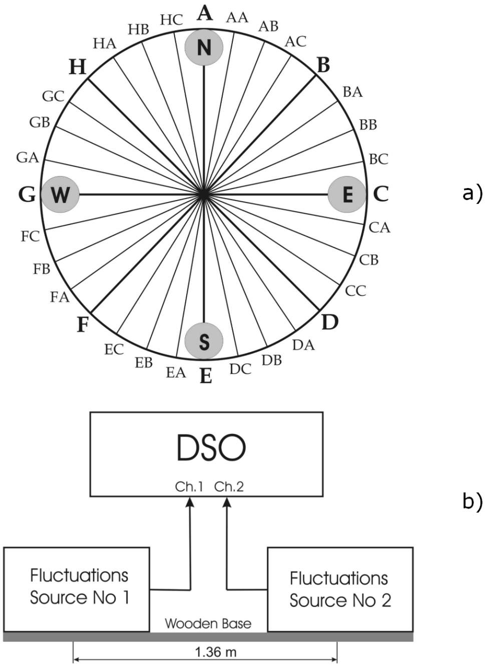

Fig. 1: Diagram of spatial directions, which was examined in experiments with fixed spatial base 1.36 m (a) and functional diagram of the experimental setup (b).

The digitizing frequency used for all series of measurements was 100 kHz. Consequently, the duration of 50-point histograms, which were used in the experiment, is 0.5 milliseconds. This means that all local-time values in the experiment are defined with an accuracy of ± 0.5 milliseconds.

Fig. 1a) depicts the spatial directions which were examined in the experiment. In Fig. 1a) every one of these directions is denoted by letters outside the circle. For example, direction AA means that the base with the sources of fluctuations is

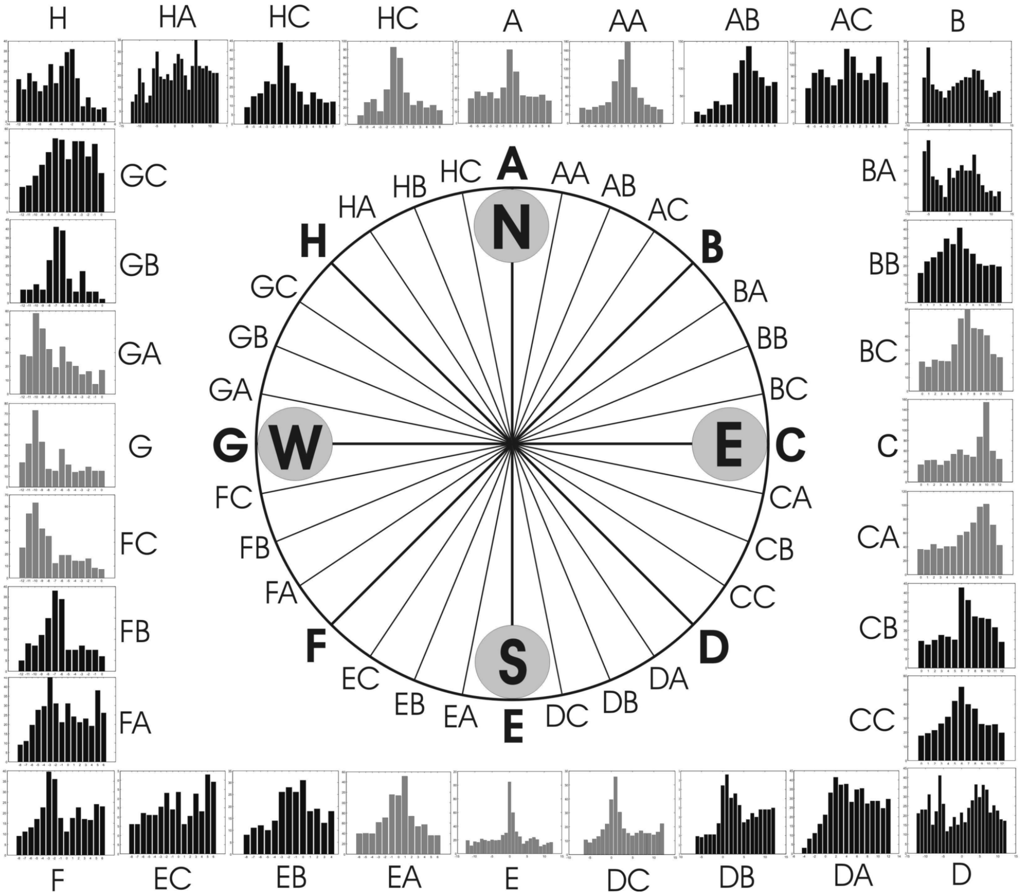

Fig. 2: Averaged interval distributions obtained for every spatial direction.

aligned in the EA-AA direction in such a way that source No 1 is placed on the AA end of the base and source No 2 is placed on the EA end. Correspondingly, direction EA means that source No 1 is on the EA end, and source No 2 is on the opposite end. Letters N, S, E, and W denote directions to the North, South, East, and West respectively. Directions A and E lie on an Earth meridian, and directions G and C lie on an Earth parallel.

The angular difference between two neighboring directions is 11.25°, so we have 32 spatial directions. To examine all the directions one series of measurements must include 32 pairs of synchronous records. Every record consists of 500,000 points. This allowed acquisition of two synchronous sets of 50-point histograms for every direction. Every set contains 10,000 histograms. The experimental results, which are presented below, are based on 8 series of measurements.

It is important to note that pairs of directions presented in Fig. 1a), for example, A-E and E-A, are actually the same because the pair of fluctuations sources used in the experiment are non-directional. For this reason the total number of directions examined is half that denoted by letters in Fig. 1a). The second measurement in an opposite pair of directions can be considered as a control. The data processing procedure used in the experiment is described in detail in [2, 9].

Fig. 2 shows the interval distributions obtained for each of the 32 spatial directions. Every one of these distributions is averaged through the interval distributions from all of the series of measurements for every one of the spatial directions. The circle inside Fig. 2 is the same as in Fig. 1a) and shows spatial directions in relation to the presented interval distributions.

All the distributions presented in Fig. 2 can be divided into two distinct groups. The first group consists of distributions in the neighbourhoods (approximately $\pm 11.25°$ of the directions A-E and C-G; labeled as A, E, C, and G. To the first group also can be related distributions that are closest to A, E, C, and G: HC, AA, BC, CA, DC, EA, FC, GA. To the second group can be related all remaining distributions. The distribution from the first group we call 'non-diagonal', and from the second, 'diagonal'. The first group in Fig. 2 is highlighted by the gray color.

The main difference between the two groups lies in the following: non-diagonal distributions always have a single peak, which corresponds to the same interval value in all series of measurements. In the case of the non-diagonal distributions, every spatial direction can be characterized by a

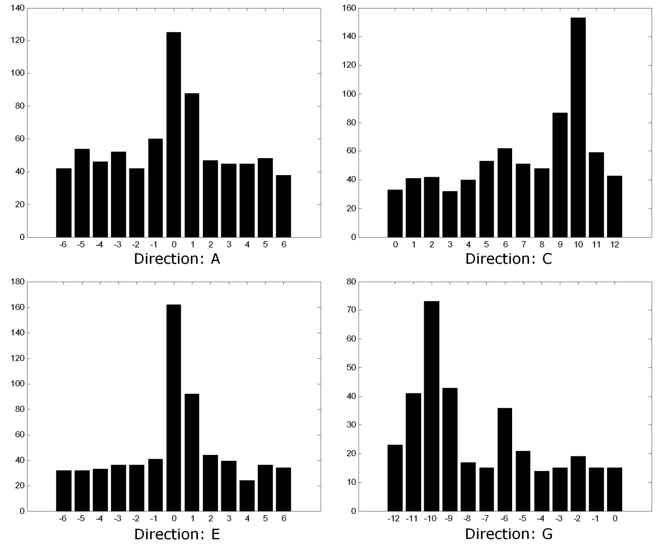

Fig. 3: Non-diagonal interval distributions for meridian (North-South) directions A and E, and for parallel (East-West) directions C and G.

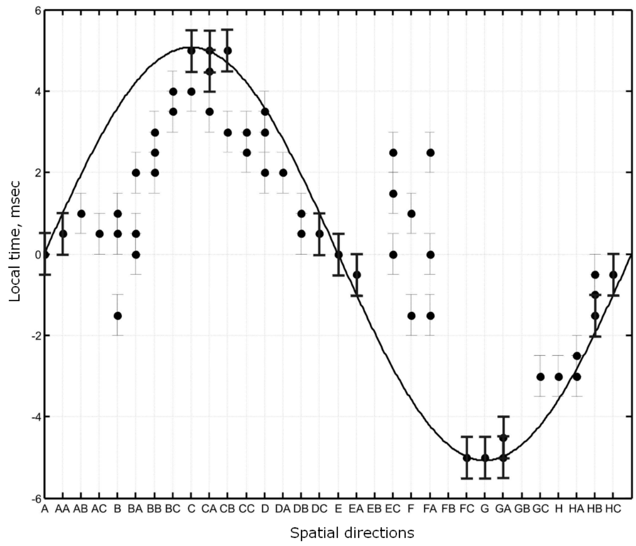

Fig. 4: Theoretical estimation (solid line) and experimentally obtained local-time values. Points with bold error bars show local-time values for non-diagonal directions.

stable, reproducible pattern of interval distribution. Contrary to non-diagonal distributions, a diagonal distribution is multi-peaked and cannot ordinarily be characterized by a stable, reproducible pattern.

Non-diagonal interval distributions are presented in Fig. 3. For Earth meridian directions (A and E), patterns of interval distributions always have a stable peak at zero intervals. In the case of Earth parallel directions (C and G), interval distributions have a peak at the interval that is equal to the local-time-difference for the spatial base of 1.36 m. This difference has the same magnitude but different sign for opposite directions. It is easy to see from Fig. 3 that interval distributions for directions C and G have peaks at the intervals 10 and -10.

3 Value of local-time-difference

As follows from previous investigations [1–6] the value of the local-time effect depends only on the longitudinal difference between places of measurements, not on latitudinal distance. From this it follows that the factor which determines the shape of fine structure of histograms must be axial-symmetric. Longitudinal dependence of local-time effect phenomenology can be considered as dependence of shape of the fine structure of histograms on spatial directions defined by the centre of the Earth and the two points where measurements are taken [8]. In this case the results of measurements depend on the solid angle between two planes defined by the axis of the Earth and the two points of measurement; such angle depends on the longitudinal difference, not on the latitudinal difference.

But for the case of separated measurements with fixed spatial base $\triangle L_0 = \text{const}$, the results of the experiment become dependent on latitude, θ. Really, the time $\triangle t$, after which fluctuation source No 2 will define the same direction as source No 1 before, depends on the velocity of the measurement system $\nu(\theta, h)$:

$$\triangle t = \frac{\triangle L_0}{\nu(\theta, h)} \sin\alpha\,, \qquad (1)$$

where $\alpha \in [0, 2\pi]$ is an angle, counter-clockwise from the direction to the North (direction A). It is important to note that the theoretical estimation of the longitudinal difference is given by (1) obtained on the assumption that the factor determining the fine structure of histograms is axial-symmetric.

The value $\nu(\theta, h)$ is determined by:

$$\nu(\theta, h) = \frac{2\pi}{T}\left(\sqrt{\frac{R_p^2}{\frac{R_p^2}{R_e^2} + \tan^2\theta}} + h\right), \qquad (2)$$

where $R_p = 6356863$ m and $R_e = 6378245$ m are the values of the polar and equatorial radii of the Earth [10] respectively, $T = 86160$ sec is the period of the Earth's revolution. For the place of measurements (Pushchino, Moscow region) we have latitude $\theta_p = 54°50.037'$ and height above sea level $h_p = 170$ m. So the velocity of the measurement system is $\nu(\theta_p, h_p) = 268$ m/sec. For near-equatorial regions $\nu(\theta, h)$ can exceed $\nu(\theta_p, h_p)$ by almost twice the latter. Consequently, for measurements with a fixed spatial base we have sufficiently strong dependence of local-time-difference (1) on latitude θ.

The value of the velocity $\nu(\theta_p, h_p)$ allows, on the basis of (1), calculation of the local-time-difference $\triangle t(\alpha)$ as function of spatial directions examined in the experiment. The solid line in Fig. 4 shows the results of this calculation.

Points with error bars in Fig. 4 show local-time values obtained for all series of measurements.

4 Discussions

It is easy to see from Fig. 4 that the experimental results are in excellent agreement with the theoretically predicted local-time values only for a narrow neighbourhood around the directions North-South (directions A and E) and East-West (directions C and G) i.e. for non-diagonal directions. At the same time, for diagonal directions, the experimental results in most cases don't follow the theoretical predictions. Results presented in Fig. 4 are in agreement with results summarized in Fig. 2, and linked to the dependence of local-time effect on spatial directions.

The results reveal the character of near-Earth space anisotropy. As pointed out above, the theoretical estimation of local-time effect values in Fig. 4 were obtained under the hypothesis that the effect is caused by some axial-symmetric structure, which has permanent properties along an Earth meridian. According to this hypothesis, the dependence of local-time effect must be the same for all spatial directions, and local-time values obtained in the experiment must follow the theoretically predicted values. But the fact that the diagonal directions experimental results don't confirm this hypothesis leads to the conclusion that at the laboratory scale local-time effects cannot be caused by some axial-symmetric structure.

Evidently, dependence of local-time effects in East-West directions is linked to the rotational motion of the Earth. In this case, after the time interval $\triangle t$, which is equal to local-time difference for the spatial base used, the position of the 'West' source of fluctuations will be exactly the same as the position of 'East' previously. In the case of diagonal spatial directions such a coincidence is absent. However, for North-South direction such an explanation is inapplicable.

Dependence of the local-time effect in the direction of a meridian is probably linked to the velocity component along the path of the Solar System in the Galaxy. This hypothesis is preliminary and may possibly change in consequence of future investigations.

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