Forecasting effect of macroscopic nonlocality

S.M. Korotaev[1], V.O. Serdyuk[1], J.V. Gorohov[2], S.A. Pulinets[2] and V.A. Machinin[1].

[1]Geoelectromagnetic Research Institute Russian Academy of Sciences, GEMRI
Post Box 30, Troitsk, Moscow Region 142190 Russia.
[2]Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation
Russian Academy of Sciences, Troitsk, Moscow Region 142190 Russia.

Modern experiments have confirmed existence of Kozyrev's transaction of the dissipative processes, which is understood now as manifestation of macroscopic nonlocality. The most prominent property of this phenomenon is transaction in reverse time. It gives the possibility, in some sense, to observe the noncontrolled future. A new approach to the forecast of the large-scale geophysical and astrophysical processes can be elaborated on the basis of this effect.

Introduction

Macroscopic nonlocality consists in correlation of different dissipative processes without any local carriers of interaction [1-3]. Nonlocal correlation (violated Bell-type inequalities) is very specific, e.g. it obeys only weak causality, but not strong one [4]. That involves, in particular, unusual advanced transaction for the noncontrolled processes.

Nature of macroscopic nonlocality is not clear, but there is a good reason to think that is macro-manifestation of quantum nonlocality. It is generally believed that quantum nonlocality is observed only at the micro-level. But beginning with [5] theoretical reasoning has evolved about persistence of nonlocality in the strong macro-limit. Most sequentially this idea was developed in Ref. [6]. On the other hand, a new way of entanglement formation via a common thermostat was suggested recently [7] and this way needs dissipativity of the quantum correlated processes. It means that dissipativity may not only lead to decoherence, but on the contrary it may play a constructive role. Namely for the dissipative processes the first experimental evidence of macroscopic nonlocality was obtained in the early experiments on causal mechanics performed by Kozyrev [8] (though they were interpreted in other terms). The observed effects consisted of transaction between two practically insulated processes. If one of them was noncontrolled (large-scale natural one) the transaction was observed with symmetrical retardation and advancement [9]. However Kozyrev's results met a contradictory reaction because of not high level of rigour of his experiments.

The idea of verification of Kozyrev's results at the modern level of rigour had been independently realized by two teams [2,10] with following joint interpretation [1]. In this paper we briefly review the main results and present the most recent ones.

Theory

Since standard blueprint of observation of quantum nonlocal correlation is willingly unfit at the macro-limit, for formulation of experimentally verified hypothesis we have introduced dissipation in the framework of Cramer interpretation of quantum nonlocality by Wheeler-Feynman action-at-a-distance electrodynamics [4]. The latter we have used in modern quantum treatment [11]. As a result the following equation of macroscopic nonlocality was suggested [12]:

$$\dot{S}_d = \sigma \int \frac{\dot{s}}{x^2} \delta\left(t^2 - \frac{x^2}{\upsilon^2}\right) dV \tag{1}$$

where $\dot{S}_d$ is entropy production in the probe-process (that is detector), $\delta \sim \hbar^4 / m_e^2 e^4$, m^e is electron mass, e is elementary charge, $\dot{s}$ is density of the entropy production in the sources, x is distance, t is time, propagation velocity υ is subluminar: $\upsilon^2 \leq c^2$, V is source volume. δ- function shows that transaction progresses with symmetrical retardation and advancement. According to Ref. [4], it does not violate weak causality if the source is noncontrolled by an observer. That is why the interesting is performance of the experiment namely with natural large-scale astrophysical and geophysical source-processes.

It should be noted that simplest Eq.(1) does not take into account absorption by the intermediate medium. In Ref. [11] it has been shown that known Wheeler-Feynman requirement on perfect absorption of the field by the matter concerns only retarded part, while absorption of advanced one must be imperfect. Therefore screening properties of the matter relative to the advanced field must be attenuated. As a result level of advanced correlation may exceed retarded one.

Role of the medium manifests itself in one more way: the transaction occurs by diffusion interparticle chains (by means of microscopic Weeler-Feynman fields) that brings to a small resulting v in Eq.(1) and correspondingly to large resulting values of retardation and advancement.

Experiment

The task of the experiment is to detect entropy change of the environment according to Eq. (1) under condition, that all known classical local interactions are suppressed. Although any dissipative process could be taken as probe one, its choice is dictated by relative value of the effect and theoretical "transparency", allowing to relate measured signal with left-hand side of Eq. (1) and consciously to take steps on screening and/or control of all possible local noise-factors (temperature, pressure, electromagnetic field etc.).

Two experimental setup for study of macroscopic nonlocality had been constructed [1]. The GEMRI setup used two types of detectors based on variations of self-potentials of weakly polarized electrodes in an electrolyte and on variations of dark current of the photomultiplier. The setup consists of nearby electrode and photomultiplier detectors, another electrode detector and apparatus for the local factors control. The CAP setup uses ion mobility detector based on variations of conductivity in a small electrolyte volume under well controlled local conditions. The CAP setup is spaced at 40 *km* from GEMRI one. All technical and theoretical details were presented in Ref. [1,10,12].

The experiments with controlled lab source-processes had shown existence only retarded transaction [10,13].

Much more interesting results were obtained in the long-term experiments devoted to study detectors reaction on various geophysical and astrophysical processes. These experiments had been conducted in 1993-96 with the electrode detector, in 1996-97 with the all 3 detectors of the GEMRI setup and in 1997 with CAP setup. From 2001 a new experiment with the best electrode detector has been conducted.

The most important results are following [1-3, 12, 14].

1. The signals of all 4 detectors of 3 types are high correlated. Level of correlation is independent of type of detectors and only slightly dependent on their separation. Analysis had shown that signals were formed by some common causes but their influence could not be local
2. Such common causes proved to be solar, synoptic, geomagnetic and ionospheric activity. Strong correlation of the detector signals advanced relative to these processes has been revealed. Retarded correlation is always less, decreasing along space scale of the processes, and becoming insignificant for the most large-scale processes (solar and

global geomagnetic activity). Value of advancement is large: about from 10 hours to 100 days and it increases along the space scale.

3. Nonlocal character of correlation was proved by Bell-type inequality violation.
4. Eq. (1) was quantitatively verified on example of the process of geomagnetic activity (because namely this process allowed relatively simply computation its right-hand side).
5. Level of advanced correlation allowed to demonstrate the possibility of solar, geomagnetic and synoptic forecast.

New results with old experimental data

In spite of long total duration of the experiments, there were technical interruptions. In Ref. [1-3, 12, 14] only continuous time series were used. As a result maximal series length was not exceeded several months. Meanwhile level of nonlocal correlation increases along the period of variations, particularly for the solar activity. Now to increase signal/noise ratio we have united data segments, interpolating the gaps and sacrificing the short periods. We applied this procedure to electrode detector, solar activity and global geomagnetic activity data. As index of the solar activity we used solar radio wave flux R at frequency 610 *MHz* (radiating from the lower corona, that is just from the level of maximal dissipation in the solar atmosphere [14]). As index of the global geomagnetic activity we used *Dst*-index [14]. It should be stressed that detector is not sensitive nor to the radio waves, neither to the magnetic field; *R* and *Dst* are only qualitative indices of the source entropy production.

United time series was chosen by criterion of maximal gap length not more than 28 days. The longest series fit this criterion turned out electrode detector signal *U* one with duration 2 years and 9 months (10/26 1994-07/24/1997). *R* and *Dst* serieses were taken from 1 year before to 1 year latter relatively to ends of *U* series. All data were daily averaged and low-pass filtered (pass periods $T > 28$ days). Data were processed by correlation analysis with variable time shift τ.

In Fig.1 the correlation function r_{UR} of the detector signal *U* and solar activity *R* is shown. Negative time shift corresponds to retardation of *U* relative to *R* , positive one – to advancement. The main maximum $r_{UR} = 0.5 \pm 0.002$ at advancement $\tau = 42$ days. Taking into account low-pass filtration probably better to say 6 weeks, but this result exactly equals $\tau = 42$ days obtained in Ref. [14] by another detector, by another time series (12/12/1996-12/11/1997) and by another, more sophisticated mathematical method (causal analysis).

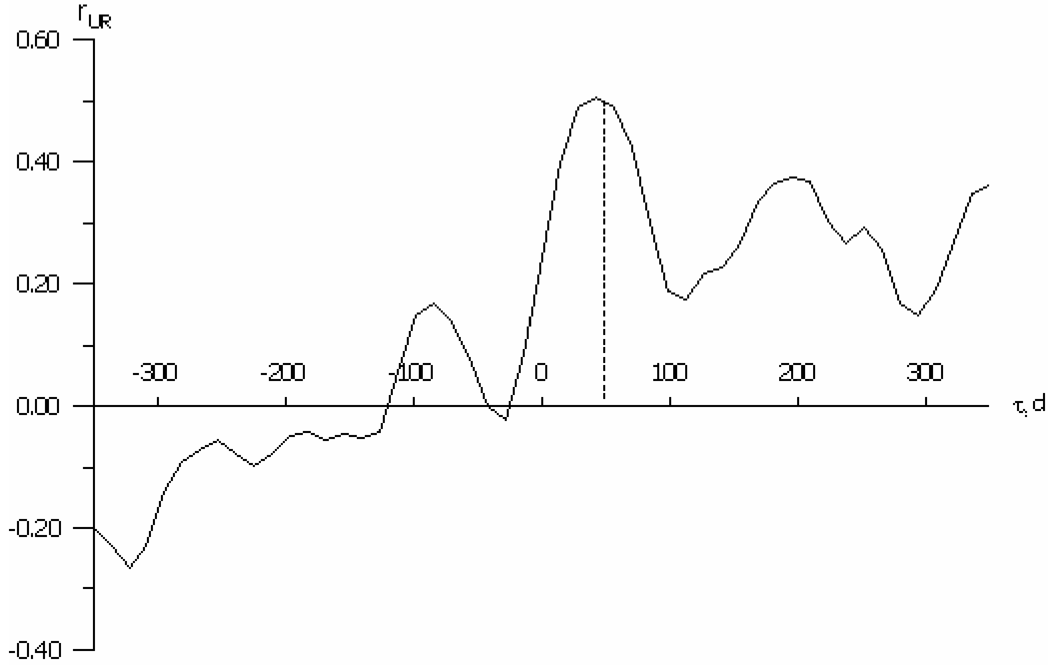

Fig.1 Correlation function r_{UR} of the detector signal *U* and solar activity *R*. Negative time shift τ, days, corresponds to retardation *U* relative to *R*, positive one - to advancement.

Retarded correlation is insignificant. Availability of other two advanced maxima also corresponds to results of Ref.[4].

Correlation of the detector signal with geomagnetic activity is almost the same: max r_{UDst} = 0.50 ±0.002 at the same τ = 42 days. The same value of τ is explained by small response time of *Dst* on *R* (1-2 days) as compared with low-pass filter parameter T = 28 days. Correlation of *Dst* with *R* seems practically synchronous at given time resolution (r_{UDst} = 0.30 ±0.002 at τ = 0).

Hence we observe probably a direct influence of the solar activity on the detector signal that is typical property of nonlocality. For proof consider Bell-type inequality [1,12]:

$$i_{U|R} \geq \max\,(i_{U|Dst},\ i_{Dst|R})\ , \qquad (2)$$

where *i* are the independence functions. The independence functions are terms of causal analysis (e.g. [15]) and defined as $i_{Z|Y} = H(Z|Y) / H(Z)$, where *H(Z|Y)* is conditional Shannon entropy and *H(Z)* is marginal one of the variables *Z* and *Y*. $0 \leq i_{Z|Y} \leq 1$, $i_{Z|Y}$ =0 if *Z* is one-valued function of *Y* , $i_{Z|Y}$ =1 if *Z* is not depended on *Y*. Value of $i_{Z|Y}$ is equally fit for linear or any nonlinear type of dependence *Z* on *Y*. It is important for given problem because relationship of *U* and *R* is essentially nonlinear [1]. The fulfillment of Ineq.(2) is sufficient condition for locality of connection along the causal chain R→ Dst→ U.

For estimation of stability of calculated values of *i* the all three channels in turn were noised by 21 % (by power) flicker-noise [1,12]. The results are: $i_{U|R} = 0.807^{+0.010}_{-0.009}$, $i_{U|Dst} = 0.836^{+0.000}_{-0.002}$, $i_{Dst|R} = 0.832^{+0.008}_{-0.000}$. Ineq. (2) is violated, therefore connection *R*→*U* is nonlocal.

Availability of advanced correlation can be applied for the forecast problem. As the detector signal variations and large-scale processes are far from δ-correlated, for real forecast the plural regression algorithm is necessary. But now we aim only to demonstrate the forecast possibility by simple shift time series on τ corresponding to the main correlation maximum. For this simplest algorithm level of correlation *r* = 0.5 is insufficient nor for *R* neither for *Dst*.

To increase correlation we tried to restrict the period range from above. For the r_{UR} it has not increased its value, but for r_{UDst} such appropriate period range has been found, namely 364 > T >28 days. The result is shown in Fig.2. At advancement τ = 42 days there is max r_{UDst} = 0.70 ± 0.02. Then we can shift filtered time serieses and see that detector signal U really forecasts the global geomagnetic activity *Dst* with advancement 42 days (Fig.3).

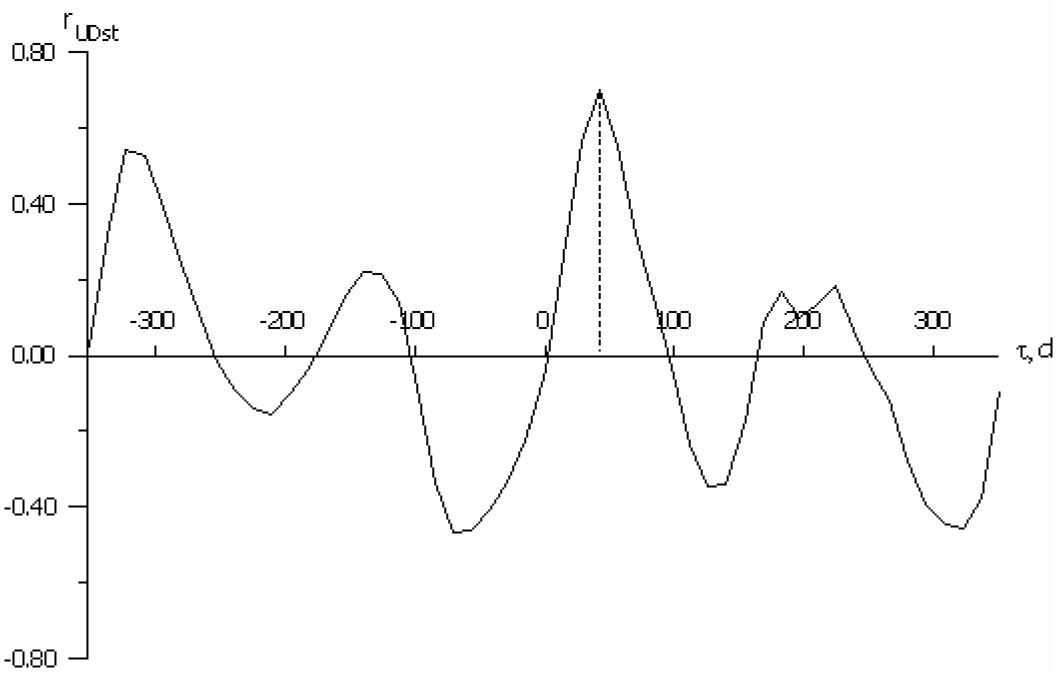

Fig. 2 Correlation function r_{UDst} of the detector signal U and geomagnetic activity *Dst* by data filtered in period range 364 > T > 28 days. Negative time shift τ, days, corresponds to retardation U relative to *Dst*, positive one – to advancement.

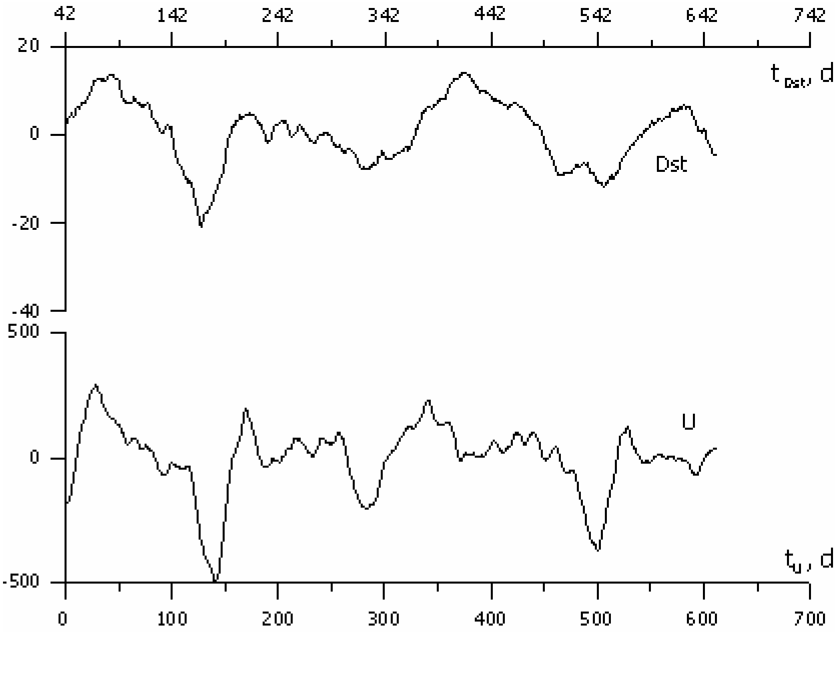

Fig. 3 The detector signal $U(\mu V)$ forecasts the geomagnetic activity *Dst* (*nT)* with advancement 42 days.

New experimental results

On October, 22, 2001 a new experimental on study of electrode detector reaction on the solar activity began. As the signals related with the solar activity is sufficiently strong at the long periods (months and years) data collection is under way yet. Visible detector signal is very smooth. But at the beginning of 2003 extremely sharp splashes (with duration of order of hour) and with big magnitude, from 4 to 134 μV (precision of measurements is $0.5\mu V$) were observed on January 1,9,14,15, February 3, 11, 13, 14. The were not any similar events from the beginning of the experiment and the were not after. The biggest splash was on February, 3 (Fig.4). Just 42 days after the famous solar flare March, 17 happened. It was very seldom, gigantic flare of class X (Fig. 5).

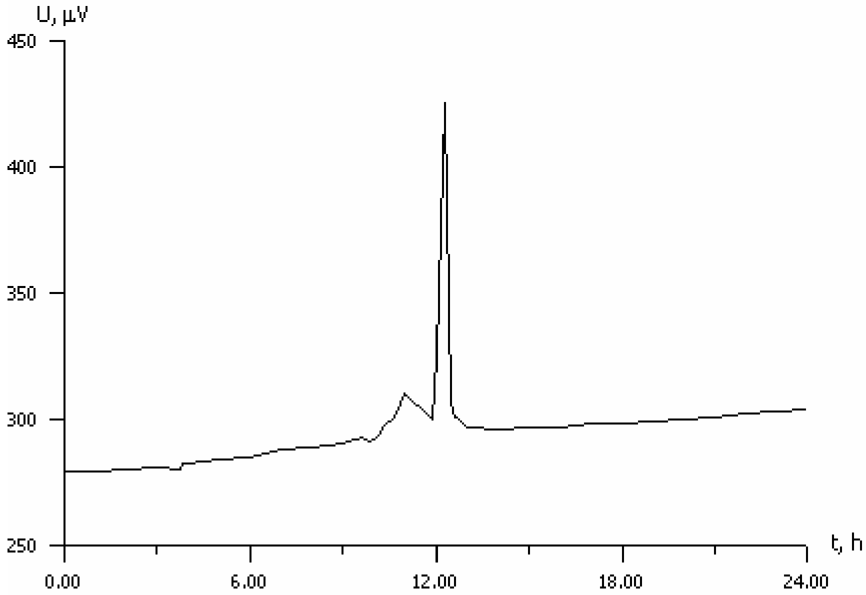

Fig. 4 Unusual splash of the detector signal U on February, 3, 2003.

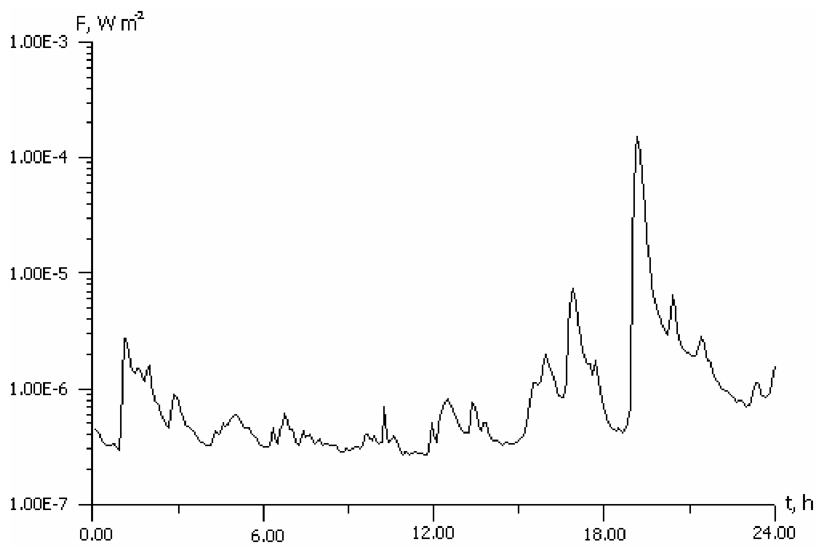

Fig. 5 Gigantic solar flare (x-ray flux F) on March, 17, 2003, i.e. 42 days after the event recorded by detector, which is shown in Fig.4.

In such a manner this powerful solar event caused advanced reaction of the electrode detector with several time shifts and with the main predictor at τ = 42 days. Moreover splash shapes of the self-potentials (Fig. 4) and solar x – rays one (Fig5) are similar.

In spite of greatest magnitude that solar flare was not geoactive (it did not cause a global magnetic storm because of its inappropriate position on the Sun). Therefore influence of this solar event on the detector signal was direct (nonlocal).

Conclusions

The long-term experiments have revealed forecasting effect of macroscopic nonlocality. It manifests as advanced transaction of practically insulated dissipative processes, that confirms early Kozyrev's results. The process of variations of self-potentials difference of weakly polarized electrodes in the electrolyte correlates with the solar and geomagnetic activity. Advancement equals about one and half month. Nonlocal character of correlation has confirmed by violation of Bell-type inequality. Forecasting applications are possible.

Theoretical interpretation of this effect too heuristic and its deeper understanding is burning. The intriguing question is: why does nonlocality give a possibility of observation of the future only noncontrolled by an observer? Is it means that observer's consciousness somehow suppresses the advanced transaction?

Acknowledgments

This work was supported by RFBR and Moscow Region Government (grants 02-05-64006 and 01-05-97015). The authors thank S.P. Gaidash, V.I. Nalivayko and A.V. Novysh for participation in the experiment.

References

1. Korotaev, S.M., Morozov, A.N., Serdyuk, V.O., and Sorokin, M. O. (2002). Manifestation of macroscopic nonlocality in some natural dissipative processes. Russian Physics Journal, 45 (5), 3-14.
2. Korotaev, S.M., Sorokin, M.O., Serdyuk, V.O., and Abramov, J. M. (1999). Experimental verification of interaction of the processes through the active properties of time. Physics and Chemistry of the Earth A, 24, 735-740.
3. Korotaev, S.M., Serdyuk, V.O., and Sorokin, M. O. (2000). Effect of macroscopic nonlocality on geomagnetic and solar-ionospheric processes. Geomagnetism and Aeronomy, 40, 323-330.
4. Cramer, J.G. (1980). Generalized absorber theory and Einstein-Podolsky-Rosen paradox. Phys. Rev. D., 22, 362-376.
5. Mermin, N.D. (1990). Extreme quantum entanglement in a superposition of macroscopically distinct states. Phys. Rev. Lett., 65, 1838-1840.
6. Home, D., and Majumdar, A.S. (1995). Incompatibility between quantum mechanics and classical realism in the strong macroscopic limit. Phys. Rev. A, 52, 4959-4962.
7. Basharov, A.M. (2002). Decoherence and entanglement by radiation decay of two-atom system. Journal of Experimental and Theoretical Physics, 121, 1249-1260.
8. Kozyrev, N.A. (1971). On the possibility of experimental investigation of the properties of time. Time in Science and Philosophy. Prague: Academia, 111-132.
9. Kozyrev N.A., and Nasonov, V.V. (1978) New method of determination of trigonometric parallaxes on the base of difference between actual and visible positions of the stars. Manifestation of Cosmic Factors on the Earth and Stars. Moscow-Leningrad: VAGO Press, 168-179.

10. Morozov, A.N. (1997) Irreversible Processes and Brownian Motion, Moscow: BMSTU Press.
11. Hoyle, F., and Narlikar, J. V. (1995). Cosmology and action-at-a-distance electrodynamics. Rev. Mod. Phys., 67, 113-156.
12. Korotaev, S.M., Sorokin, M.O., Serdyuk V.O., and Abramov, J.M. (1998). Experimental study of nonlocal interaction of the macroscopic dissipative processes. Physical Thought of Russia, 2, 1-17.
13. Korotaev, S.M., Serdyuk, V.O., Sorokin, M. O., and Machinin, V.A. (2000). Experimental study of nonlocality of the controlled dissipative processes. Physical thought of Russia, 3, 20-26.
14. Korotaev, S.M., Serdyuk, V.O., Nalivayko, V., I., Novysh, A.V., Gaidash, S. P., Gorokhov, Yu.V., Pulinets, S.A., and Kanonidy, H. D. (2003). Experimental estimation of macroscopic nonlocality effect in solar and geomagnetic activity. Physics of Wave Phenomena, 11 (1), 46-54.
15. Korotaev, S.M. (1992). On the possibility of causal analysis of the geophysical processes. Geomagnetism and Aeronomy, 32 (2), 27-33.