News & Views

Forecasting Effect of Macroscopic Nonlocality

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Abstract

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

The nature of macroscopic nonlocality is not clear, but there is a good reason to think that it is a macro-manifestation of quantum nonlocality. It is generally believed that quantum nonlocality is observed only at the micro-level. But beginning with Mermim,[5] theoretical reasoning has evolved about persistence of nonlocality in the strong macro-limit. Most consecutively this idea was developed in Home and Majumdar.[6] On the other hand, a new way of entanglement formation via a common thermostat was suggested recently in Basharov [7] and this way needs the dissipation of the quantum-correlated processes. It means that the dissipation 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 his experiments do not have a high enough level of precision and rigor.

The idea of verification of Kozyrev's results at the modern level of rigor 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 Weeler-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]

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

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. The δ-function shows that transaction progresses with symmetrical retardation and advancement. According to Cramer,[4] it does not violate weak causality if the source is noncontrolled by an observer. That is why it is interesting to perform the experiment just with natural large-scale astrophysical and geophysical source-processes.

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

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

Two experimental setups for study of macroscopic nonlocality had been constructed.[1] The Geoelectromagnetic Research Institute (GEMRI) setup used two types of detectors based on variations of self-potentials of weakly polarized electrodes in an electrolyte and on variations of the dark current of the photomultiplier. The setup consists of nearby electrode and photo-multiplier detectors. Another electrode detector and apparatus are used 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 the GEMRI one. All technical and theoretical details were presented.[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 three detectors of the GEMRI setup and in 1997 with the CAP setup. From 2001 a new experiment with the best electrode detector has been conducted. The most important results follow:[1-3,12,14]

1. The signals of all four detectors of three types are highly correlated. The level of correlation is independent of the 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 in relation 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). The value of advancement is large: about from 10 hours to 100 days and it increases along with the space scale.
3. Nonlocal character of correlation was proved by Bell-type inequality violation.
4. Equation (1) was quantitatively verified on example of the process of geomagnetic activity (because namely this process allowed relatively simply computation of its right-hand side).
5. The level of advanced correlation demonstrated 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 some experiments,[1-3,12,14] only continuous time series were used. As a result, maximal series duration did not exceed several months. Meanwhile, the level of nonlocal correlation increases along the period of variations, particularly for the solar activity. To increase the signal/noise ratio in the present study 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 an index of the solar activity, we used solar radio wave flux R at frequency 610 MHz (radiating from the lower corona, which is just from the level of maximal dissipation in the solar atmosphere.[14] As an index of the global geomagnetic activity, we used *Dst*-index.[14] It should be stressed that the detector is not sensitive either to the radio waves, or 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 of not more than 28 days. The longest series fit this criterion for electrode detector signal *U* with duration two years and nine months (10/26 1994-07/24/1997). *R* and *Dst* series were taken from one year before to one year after relatively to the ends of the *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 *t*. In Figure 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*, and a positive one corresponds to advancement. The main maximum $r_{UR} = 0.51 \pm 0.02$ with advancement $t = 42$ days. Taking into account low-pass filtration, it is probably better to say six weeks, but this result exactly equals to $t = 42$ days obtained in Korataev [14] by another detector, by another time series (12/12/1996-12/11/1997), and by another, more sophisticated mathematical method (causal analysis). Retarded correlation is insignificant. Availability of other two advanced maxima also corresponds to results of Cramer.[4]

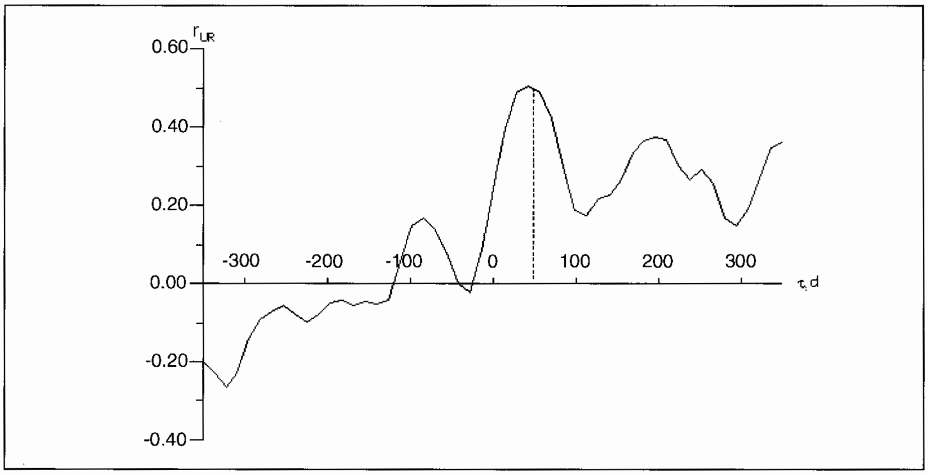

Fig.1 Correlation function r_{UR} of the detector signal *U* and solar activity *R*. Negative time shift *t*, days,corresponds to retardation *U* relative to *R*, positive one - to advancement.

Correlation of the detector signal with geomagnetic activity is almost the same: max $r_{UDst} = 0.50 \pm 0.02$ at the same $t = 42$ days. The same value of *t* is explained by small response time of *Dst* on *R* (1-2 days) as compared with the low-pass filter parameter $T = 28$ days. Correlation of *Dst* with *R* seems practically synchronous at given time resolution ($r_{UDst} = 0.30 \pm 0.02$ at $t = 0$).
Hence, we probably observe a direct influence of the solar activity on the detector signal that is typical property of nonlocality. For proof, let us consider the Bell-type inequality: [1,12]

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

where *i* are the independence functions. The independence functions are terms of causal analysis (e.g., Korotaev) [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 *X*. Value of $i_{Z|Y}$ is equally fit for linear or any nonlinear type of dependence *Z* on *Y*. It is important for the given problem because the relationship of *U* and *R* is essentially nonlinear .[1] The fulfillment of Inequality (2) is sufficient condition for locality of connection along the causal chain $R \rightarrow Dst \rightarrow U$.

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

The 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 *t* corresponding to the main correlation maximum. For this simplest algorithm level of correlation, $r = 0.5$ is insufficient neither for *R* neither

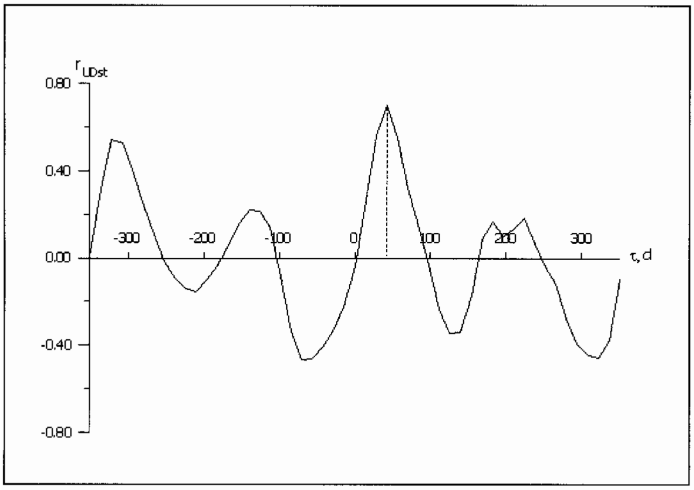

Fig. 2 *Correlation function r_{UDst} of the detector signal U and geomagnetic activity Dst by data filtered in period range 364 > T > 28 days. Negative time shift t, days, corresponds to retardation U relative to Dst, positive one – to advancement.*

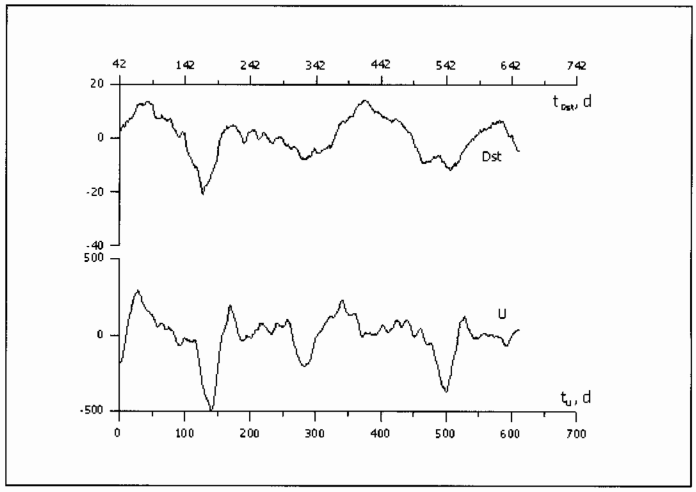

Fig. 3 *The detector signal U (mV) forecasts the geomagnetic activity Dst (hT) with advancement 42 days.*

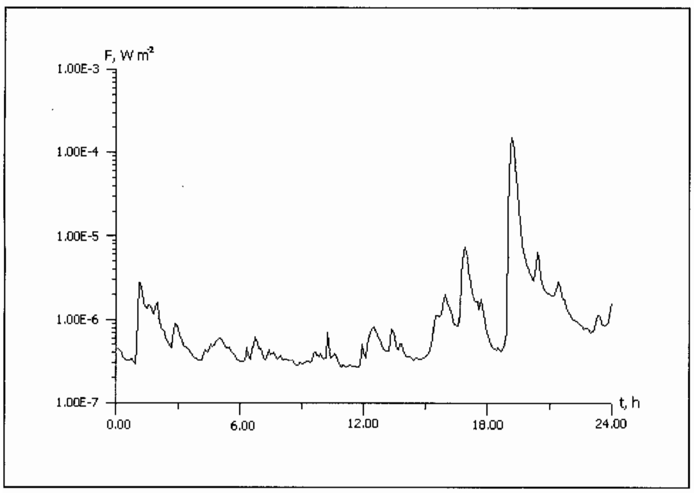

Figure 4 *Unusual splash of the detector signal U on February 3, 2003.*

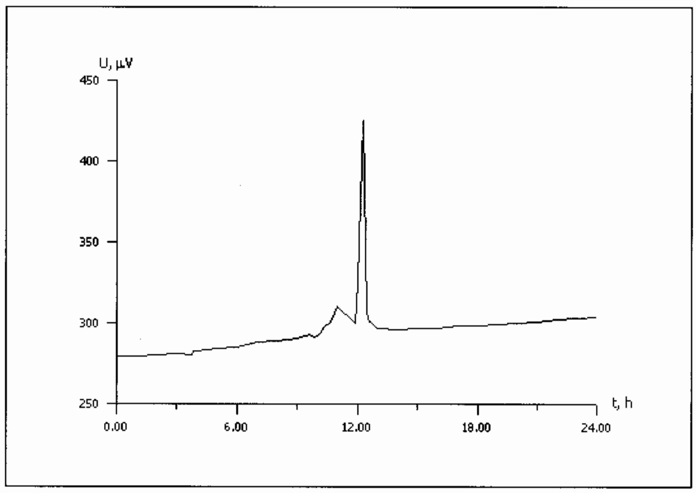

Figure 5. *Gigantic solar flare (X-ray flux F) on March 17, 2003, i.e., 42 days after the event recorded by the detector, which is shown in Figure 4.*

nor 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} an appropriate period range has been found, namely 364 > *T* >28 days. The result is shown in the Figure 2.

At advancement *t* = 42 days there is max $r_{UDst} = 0.70 \pm 0.02$. Then we can shift filtered time series and see that detector signal *U* really forecasts the global geomagnetic activity *Dst* with advancement 42 days (Figure 3).

New Experimental Results

On October, 22, 2001, a new experimental study of electrode detector reaction on the solar activity began. As the signals related with the solar activity are sufficiently strong at the long periods (months and years) data collection is underway yet. Visible detector signal *i* 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 μV) were observed on January 1,9,14,15, = and February 3, 11, 13, 14. No similar events from the beginning of the experiment and after it were observed. The biggest splash was on February 3 (Figure 4) and just 42 days after, the famous solar flare on March 17 occurred. It was a very seldom, gigantic flare of class *X* (Figure 5).

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 t = 42 days. Moreover, splash shapes of the self-potentials (Figure 4) and solar X–rays one (Figure 5) are similar.

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

Conclusions

The long-term experiments have revealed the forecasting effect of macroscopic nonlocality. It manifests as advanced transaction of practically insulated dissipative processes, which confirms Kozyrev's early 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 months. Nonlocal character of correlation was 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 the following: Why does nonlocality give a possibility of observation of the future only noncontrolled by an observer? Does this mean that observer's consciousness somehow suppresses the advanced transaction?

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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. Rus. Phys. J., 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. Geomagn. Aeron, 40, 323-330.

4. Cramer, J. C. (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.

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.

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., et al. (2003). Manifestation of macroscopic nonlocality in the processes of solar and geomagnetic activity. Herald of Bauman Mosc. Tech. Univ., 1, 86-95.

15. Korotaev, S. M. (1992). On the possibility of causal analysis of the geophysical processes. Geomagnetism and Aeronomy, 32(2), 27-33.