Experimental Study of Advanced Correlation of Some Geophysical and Astrophysical Processes

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Abstract
Macroscopic nonlocality represents itself in correlation of different dissipative processes without any local carriers of interaction and with Bell-type inequality violation. Nonlocal correlation obeys weak causality principle. It involves the possibility of advanced transaction between the random dissipative processes. Wide series of long-term experiments on observation of correlation of insulated lab probe-processes with the large-scale source-processes have been performed. For the natural random source-processes: the solar, meteorological and geomagnetic activity the advanced reaction was reliable detected. Moreover advanced correlation proved to be stronger than retarded one. Due to high level of advanced correlation forecasting applications have a sense. This possibility was demonstrated by the forecast of the random component of geomagnetic activity.
Keywords: nonlocality, dissipation, causality, entropy, forecast

1 Introduction

Phenomenon of quantum nonlocality attracts increasing attention due to number of its unusual properties. In particular, transactional interpretation of quantum nonlocality in the framework of Wheeler-Feynman action-at-a-distance electrodynamics [2] suggests existence of signals in reverse time. According to principle of weak causality [2] it leads to observable advanced correlation of unknown (not determined by evolution) states [3] or, in other terms, random processes. Further, although it is generally supposed that nonlocality exists only at the micro-level, there is reason to believe that it asymptotically persists in the strong macro-limit and it has been proved in the numerical [5] and real [4, 7] experiments. Moreover a new way of entanglement formation via a common thermostat (which can be served the electromagnetic field) has been suggested [1] and this way needs dissipativity of the quantum-correlated processes (namely radiation ones). It means that dissipativity may not only lead to decoherence, but on the contrary, it may play a constructive role.

On the other hand, more than 30 years ago N.A. Kozyrev had suggested causal mechanics theory and conducted the various experiments [19], which originated from the idea of fundamental time asymmetry, but led to macroscopic phenomena similar to microscopic nonlocal ones. Specifically, he had observed correlation of the probe dissipative process (in the telescope detector) with large-scale ones of the stars with three time shifts, corresponding classical retardation, symmetrical advancement and zero between them, i.e. instantaneous [20]. According to causal mechanics such correlation of different dissipative processes was explained by not any local carriers of interaction, but by some physical properties of time as an active substance. Kozyrev's theoretical and experimental conclusions were so unexpected (with weakly formalized theory and not too strict performance of the experiment), that they could not be accepted in due course.

But in 1990s similarity of the results of causal mechanics and some recent ones of quantum mechanics had become obvious. Understanding of causal mechanics effects as possible manifestation of quantum nonlocality at the macro-level had allowed to perform the experiments showed availability of advanced correlation [11 - 18]. In this article obtained results are generalized and particular attention to the most recent ones is paid. In Sec. 2 theoretical ideas and in Sec. 3 experimental ones are presented. In Sec.4-10 experimental data, results of their processing and interpretation are shortly described. Conclusion is in Sec. 11.

2 Heuristic Model

As a development of strict theory of macroscopic nonlocality is very difficult problem, we consider the simplest heuristic model. We follow Cramer's interpretation of quantum nonlocality within Wheeler-Feynman action-at-a-distance electrodynamics [2], but we use the latter in modern quantum treatment [6]. This theory considers direct particle field as superposition of retarded and advanced ones. The advanced field is unobservable and manifests only via radiation damping, which is the dissipative process.

But first of all let's take notice to likeness of axioms of causal mechanics and action-at-a-distance electrodynamics. In the electrodynamics transaction of the charges separated by finite distance 8*x* and lapse *8t* (with zero interval) is postulated. Self-action of the charges is absent. Two from three Kozyrev's axioms [19] (there are 8*x*^0 and *8t Ф* 0 between any cause and effect) assert the same, replacing only terms «charges» by «cause» and «effect» (third axiom postulates time asymmetry), while in Ref[20] N.A. Kozyrev grounded that transaction occurs through zero interval. In Ref[8] uncertainty of the terms «cause» and «effect» had been removed. Essentiality of the formalism is as follows. For any observables X and Y the independence functions / can be introduced:

S(Y|X) S(X|Y) 0^ ^1 (1)
Л(У) Ь(л)

where *S* denote conditional and marginal Shannon entropies. For example if *Y* is single-valued function of *X* then $i_{YX} = 0$, if *Y* does not depend on *X,* then $i_{YX} = 1$. Roughly saying, the independence functions behave inversely to module of correlation one.

Next, the causality function y is considered:

y = , *0<y<*™. (2)
X\Y

It can define that X is cause and Y is effect if **y** <1. And inversely: Y is cause and X is effect if $y>1$. The case $y=1$ means non-causal relation X and Y (they are related with some common cause).Theoretical and multiple of experimental examples have shown that such formal definition of causality does not contradict its intuitive understanding in obvious situation and can be used in non-obvious ones (e.g.[8 - 10]). Our definition allows formulating all three Kozyrev's axioms in the form of one:

$$y<1\hat{}>t_Y >t_x,x_r\ \boldsymbol{\Phi x_x};$$
$$y>1\hat{}>t_Y <t_x,x_r\ \boldsymbol{\Phi x_x}; \qquad (3)$$
$$_r\hat{}1\hat{}t_Y\ \hat{}t_x,x_T \boldsymbol{->x_x}.$$

Statement (3) is very natural, but it is axiom of strong or local causality. For nonlocal transaction this statement might be invalid due to advanced correlations of the dissipative processes. Indeed any dissipative process [21] is ultimately related to the radiation and therefore to the radiation damping. As a result it can be shown that advanced field connects the dissipative processes [12].

Time asymmetry is expressed as absorption asymmetry. While absorption of retarded field is perfect, absorption of advanced one must be imperfect. Having accepted that total field E is superposition

$$E = AE \quad + BE \quad , \qquad (4)$$

where A and $\boldsymbol{B}$ are constants, and having denoted efficiency of absorption of retarded field by a (a = 1 corresponds to perfect absorption, a = 0 - to absence of absorption), advanced one by b, it is easily to obtain [6], that

$$A = \frac{1-b}{2-a-b}, \quad B = \frac{1-я}{2-a-b}, \qquad (5)$$

Substitution to Eq. (4) A = 1, $\boldsymbol{B}$ = 0 corresponds to really observing situation, that is compatible with Eq. (5) only if a = 1, 0 < # < 1. It should be stressed wide a priori arbitrariness in value b, which may be close as to unit so to zero. Therefore the screening properties of the matter must be in one degree or another attenuated. The fact itself of imperfect absorption of the advanced field means a possibility of its separate detection. From the operational consideration it is possible to formulate the following equation:

$$S = <T\backslash—\boldsymbol{S}\, t^{2} —^{\cdot} \, dV, \qquad (6)$$

s

$2 \quad 2$

$\mathbf{v} \quad v\boldsymbol{J} \ X$

where

$$<5 \frac{\Pi^4}{m_e e} 24, \quad v^2 < \mathbf{c}^2, \qquad (7)$$

S is the entropy production in a probe process (that is detector), *s* is density of entropy production in the sources, **<r** is cross-section of transaction. (The specific dimensionless thermodynamical entropy featuring here and the entropy of levels from Eq. (1) are distinguished by the definition spaces of the probability operator and are easily related within the exfoliated spaces theory [10]). The ^-function shows that transaction progresses with symmetrical retardation and advancement. In particular, if the transaction occurs through a medium by entanglement diffusion, then values of resulting retardation and advancement are large.

3 Experimental Technique

The task of the experiment is to detect the entropy change of the environment according to Eq. (6) under condition that all known kinds of classical local interaction are suppressed. Although any dissipative process may be used as the probe one, its choice is dictated by relative value of effect and theoretical distinctness, allowing to relate the measured macro-parameter (signal) with the left-hand side of Eq. (6) and consciously to take steps on screening and/or control of all possible local noise-factors.

Two experimental setups for study of macroscopic nonlocality had been constructed [11, 14]. In the Geoelectromagnetic Research Institute (GEMRI) setup two types of detectors based on spontaneous potential variations of weakly polarized electrodes in an electrolyte and on spontaneous variations of the dark current of the photomultiplier had been used. In the Center of Applied Physics (CAP) setup ion mobility detector based on spontaneous variations of conductivity fluctuation dispersion in a small electrolyte volume had been used. As in this paper the results mainly with GEMRI setup are considered, we concern only its detectors. Theory of detectors [11,12,18] allows to relate the measured signals with the rate of entropy production in the probe-process. Final formulae in small amplitudes approximation are:

ло 1 |*4*| **л**
До =—*1*=-------- *AU* , (8)
л6 ***кв***

AS =--------- , (9)
<*I* >

where *q* is ion charge, ***в*** is temperature, *U* is measurable variable electrode potential difference, /is measurable photomultiplier dark current.

All known local factors influencing on *U:* temperature, pressure, chemism, illumination, electric field, concentration and movement of the electrolyte must be excluded. Analogously, noise-forming factors influencing on / to be excluded are: temperature, electric and magnetic field, illumination, moisture and feed voltage instability. Design of the detectors provides this exclusion. All technical details about design of the detectors and their parameters are presented in Ref [11, 14, 17, 18].

The GEMRI setup consists of nearby electrode and photomultiplier detectors, another electrode detector spaced at 300 m and apparatus for the local factors control. The CAP setup with ion mobility detector operating under well controlled local conditions is spaced at 40 km from GEMRI one.

It is known that quantum nonlocality violates strong causality and persists weak one [2]. It means, that if a source process is noncontrolled (random), we can observe both retarded and advanced correlations. But if an observer initiates a source-process, only retarded correlation is possible. That is why the most interesting source process are random large-scale natural ones. The experiment described below was devoted to study detectors reaction on various geophysical and astrophysical processes with big random component. The experiments with controlled lab artificial source-processes had also been conducted, though they had, of course, demonstrated only retarded correlation.

4 Data and Processing

The experiments with natural source processes were long-term (with duration of continuous series not less than several months). They were 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, and in 2001-2003 again with GEMRI and CAP setups. Except the detector signals the following parameters were measured: internal detectors temperature (residual variations strongly suppressed by thermostating system) accurate to 0.001 *K*, external (lab) temperature – 0.1 *K*, outdoor (atmospheric) temperature – 0.1 *K* and geomagnetic field – 0.01 *nT*. Sampling rate was chosen from 1^m to 1^h. In addition hourly data on cosmic ray counting rate (as one more reasonable noise-factor) and atmospheric pressure (as index of nonlocal influence of synoptic activity) were taken from nearby IZMIRAN neutron monitor. Standard international data on the global geomagnetic (*Dst* and *Ap* indices) and solar (radio wave flux at 9 standard frequencies within range 245 … 154000 *MHz* and also X-ray flux from GOES satellite) activity were taken to study the most large-scale processes.

Data were processed by the methods of causal, correlational, regressional and spectral analysis. Algorithm of the causal analysis was described in Ref. [8 – 10, 14,18] in detail. The main point is calculation of conditional and marginal probability distributions of detector signals (*X*) and source processes indices (*Y*) by the time series. The *Y* series where taken with enough long "tails" before and after the *X* series ends to provide calculation of the distributions and their entropies in corresponding time shift range. Other processing methods were standard.

5 Relation of the Signals of Different Detectors

So we had long-term measurements with 4 detectors of 3 types. Their signals proved to be rather high and synchronous correlated. For any pairs maximum of correlation function *r* achieves 0.7 – 0.8 at time shift $t = 0$. Mathematical exclusion of single possible common local factor not completely suppressed by screening, namely internal temperature (other non-suppressed local factors – the magnetic field and cosmic rays proved to be not influencing on the detectors within their sensitivity at all) leads to correlation increasing. Therefore there is not any local common cause of the signals. Level of correlation proved to be independent on type of detectors and on their separation within 40 *km.* Such correlation can be explained only in Cramer's spirit [2]: by exchange of the detectors and some large-scale common sources (geophysical or astrophysical processes) by the pairs of retarded and advanced signals, that is to be nonlocal. Due to that correlation we shall consider in the following sections mainly results with the electrode detector, which proved to be the most reliable and with which historically the greatest volume of data was obtained.

6 Correlation of the Detector Signal with the Meteorological Activity

First of all temperature variations of the environment lead to its entropy changes. The problem is complicated by trivial local influence of small residual variations of the internal temperature on the probe process, evoking weak retarded correlation. Thus for the electrode detector retarded correlation equals - 0.33 ± 0.02 at **r** = -20.4 . But in the advanced domain, where correlation must be classically damped out, there is unusual big correlation maximum 0.87 ± 0.01 at **r** = 12.8 . Just at the same time shifts there are two minima of the independence functions. The advanced minimum is much deeper. Analysis of connection between the detector signal and external lab temperature has shown three maxima of correlation (minima of independence) at shifts 0 and ± 27 . The advanced minimum proved to be deepest and therefore could not be explained by any periodic effect. It corresponds to theoretical prediction: we observe symmetrical retardation and advancement, the advanced signal is stronger due to less absorption by the intermediate medium. Availability of the apparent synchronous signal can be explained by interference of the retarded and advanced signals.

Analysis of influence of the synoptic activity has also shown prevalence advanced correlation over retarded one. Level of correlation and value of advancement proved to be directly related with space scale of the process. Thus as qualitative index of synoptic activity simply atmospheric temperature can be taken (typical space scale is a few hundred *km).* In this case symmetrical by time shift advanced and retarded correlations have been revealed and level of advanced correlations are about twice as much retarded ones. Maximum of correlation (0.73 ± 0.01) is observed at advancement 13 days (Fig. 1). If the atmospheric pressure is taken as the index (space scale is a few thousand *km)* correlation pike achieves - 0.86 ± 0.01 at advancement 73 days. The same results are in terms of the independence and causality function. The latter achieves 2.3, that means synoptic activity is a cause of the detector signal but the progress in reverse time! This result is independent on type of detector [11].

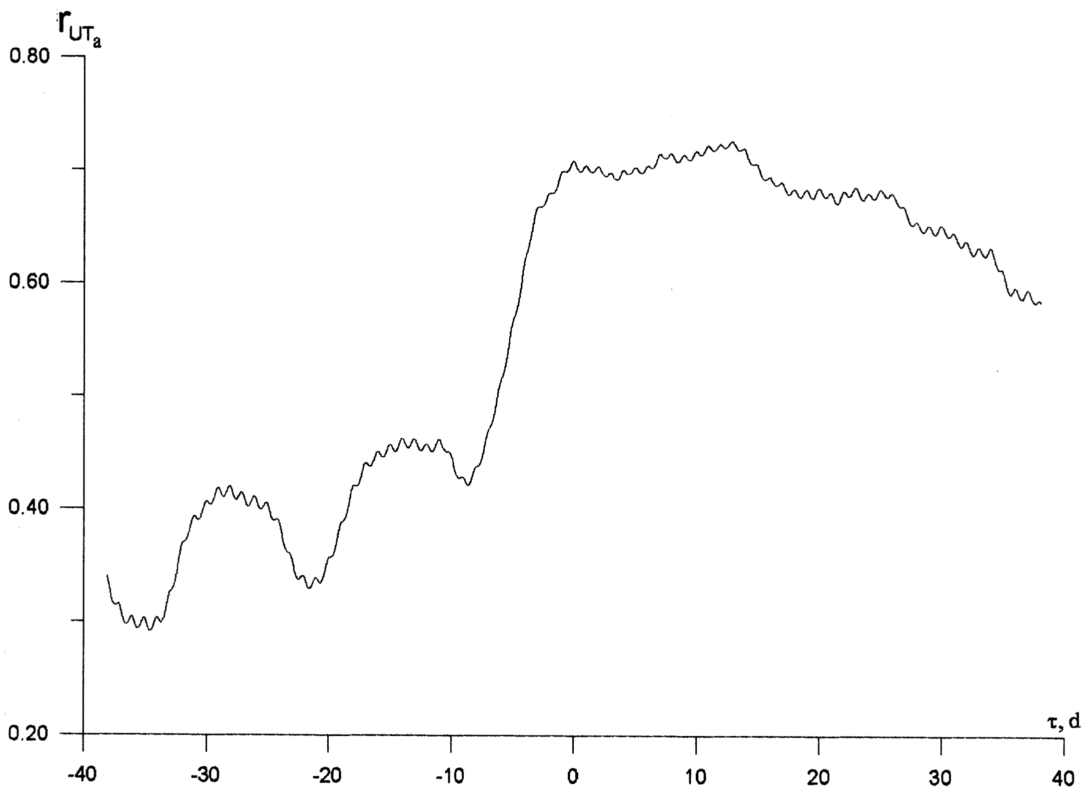

Figure 1. Correlation function of the detector signal U and atmospheric temperature T_a r_{UTa}. The t is time shift of T_a relative to U in days (negative t corresponds to retardation of U relative to T_a , positive t – to advancement).

7 Correlation of the Detector Signal with the Solar and Geomagnetic Activity

The solar activity proved to be the most powerful dissipative process acting on detectors. It should be stressed that detectors are insensitive to the solar radio waves, their flux is only index of the source entropy production.The detector signals proved to be most correlated with the solar radio wave flux in the frequency range 610…2800 *MHz*, corresponding to emission from the upper chromosphere – lower corona level, that is just from the level of maximal dissipation the magneto-sound waves energy. The optimal frequency may change within the mentioned range in different years. The process of geomagnetic activity is an effect of the solar one and it is weaker, but convenient for quantitative interpretation (Sec. 9). The variable magnetic field is index of electric current dissipation in its source, that is magnetosphere (while the detectors are insensitive to the local variable geomagnetic field). The amplitude spectra of solar radio wave flux R at the optimal frequency 610 *MHz* (R_{610}), *Dst*-index of geomagnetic activity and detector signal U are shown in Fig. 2. All the spectra have two main maxima at period of solar rotation and its second harmonic. The spectrum of the detector signal is obviously more similar to the solar than to geomagnetic activity. It is a consequence of direct influence of the solar activity on the probe process.

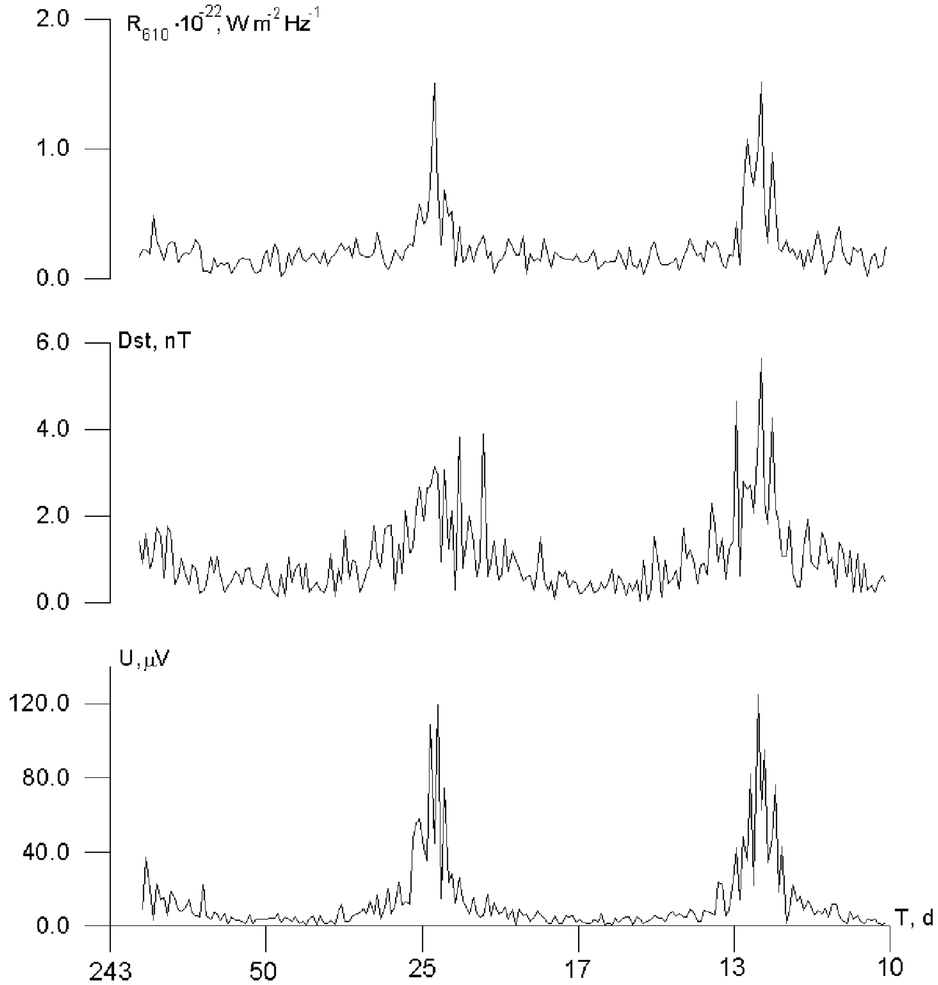

Figure 2. Amplitude spectra of the solar activity R_{610}, geomagnetic one *Dst* and *U* in the period range *T* from 10 days to 274 days.

For the analysis of the anticipatory effects the periodic components were suppressed by filtration and we consider further only the random component. The qualitative results are the same as in Sec. 6: advanced correlations exceed retarded ones and level of correlation increases along source space scale.

Thus for magnetic field measured by setup's magnetometer advancement equals 2 days [11, 14, 17, 18], while for *Dst*-index of global geomagnetic activity, reflecting the most large-scale magnetosphere current systems it equals about month (it is not stable value; for different realizations and for different period range position τ of the main pike of γ, *i* or *r* may be from 8^d to 140^d [11, 12, 15, 16]). Value of maximal, i.e. advanced, γ does not exceed 1.15 (expectation errors of *i* and γ are about 1%). The level of advanced correlation with *Dst* after appropriate filtration, increasing signal/noise ratio (the noise includes direct influence of the Sun on the detector signal), can achieve 0.70– 0.95. Herewith correlation time asymmetry (defined as *max* $|r^{adv}|$ / *max* $|r^{ret}|$) in the shift $t$range ± 371^d are within from 1.10 ± 0.01 to 2.64 ±0.01 [12, 15]. Typical example of correlation function showing advanced detector response at t = 42^d is presented in Fig. 3.

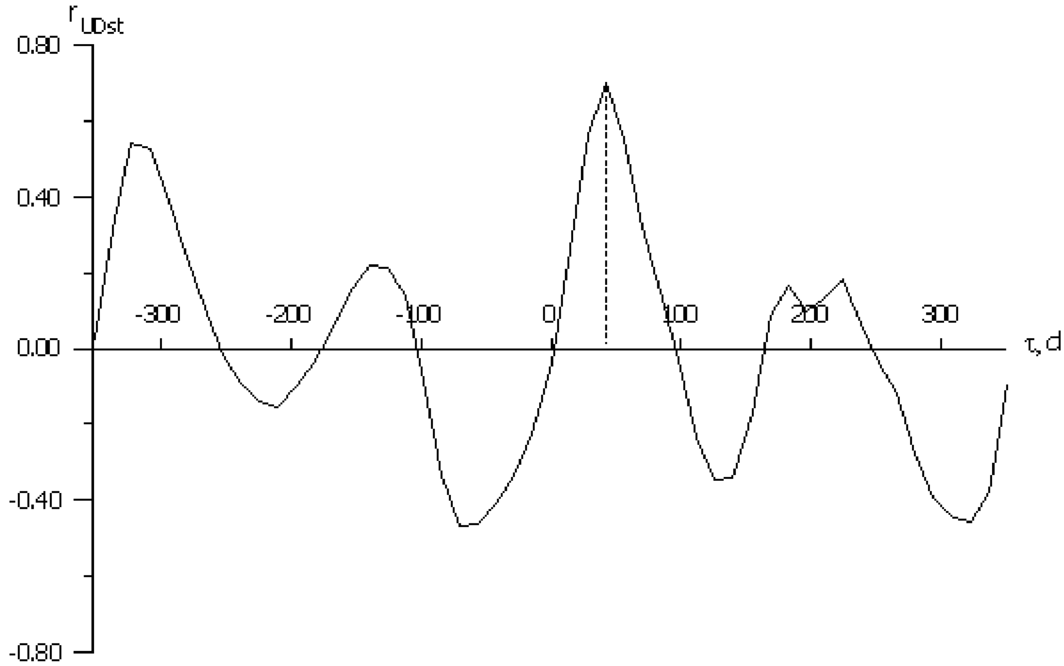

Figure 3. Correlation function of the detector signal *U* and geomagnetic activity *Dst* by data filtered in period range 364 > *T* > 28 days.

The results of causal analysis of the detector signals and solar activity *R* have shown that in the advanced domain (t >0) values of the independence function are much less and ones of causality function are much more than in the retarded domain (t<0), position $t$of the main pike of g, *i* or *r* may be from 42^d to 280^d. Value of maximal, i.e. advanced, $g$amounts up to 1.58, while *r* ranges into 0.50 – 0.92 (and relation with *R* is explicitly nonlinear). Big t- interval corresponding to significant g >1 is explained by big volume of the solar atmosphere occupied by the source processes with diffusion propagation [16]. An example of correlation function, corresponding advanced detector response at t = 42^d is presented in Fig. 4. This is result of computation by the same time series of *U* as for Fig. 3 (without suppressing the annual period which is associated with the determined component for *Dst*). For the given time series retardation of *Dst* relative to R_{610} turned out small in our scale, therefore t = 42^d in the both cases.

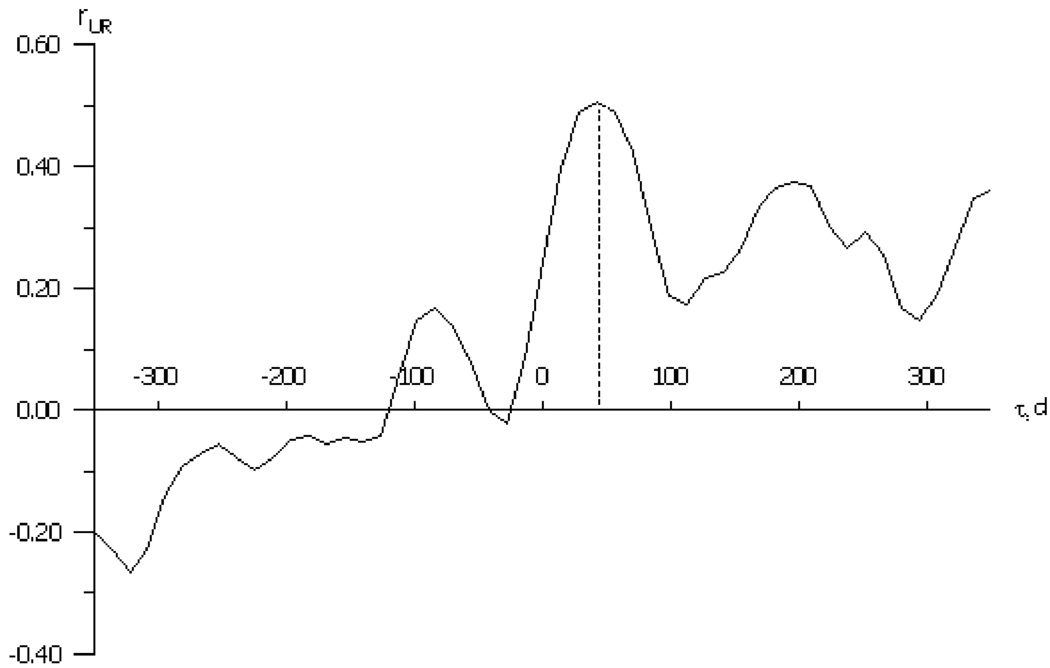

Figure 4. Correlation function r_{UR} of the detector signal U and solar activity R_{610} by low-pass filtered data $T > 28$ days.

8 Bell-type Inequality Violation

Suppose a process Z can influence on X only through Y along the local causal chain: Z —> Y —> X. There is Bell-type sufficient condition of locality of Z - X connection [11, 14, 15, 18,]:

$$/_{\mathbf{x}|\mathbf{z}} > \max(/_{\mathbf{x}|7}, /_{7|\mathbf{z}}). \qquad (10)$$

Sense of Ineq. (10) is simple: connection between the origin and end of the chain can not be stronger than in the weakest of two intermediate links. In our case Z and Y are some source processes, while X is a probe process measured by the detector signal. We had opportunity to test Ineq. (10) in such a way that connection in Z - Y was known to be local (and certainly only retarded).

In the first variant we used the random temperature variations (of external origin as there were no any heat sources inside of the detector dewar. Thus Z was external (lab) temperature and Y was internal one. For the advanced connections Z with X and Y Ineq. (10) was reliably violated, for symmetrical retarded ones was not (due to classical interaction) [11, 14, 18].

In the second variant we used the random variations of solar ($Z = R$) and geomagnetic *($Y = Dsi$)* activities. Retarded connection with X in this case was insignificant. For corresponding advanced connections Ineq. (10) was also reliably violated [15].

Consider this matter again by the most recent experiment, namely data of continuous measurements with the electrode detector of GEMRI setup. As compared with the previous experiments, the system of its temperature stabilization was improved and thus signal/noise ratio was magnified. Duration of time series was 1 year (10/19/2002 - 10/18/2003). The detector signal (potential difference) f/was measured accurate to 0.5 *JUV* with data sampling 1 hour. As solar activity data we took daily solar radio flux *R* at optimal for the given case frequency 1415 *MHz* and two adjacent ones: 610 and 2800 *MHz*. Time series was taken for about 3 years (beginning 371 days before and finishing 371 days after the ends of *U* series). As geomagnetic activity data we took international hourly *Dst-index* for the same time as *R*. For correlation with *R, U,* and *Dst* data were previously daily averaged.

We have been considering problem of detection of advanced correlation in more distilled performance (so did it in Ref [18, 19]). The matter of fact is, advanced correlation is physical property only the random processes. If the determined, that is in given case periodic, components of variations are not suppressed, then advanced cross-correlation could be amplified by auto-correlation. It would be useful in forecasting practice, but here we are going to investigate namely advanced cross-correlation. Therefore we have to suppress the periodic components with care. The main periodicity in *R* (having a response in £/[16]) is synodic solar rotation period. In addition, a lot of geophysical processes have annual period, including its second harmonic. For these reasons *U* and *R* data were wide-band filtered in the period range 183 >i>28 . (For *Dst* because of splitting of the spectral line corresponding to the solar rotation period, optimal lower bound of the wide-band filtration was more: 32^d [12]).

After this filtration the correlation function r_{UR} was calculated in the time shift range 371 ($T<0$ corresponds to retarded correlation r^{ret}, $T > 0$ - advanced one r^{adv}).

Correlation time asymmetry $\max |r_{UR}^{adv}| / \max |r_{UR}^{ret}| = 1.18 \pm 0.06$, that is quite reliable.

Maximal correlation $r_{UR}^{adv} = 0.92 \pm 0.03$ is at advancement $T = 130^d$. At the adjacent frequencies the main maximum is also at $T = 130$, but level of correlation is slightly less: for 610 *MHz* r_{UR} =0.88 ± 0.04 and for 2800 *MHz* r_{UR} =0.90 ± 0.03. T hat is the frequency 1415 *MHz* is optimal.

But the solar activity excites much more close (to the detector) the process of geomagnetic activity and it is legitimately to speculate that latter is direct cause of t/variation. The main extremum of correlation is almost at the same time shift (about 10 more for the given case), but it is weaker: $r_{UDst}^{adV} = -0.87 \pm 0.04$. Correlation time asymmetry is also weaker: $\max | r_{UDst}^{adV} | / \max | r_{UDst}^{ret} | = 1.11 \pm 0.06$. On the other hand, though the *Dst*-variations are excited just by solar activity, due to complexity of their relation, their correlation (negative by nature of Lto-index) is rather weak. For given series *Dst* and *R* at 1415 *MHz* the main extremum $r_{DstR} = -0.38 \pm 0.07$ is observed at $T = -10$ *(Dst* is retarded relative to *R)*.

Thus we have 7^=0.92 ± 0.03, r_{UDst} = -0.87 ± 0.04 (both advanced) and *rDstR* = -0.38 ± 0.07 (retarded). Such relationship suggests that connection of *U* and *R* is direct, i.e. nonlocal. But all three links might be nonlinear. Indeed nonlinearity of (classical local) $R - Dst$ link is well known, as well as $Dst - U$ (Sec. 9) and $R - U$ [11, 14, 16]. But independence functions are equally fit for linear or any nonlinear type of dependence and we let $Z = R$, $Y = Dst$ and $X = U$. The fulfillment of Ineq.(10) is sufficient condition for locality of connection along the causal chain $R \rightarrow Dst \rightarrow U$ (since any local solar influence on the detector can not come avoiding the magnetosphere that is source of Dst variations). All three independence functions of Ineq. (10) were calculated with mentioned above time shifts. For estimation of their stability all three serieses were alternately noised by 21% (by power) flicker-noise [14].

The results are: $i_{U|R} = 0.46^{+0.01}_{-0.02}$, $i_{U|Dst} = 0.51^{+0.00}_{-0.02}$, $i_{Dst|R} = 0.83^{+0.00}_{-0.02}$. Ineq. (10) is reliably violated, therefore connection $R \rightarrow U$ is nonlocal. Even choice of optimal frequency of R 1415 MHz is not crucial: for 610 MHz $i_{U|R} = 0.50^{+0.03}_{=0.01}$, for 2800 MHz $i_{U|R} = 0.49^{+0.02}_{-0.01}$, Ineq.(10) is violated, though slightly less.

9 Quantitative Interpretation

Taking into account complexity and, as a rule, poor knowledge of large-scale natural source-processes parameters, it is extremely difficult to verify theoretically values of time shifts by the detector signal and standard geophysical data. But it is possible to hope on order estimation of s in Eq. (6), i.e. on verification of effect magnitude. The process of geomagnetic activity is the most convenient, because it admits to use in the right-hand site of Eq. (6) the simplest model for the source entropy production density:

$$s\& = \frac{<E^2(f)>}{rkq} = \frac{|Z(f)|^2<F^2(f)>}{rkq}, \qquad (11)$$

where E is electric field, f is frequency, r is medium resistivity, q is medium temperature, Z is impedance, F is magnetic field. The Z and r we may consider for simplicity as scalars. By substituting Eq. (11) into Eq. (6) further simplification is possible, using the known properties of the electromagnetic field of the magnetospheric source. First, the field F is well approximated by plane wave, therefore it is possible to factor out the $s\&$ from the integral, and, restricting our consideration to the spectral amplitudes, we reduces this integral simply to thickness of dynamo-layer. Second, use quasi-steady-state approximation of the plane wave impedance of homogenous medium: $| Z(f) |^2 = 2pfm_0r$ .Dependence on r disappears, and for spectral amplitudes it is easily to show [11, 14, 17, 18] that following ratio is frequency-independent:

$$\frac{U(f)}{77^2 (/) \; / r} = const \qquad (12)$$

and analogously for / *(f).* Of course, Eqs. type of (12) are approximated, because above simplest expression for |*Z (j)*| is rather rough approximation.

But the geomagnetic activity, as a separate source process, has a flaw - it is close correlated with solar activity especially at long periods $T > 27$ days. On the other hand, short periods (and correspondingly small space scales) $T < 1$ day do not cause enough strong detector reaction. It holds significance also choice of an index of geomagnetic activity. As it had been shown in the previous studies the most effective was to correlate the detector signals not with the magnetic field measured at the setup site (although it was possible [11, 14, 17, 18]), but with Lto-index of global geomagnetic activity, which corresponded to the most large scale electric current system in the magnetosphere [11, 14 - 16]. *Dst-index* due to procedure of its calculation is most representative at $T > 2$ days. *F* or these reasons the spectral window 20 > ***1*** > *2* was selected for analysis.

However in that window nonlocal interference from the synoptic activity is just possible. Therefore it is a need to select for analysis enough long time segment with quiet weather condition. That is why in the all previous studies we succeeded in estimation of <7only in one case [18]. It was estimation by electrode detector and setup's quantum magnetometer data: <***J*** ~ *2* • 10" *m* . The last reference also indicates the desirability to estimate <7 by data of different detectors, because every of them may be noised in different manner.

Close examination of recent data has shown that the most appropriate data segment turns out series 07/14/2003 - 10/27/2003. Amplitude spectra of/ and *Dst* are rather similar [12]: many of individual pikes coincide (at periods 450, 371, 321, 135, 92.2, 79.9, 72.9, 61.8, 59.4, 55.8 and 49.5 hours). Pike-to-pike variation coefficient (ratio of the standard deviation to the mean) for *1/Dst* equals 0.12, while for ***1*** */Dst* it equals 0.31, that confirms approximate validity of equation type of Eq. (12).

For ***a*** estimation we combine Eqs. (6) in plane wave approximation, (9) and (11). In this approximation the source is characterized by two parameters: thickness of dynamo-layer *h* and temperature ***в****,* for which we take well known $h \sim 1.3\ 10^{6}\ m$ and $в \sim 1310^{3} K$. Then for realization/we obtain the average estimation ***a*** ~ 5 $10\sim^{20}$да^2.

Realization of *U* synchronous to / proved to be noisier, that probably shifts the estimation up. But using Eq. (8) instead of (9) we obtained in the same spectral window close average estimation ***a*** ~ 8 • $10\sim^{20} m^2$.

In view of the fact that accepted model of the complex source of the variable geomagnetic field is extremely approximated and separation of the useful signal from interference is poor, coincidence of above estimations with theoretical one (about 10 **да** by Eq. (7)) may be thought as satisfactory. Thus transaction cross-section is of order of an atom one.

10 Forecasting Applications

Availability of essential advanced detector response on natural large-scale dissipative processes gives sense attempt of performance of the forecast problem. As it is seen in Figs.1, 3, 4 relation of the probe and source processes is far from 8-correlated (the domain of advanced dependence is spread in wide t range). Therefore forecast algorithm must be based on plural (perhaps, nonlinear) regression – one forecasted value is calculated as convolution of impulse transition characteristic with multitude of the preceding detector signal values. In addition, the problem of optimal filtration, suppressing interference from nonlocal influence of other natural processes must be previously solved. Elaboration of such algorithm is complicated though quite standard task. For the present we will confine ourselves by wittingly primitive simplest demonstration of the forecast possibility by the example of geomagnetic activity. We select the highest observed correlation pike of optimal filtered time series (Fig 3) and shift them on corresponding t.

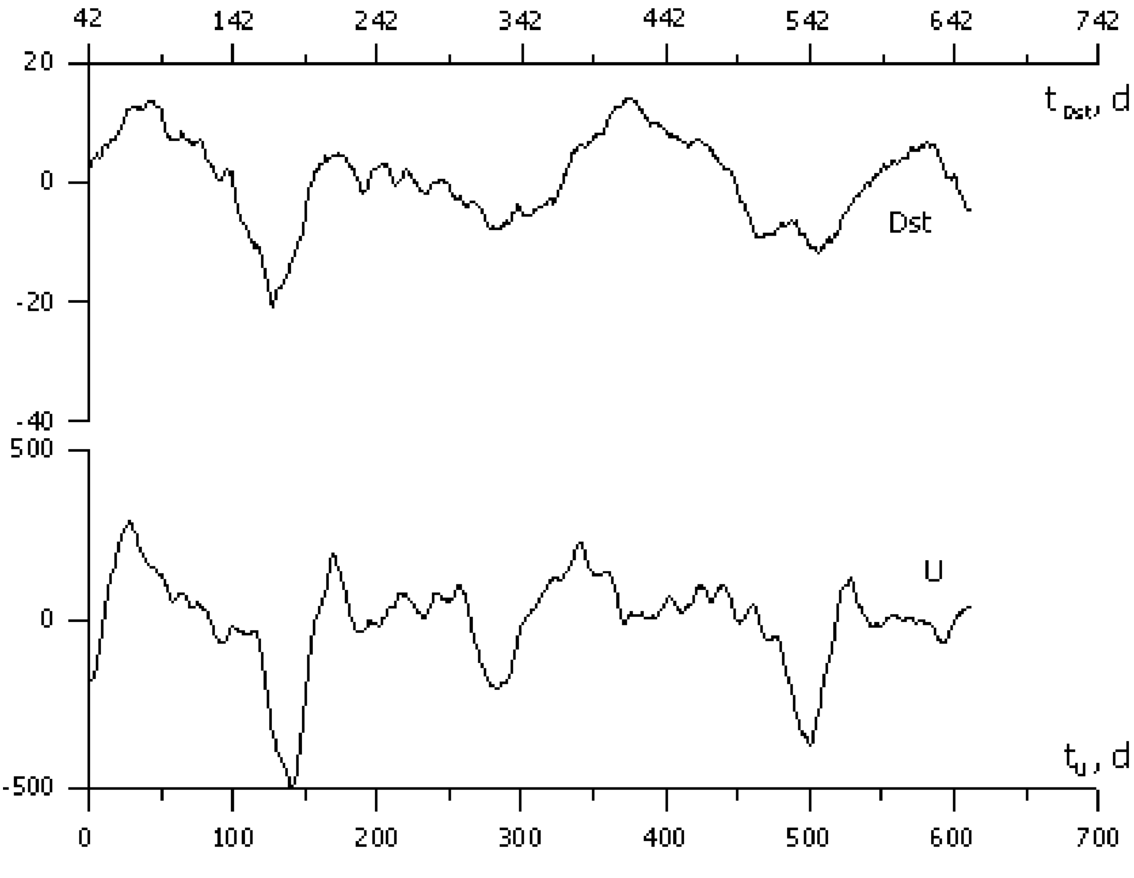

Figure 5. The detector signal *U*(*mV*) forecasts the random component of geomagnetic activity *Dst* (*nT)* with advancement 42 days. The origin of time count corresponds 5/10/1995.

In Ref. [11 – 14 ,16] the number of examples of the solar (advancement 42 – 130. days), synoptic (advancement 73 days) and other geomagnetic (advancement 33 – 130 days) forecasts are presented.

The showed in Fig. 5 and cited forecasts are background statistical ones. As for some individual events, our experience had shown that detector responded only to the most powerful of them, such as solar flares of *X*-class [15]. Visible detector signal is very smooth usually. But sometimes, e.g. at the beginning of 2003 extremely sharp splashes (with duration of order of hour) were observed in the detector signal. The biggest splash (134 ± 0.5 μV) was on February 3. And just 42 days after, the famous solar flare on March, 17 happened. It was seldom, gigantic flare of class *X*. In such a manner this powerful solar event caused advanced response of the electrode detector. Moreover splash shapes of the self-potentials and solar *X* – rays one [15] 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, i.e. nonlocal.

11 Conclusion

The long-term experiments have confirmed existence of nonlocal transaction of some large-scale dissipative processes. The most prominent property of this phenomenon is transaction in reverse time. It gives the possibility of observation of the future noncontrolled by an observer.

This conclusion is consequence of the experimentally verified fact, that nonlocal correlation not only violates Bell-type inequality, but also strong causality. It has been demonstrated by the successful forecast of random component of geomagnetic activity.

Of course, presented theoretical approach was essentially heuristic and the model might be naive approximation of reality. Therefore development of the theory at crossing of quantum nonlocality, action-a-distance electrodynamics and causal mechanics is burning. Nevertheless the effect of macroscopic nonlocality can be utilized for forecasting and anticipatory purposes at present level of knowledge yet.

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