# GEOPHYSICAL MANIFESTATION OF INTERACTION OF THE PROCESSES THROUGH THE ACTIVE PROPERTIES OF TIME

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**Abstract**

**The experiment on verification of existence of new type of physical interaction suggested by N.A.Kozyrev was performed. The experimental setup included two types of detectors measuring the self-potentials of the electrodes in marine water and the dark current of the photomultiplier. Both detectors were protected of known sources of classical effects. Natural time variations of the potentials and the dark currents were recorded in period range 1 minute - 1 year. Number of new effects was discovered: correlation of the potentials with the dark current and the potential on another distant setup; advanced reaction of the potentials on the Earth magnetic field; nonlocal reaction of the potentials on the environmental temperature with retarded, instantaneous and advanced lag; relation the of potentials with the sudden ionospheric disturbances. Interpretation of this effects on the base of developed Kozyrev's idea on the active properties of time is rather successful.**

## 1. Introduction

During the last decades much evidence on interaction of the dissipative processes, which can not be come to electromagnetic or gravitational ones were collected in geophysical and astrophysical observations as well as in laboratory experiments (e.g. relationship between the velocity of some physical-chemical reactions and the solar activity). Kozyrev (1971) suggested concept of the active properties of time originated from accepting of its fundamental asymmetry. This concept was based on theoretical grounds and number of original experiments. The main consequence is existence of a new type of physical interaction between any dissipative processes. But there was rather negative reaction on Kozyrev`s hypothesis in due time because of weekly formalised theory and doubt of cleanness of experiments. Recently the situation has changed. Basic statements of concept of active time have been strictly formulated (Korotaev, 1993). Some geophysical phenomena, e.g. asymmetry of the Earth figure, structure and distribution of physical fields have been quantitative explained on the base of development of Kozyrev`s theory (Arushanov et al., 1996). Kozyrev`s experiments have been successfully reproduced by Savage (1985, 1986, 1987) and Lavrentyev et al. (1990a, 1990b, 1991, 1992), though doubt of their cleanness have remained. On the other hand Home et al. (1995) suggested theoretical reasons on preservations of the effect of quantum nonlocality in the strong macroscopic limit and though an idea of experimental verification had not been proposed, the properties of the possible macroscopic nonlocality must be very similar to Kozyrev`s interaction. Our work aims performance of experiment which firstly would verify a strictly formulated hypothesis and secondly would fulfil on the modern level of cleanness.

## 2. Formulation of the hypothesis

Generalisation of previous results of development of active time concept might be formulated in the following statements.

(1) A new type of interaction between the dissipative processes of any nature exists.

(2) This interaction transmit the energy, the rotational moment, but not the momentum.

(3) The energy of interaction directly related with the entropy production and inversely related with the squared distance.

(4) The interaction is screened by the matter, but the screening properties of the matter does not coincide with such properties for the electromagnetic field.

(5) The interaction can have positive, zero and symmetrical negative time lag.

With the exception of the dissipativity one can see similarity with the quantum nonlocality. But the dissipativity may be included by interpretation of the nonlocality within Wheeler-Feynman absorber theory of radiation (Cramer, 1980). This theory considers the electromagnetic field as superposition of retarded and advanced parts. The last one is unobservable due to specific interference and manifested only through the radiation damping which is dissipative process. Therefore advanced field connects dissipative processes. Moreover according to the modern treatment of the absorber theory (Hoyl et al. 1995) the efficiency of absorption of the advanced field must be imperfect (Statement (4)). It means the possibility of detection of the advanced field (Statement (5)).

From above operational consideration it is possible to formulate the following hypothesis:

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

where $\dot{S}_d$ is the thermodynamical entropy production in the absorber (detector), $\dot{s}$ is density of the entropy production in the sources, $\sigma$ is cross-section of the interaction, $x$ is distance, $t$ is time, velocity $v$ is bounded by $v^2 \le c^2$, the integral takes over infinite volume $V$.

## 3. Statement of the experimental problem

The task of the experiment is the detection of connection of the entropy change in some testing process with the entropy change of the environmental medium according to Eq. (1) under condition of all known kinds of the classical local interactions. Although any dissipative process may be used as the detector, not the entropy, but one or other circumstational connected with it observable is measured. Therefore choice of the detector type is resolved from the expected value of the relative effect. Two types of the detectors had been chosen by this criterion. The first was based on measurements of self-potentials of the weekly-polarised electrodes in marine water, the second was based on measurements of dark current of the photomultiplier. As the experiment implied, the first type turned out much more appropriate, therefore consider its work in great detail.

Self-consistent solution for the potential $u$ in the liquid phase is (Korotaev, 1979):

$$u = \frac{2kT}{q} lncos\left(x\, arccos\, exp\frac{q\zeta}{2kT}\right), \qquad (2)$$

where $q$ is charge of the main ion of the liquid phase, $x$ is dimentionless length ($x$=1 corresponds to half of the distance between the electrodes), $\zeta$ is full (electrokinetic) potential. The entropy $S$ can be expressed in term of the normalised potential $\varphi$:

$$\varphi = \frac{u}{\int_0^1 udx} \qquad (3)$$

$$S = -\int_0^1 \varphi ln\varphi dx \qquad (4)$$

Substituting Eq. (2) to Eq. (3) and (4), after number of transformations one can obtain the linearized expression for the entropy production:

$$\dot{S} \approx -\frac{1}{\sqrt{6}} \frac{|q|}{kT} \dot{\zeta} \qquad (5)$$

All known local factors influencing on $\zeta$: temperature, pressure, chemism, illumination, electric field etc. must be excluded or stabilised. In fact, only difference $U=\zeta_1-\zeta_2$ of pair of the electrodes can be measured. Let $\zeta_i$ ($i$=1,2) can be decomposed into constant $\zeta_i^c$, variable multiplicative $g_i \zeta_i^c$ and variable additive $\delta\zeta_i$ portions:

$$U = \left(\zeta_1^c + g_1\zeta_1^c + \delta\zeta_1\right) - \left(\zeta_2^c + g_2\zeta_2^c + \delta\zeta_2\right)$$

Except external screening, influence of mentioned above noise-forming factors might be minimised by measuring $U$ on minimal electrode space separation. In this case $\delta\zeta_1=\delta\zeta_2$, $g_1=g_2=g$ and therefore:

$$U = g\left(\zeta_1^c - \zeta_2^c\right), \qquad (6)$$

where $g$ is efficiency of the detector, the averaged measure of which is the variability coefficient.

For the detector based on the photomultiplier analogue $U$ is work function. Noise-forming factors to be excluding or control are: temperature, electric and magnetic fields, illumination, moisture, feed voltage unstability.

## 4. Experimental setup

The experimental setup included two types of detectors and apparatus for accompanying measurements.

The detector based on weekly-polarised electrodes was constructed as follows. As the electrodes marine geophysical C-Mn ones were chosen. The electrodes were positioned in the glass vessel with marine water, space separation between contact windows measured 1.5 cm. The vessel was rigidly encapsulated so that evaporation as well as atmospheric pressure variations were fully eliminated. The vessel was positioned in the dewar, covered on the outside by the additional layers of light and heat insulation. For remained temperature variations control the sensor of temperature (allowing to measure it continuously accurate to 0.001 $K$ ) was positioned between internal wall of the of the dewar and the electrode vessel. Thus influence of all noise-forming factors, except temperature, was eliminated. Influence variation of the last was minimised and controlled. The quantity $U$ was measured continuously accurate to 0.5 $\mu V$.

The second type detector was constructed on the base of photomultiplier with the Cb-Cs cathode of small area. The photomultiplier was positioned in the similar dewar with the temperature sensor and the additional external electric field screen. Possible magnetic field influence was controlled by quantum modulus magnetometer accurate to 0.01 $nT$. The dark current $I$ was measured continuously accurate to 0.05 $nA$.

Magnetic field measurement served also as indicator of the most important geophysical process – dissipation of ionospheric electric current. Lastly, the overall air temperature in the lab was recorded continuously accurate to 0.1 $K$. Thus measurements on the setup included 2 major channels and 4 satellite ones.

Accidentally during the part of period of our experiment and absolutely independently, similar measurements of electrodes self-potentials in other purposes were conducted by V.I. Nalivayko, bindly presented us his data. His setup did not provide measurements of the noise-forming factors and protection against them. Nonetheless, if a signal associated with the geophysical processes in *U* variations is sufficiently strong then, taking into account relatively small distance between the labs (300 m), it would have hoped on correlation of data. That is why V.I. Nalivayko` s measurements were included as 7-th channel in set of processing data.

## 5. The execution of experiment and data processing

The measurements carried out in continuous regime from 1996, December, 10 till 1997, December, 11.

Data were processed by the methods of causal, correlational, regressional and spectral analysis.

The first should be particularly mentioned because of its adequacy to modern treatment of theoretical foundation of active time concept (Korotaev, 1993). The method in essence is this. For the observables *X* and *Y* through conditional and unconditional Shannon` s entropies*H* the independence functions are introduced:

$$i_{Y|X} = \frac{H(Y|X)}{H(Y)},\ i_{X|Y} = \frac{H(X|Y)}{H(X)},\ 0 \le i \le 1, \qquad (7)$$

where: $H(X) = -\sum_{j=1}^{J} P(X_j) \ln P(X_j)$,

$H(Y) = -\sum_{k=1}^{K} P(Y_k) \ln P(Y_k)$, $P(X_j)$ and $P(Y_k)$ are probabilities of *j*-th (*k*-th) level of *X* and *Y* respectively,

$$H(Y|X) = -\sum_{j=1}^{J} P(X_j) \sum_{k=1}^{K} P(Y_k|X_j) \ln P(Y_k|X_j),$$

$$H(X|Y) = -\sum_{k=1}^{K} P(Y_k) \sum_{j=1}^{J} P(X_j|Y_k) \ln P(X_j|Y_k).$$

For example, if *Y* is one-valued function of *X* then $i_{Y|X}$=0, if *Y* does not depend on *X* then $i_{Y|X}$=1. Next the causality function is considered:

$$\gamma = \frac{i_{Y|X}}{i_{X|Y}},\ 0 \le \gamma < \infty. \qquad (8)$$

and it definited that cause *X* and effect *Y* called observables for which $\gamma$<1. If $\gamma$<1 then *Y* is effect, *X* is cause. The case $\gamma$=1 means adiabatic (non-causal) relation *X* and *Y*. On theoretical and multiplicity of experimental examples (e.g. Korotaev et al., 1993, Korotaev, 1995) it has been shown that such formal definition of causality does not contradict intuitive understanding of causality in obvious situations and can be used in unobvious ones. The method had also been generalised on three or more variables (Korotaev et al., 1992).

## 6. Results of experiment and their interpretation

### 6.1. Relation of the potentials on the remote setups

Above all it has a meaning to compare our measurements *U* with ones on remoted (300 m) setup $U_r$. It immediately allows to establish, are not variations of these quantities merely internal noises. Correlation coefficient turned out equal to 0.68 ± 0.01. It is possible only one common trivial cause – the internal temperature. Partial correlation coefficient by eliminating influence of the internal temperature $T_U$ of the detector *U* turned out equal to 0,74±0,01. Therefore local influence of the temperature is not a common cause of correlated potential variations. It remains to consider such common cause nontrivial influence of the external geophysical processes.

### 6.2. Relation of the potentials with the internal and external temperatures

Due to passive thermostating dispersion of internal temperature $T_U$ of air in the dewar of detector *U* is very small (it is decreased on two orders relative to one of external (lab) temperature $T_e$). Indeed, there is small correlation pike $r_{UT_U}$ =-0.33 ±0.02 (corresponding to normal negative temperature coefficient of the electrodes -141±9 $\mu V/K$) which is accompanying by minimal $i_{U|T_U} = 0.50^{+0.02}_{-0.01}$, $g = i_{U|T_U} / i_{T_U|U} = 0{,}97^{+0.01}_{-0.01}$ at the time shift $t$ = -20.4$^h$ (negative sign of $\tau$ corresponds to retardation $U$ relative to $T_U$). But at the positive time shift $\tau$=11.2$^h$ there is great correlation pike $r$=0.87±0.01 (anomaly positive sign) which is accompanying by minimum $i_{U|T_U} = 0.43^{+0.01}_{-0.00}$, $\gamma$= 1.08$^{+0.01}_{-0.00}$. Thus except normal causal relation $T_U \to U$, there is more strong anomaly unversed relation $U \to T_U$, therewith in both cases the effect is retarded relative to the cause.

Turn now to analysis of connection $U$ with the external temperature $T_e$. As there is not heat sources inside of the dewar, where $T_U$ is measuring, then local connection of potential variations with temperature engages along the causal chain $T_e \to T_U \to U$. It imposes the restrictions on independences (Korotaev et al. 1992):

$$i_{U|T_e} \geq max\left(i_{T_U|T_e}, i_{U|T_U}\right), \; i_{T_e|U} \geq max\left(i_{T_e|T_U}, \; i_{T_U|U}\right) \quad (9)$$

Violation of Ineq. (9) is sufficient evidence of nonlocality of interaction $T_e$ and $U$. It has turned out that $i(\tau)$ has 3 almost symmetrical minima at $\tau$=0 and ± 27.0$^h$. It corresponds qualitatively results of known astrophysical experiment (Kozyrev, 1980). Asymmetry amounts to more strong connection of advanced interaction as compared to retarded one: at $\tau$=-27.0$^h$ $i_{U|T_e} = 0.81^{+0.07}_{-0.00}, i_{T_e|U} = 0.77^{+0.10}_{-0.00}$; at $\tau$=0 $i_{U|T_e} = 0.77^{+0.10}_{-0.00}, i_{T_e|U} = 0.72^{+0.13}_{-0.00}$; at $\tau$=27.0$^h$ $i_{U|T_e} = 0.75^{+0.11}_{-0.00}, i_{T_e|U} = 0.71^{+0.12}_{-0.00}$. Therewith independences of $T_U$ and $T_e$ have only single normal minimum: at $t$ = -11.5$^h$ $i_{T_U|T_e} = 0.77^{+0.03}_{-0.00}, i_{T_e|T_U} = 0{,}84^{+0.05}_{-0.00}$, i.e. $T_e \to T_U$. Substituting these and mentioned above values of independences $T_U$ and $U$ we concluded that there are two channels of connection $T_e$ and $U$: classical local retarded and unusual nonlocal advanced. For the former at $\tau$<0 left Ineq. (9) is asserted, for the last at $\tau$>0 right Ineq. (9) is reliably violated.

Thus existence of nonlocal advanced interaction has experimentally confirmed. Availability of zero time lag may

Fig.1 Correlation function of potentials $U$ and magnetic field $B$

be explained by interference of retarded and advanced signals (Cramer, 1980). But it is difficult quantitatively to transfer from $T_e$ to the entropy. Study of the Earth electromagnetic field is more convenient in this sense.

## 6.3. Relation of the potentials with variations of the Earth magnetic field

It is beyond reason to consider $U$ depended on magnetic field $B$ by any way. Therefore detection of relation of the potential with the Earth magnetic field variations would be a good test for the hypothesis (1), as these variations could be easy related with electric current dissipation in the source (ionosphere). Special experiments on influence on the detector of $U$ by artificial magnetic field (up to $10^{-3}$ $T$) in frequency range from 0 to 1 Hz had confirmed absence of any reaction of $U$ within sensitivity of the apparatus.

Analysis of long time series have shown existence of stable correlation $r_{UB}$= -0.56±0.01 with great advancement $U$ relative to $B$ ($\tau$=48.0$^h$) (Fig.1). In the causal analysis at this $\tau$ there is minimum $i_{B|U}$=0.79$^{+0.02}_{-0.01}$ ($\gamma = i_{U|B}/i_{B|U}$= =1.03$^{+0.01}_{-0.01}$). Thus relation $U$ and $B$ is statistically reliable, but both from prior reasons and from advancement $U$ relative to $B$ it can not be result of a direct influence $B$ on $U$. Therefore $B$ is indicator of some process interacting with $U$.

In Fig.2 an example of synchronous amplitude spectra of $U$ and $B$ is shown. There is good similarity of them, in particular, positions of the main long-period pikes are almost coincided ($80^h$), positions of pikes at periods $32.0^h$, $15.0^h$, $12.0^h$, $6.15^h$ and $5.33^h$ are exactly coincided. In Fig.3 the period dependence of amplitude ratio *U/B* is shown. It is approximated by formula $U\,/\,B,\ m^2\,/\,s = 19\sqrt{t}$.

For the following it would be more convenient to use $F=B/\mu_0$. Whereas *U(f)/F(f)* depends on frequency *f*, it has turned out that $U(f)/F^2(f)$ does not depend on *f*: $U(f)/F^2(f)=(1.7\pm0.2)\cdot10^{-5}\Omega\, m^2/A$. It is the most important result pointing to relation of *U* with the entropy production.

For proof consider application of Eq.(1) to the concrete case. Magnetic field *F* is related with electric currents in the source – ionosphere, and also with induced currents in the Earth. For simplicity of the problem, neglect by the last and consider entropy production only in the source of *F*. It is easy to express the density of entropy production through electric field *E(f)* (which in turn through impedance *Z(f)* is related with *F(f)*), resistivity $\rho$ and medium temperature *T*. $\rho$ and *Z(f)*consider for simplicity as scalar. Then:

$$\dot{s} = \frac{\langle E^2(f)\rangle}{\rho kT} = \frac{|Z(f)|^2\langle F^2(f)\rangle}{\rho kT} \qquad (10)$$

Combining Eq. (1), (5), (6) and (10) and using for the electromagnetic field the plane wave approximation (Rokityansky, 1981), we have:

$$\frac{U(f)}{F^2(f)} = \frac{\sqrt{6}}{2}\frac{T_U g\sigma\mu_0}{|q|}\int\frac{dV}{Tx^2} = const. \qquad (11)$$

Thus the experimental fact $U(f)/F^2(f)=const$ is explained within the hypothesis (1).

Fig. 2 Amplitude spectra *U* and *B* in the period range from 5 hours to 10 days

Fig.3. Period dependence of *U/B*

It is of interest to estimate the constant $\sigma$ from observations. If presented reasoning with references to Kozyrev` s concept has meaning, the value$\sigma$ could be related with known Kozyrev` s constant of course of time$c_2$ (velocity of causal-effect transition on the microscopic level). From theoretical consideration $c_2\to\infty$ in classical limit, while from causal-mechanical experiments $c_2=+(2.2\pm0.1)10^6$ m/s (Kozyrev, 1977). $c_2$ was also related with Plank constant and electron charge: $ñ_2=e^2/\hbar$ . As on this stage only order of $\sigma$ is of interest, for its estimation simplify Eq.(11), supposing, that similarly to an ordinary electromagnetic field, it is possible to employ the plane wave approximation. Then, instead of Eq.(11), we have

$$\frac{U(f)}{F^2(f)} = \frac{\sqrt{6}}{2}\frac{T_U g\sigma\mu_0 h}{|q|T} \qquad (12)$$

where *h* is thickness of the dynamo-layer. For estimation of $\sigma$ accept corresponding to the detector parameters: $T_U=3\cdot10^2K$, $q=1.6\cdot10^{-9}\ A\cdot s$, $g=6\cdot10^{-2}$, and known typical values of the ionospheric parameters: $Ò=10^3Ê$, $h=5\cdot10^4m$. Then with mentioned above value $U(f)/F^2(f)$ we obtain from Eq.(11) $\sigma=2\cdot10^{-21}ì^2$. It is most reasonable value – of order an atom cross-section. And really this value may be related with $c_2$, mass and charge of electron:

$$\sqrt{\sigma} \approx \frac{e^2}{m_e c_2^2} \qquad (13)$$

If Eq.(13) is true, then in classical limit $\sigma\to0$.

### 6.4. Relation of the potentials with solar-ionospherical activity

Obviously, *U* must be related with multitude of the external processes, from which only variations of $T_e$ and *B* have been considered above. Estimate how much is possible contribution of the all other processes on variation of *U*. Synchronous estimation of independence is $i_{U|T_eB} \approx 0.54$. It means that total contribution of the all other processes is approximately the same as the joint contribution of $T_e$ and *B*. Therefore, there are enough degrees of freedom for the other external processes in *U*-variations.

Among the external processes the solar activity is a matter of particularly interest.

It is most simply to establish availability of influence of the solar activity by presence of maximum in spectrum at the period of solar rotation. Indeed in period range 10-100 days single significant maximum in spectrum *U* is just at period $27^d$ (Fig.4).

It was disclosed an interesting manifestation of ionospheric activity in *U* variations. It has been turned out that probability of the sudden ionospheric disturbances during phase of increasing of U substantionally exceed that one during phase of decreasing. Probabilities ratio is 4.5. If only sudden enhancements of atmospheric were selected such probability ratio became to 7.1.

Fig.4. Amplitude spectrum *U* in the period range from 5 days to 3.5 months

It may be suggested following qualitative interpretation of these facts. Sudden ionospheric disturbances are sharp increasing of ionisation of the lower ionosphere. That corresponds to decreasing of the entropy resulting, according Eq.(1) and (5), to increasing potentials. In the case of sudden enhancements of atmospheric there is an additional effect related with enhancements of the thunderstorm activity.

### 6.5. Dark current variations

The same effects (except of sudden ionospheric disturbances) were discovered with the detector of dark current *I*, but they are rather weak as compared with *U*. As this take place, the strong interplay of *I* and *U*, not reducing to a trivial influence of the common causes, has been uncovered. It can be illustrated by set of partial correlations: $r_{UI|T_e} = 0.78 \pm 0.01$, $r_{UT_e|I} = 0.24 \pm 0.02$, $r_{IT_e|U} = 0.09 \pm 0.02$ (not significant)

The analysis of all data, conducted in similar manner to one in Section 6.3 has demonstrated that *I* and *U* are related by the nonlocal mechanism.

## 7.Conclusion

Thus the results of long-term experiment completed on acceptable level of rigour allow to make positive conclusion about the truth of the hypothesis of interaction of the natural dissipative processes through active properties of time. The characteristic properties of this interaction is nonlocality and existence advanced time lag. A lot of known strange correlations of the geophysical and astrophysical processes may be reconsidered from this viewpoint. On the other hand a new method of investigation of geophysical irreversible processes may be developed on the base of the technics described here. However, admittedly our approach was essentially heuristic and further development of theory is burning.

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