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THE FUNDAMENTALS OF N.A.KOZYREV'S CAUSAL MECHANICS[1]

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Nikolay Alexandrovich Kozyrev (2.09.1908 — 27.02.1983), astronomer and thinker, is a brilliant distinctive scientist who left a considerable scientific heritage. Kozyrev's works on theoretical astrophysics and observational astronomy received universal recognition even during his life-time, in particular, the International Academy of Astronautics awarded him a personal gold medal. *Causal mechanics*, a science of physical properties of time founded by N.A.Kozyrev, takes a significant place in his scientific heritage (Kozyrev 1991).

The present paper contains an outline and critical analysis of the starting points of Kozyrev's causal mechanics.

1. The methodological principles of causal mechanics

Kozyrev's theory is based on several methodological premises (hypotheses). N.A.Kozyrev himself does not formulate them in the form of separate axioms. The ideas contained in these premises are, however, running through all his theory. Therefore it appears to be reasonable to write them down in an explicit form.

The first methodological premise lies in *adopting the substantial conception of time*.

The substantial conception of time implies that time is an independent phenomenon of nature existing side by side with matter and physical fields, and it may somehow affect objects and processes of our World (a reverse action of the objects and processes on the properties of time is not ruled out as well). The opposite, relational conception of time, by contrast, denies time as an independent essence and treats it as a specific property of physical systems and changes happening to them (Chernin 1987, Molchanov 1977, 1990, Space and Time 1983 and others).

Modern physics is built on the basis of the relational conception of time. However, the use of this conception has not so far resulted in resolving all the problems related to time. Moreover, so far even an essential definition of time has not been formulated in physics, there are only operational definitions indicating different methods of measuring time intervals. The adherents of the substantial conception of time, including N.A.Kozyrev, in their turn, have not answered all the questions concerning time and have not given a rigorous mathematical formalism describing the time substance. Hence one can state that nowadays both the relational and substantial conceptions of time are certain points of view

[1] A revised version of the present author's final paper in the book of N.A.Kozyrev's selected works (Kozyrev 1991).

rather than physical hypotheses developed in detail. Each of them has its own positive aspects. The fact that the relational conception rests on a firm experimental foundation and does not admit an unrestrained flight of fancy may be assigned to its advantages. The positive feature of the substantial conception lies in that it gives the researcher carte blanche for creative search, which may promote a successful resolution of the scientific problem.

It should be emphasized that, from the viewpoint of modern physics based on the relational conception of time, the statement of the substantial conception on the existence of a time substance can be in principle neither confirmed nor refuted since it is impossible to prove the presence or absence of something having no definition within the framework of a given scientific paradigm.

Note that N.A.Kozyrev would use regarding time the term “phenomenon of nature” rather than “substance”.

The second methodological premise used by N.A.Kozyrev, may be formulated as follows.

Along with the conventional property of duration measured by clocks, time possesses some other properties, as well. The researcher called these properties *physical* or *active*, in contrast to the geometric (passive) property of duration.

This premise is a reasonable working hypothesis, since a theory assuming that time has some additional properties along with duration, cannot turn out to be erroneous but only risks to be superfluous. Indeed, if the real time possesses no property other than duration, then setting all the parameters corresponding to the additional properties in the equations of the theory, equal to zero, we obtain a theory which assumes that time has a single property, namely, duration. The contrary is not true: any theory, based on the idea that time lacks properties other than duration, will be unable to describe the reality correctly if in fact time does possess other properties. It should be mentioned that N.A.Kozyrev in his theory never revised the conventional notions concerning time duration and used the concept of time interval in his considerations and calculations in the same way as was done by everybody.

The third premise reads: *the physical properties of time can be studied experimentally*. Evidently the reasonable character of this premise does not require a foundation.

The above three assumptions are, in our view, of utmost significance. They are, so to say, strategic in nature. In one of his works N.A.Kozyrev formulated the essence of these assumptions as follows: “Time is a phenomenon of nature possessing various properties which may be studied in laboratory experiments and astronomical observations” (Kozyrev 1991, p.384).

The next two initial premises may be regarded as tactical. The first one concerns a choice of mathematical models to describe objects of our World. The scientist was above all interested in manifestations of the properties of time in common practice, i.e. in the conditions when the laws of Newton’s classical mechanics are valid to a high accuracy. Therefore he believed that causal mechanics can be built as a refinement of classical mechanics and hence may use the same mathematical models as the Newtonian mechanics does to describe the objects of our World. In this connection in causal mechanics it is assumed that *the mathematical images of physical objects are material points or their systems, that force vectors serve as images of their action upon one another, and that the stage where the events of the World occur, is the three-dimensional proper Euclidean space combined with time, the one-dimensional, continuous and homogeneous entity geometrically describing the property of duration*. It is unlikely that there are reasons for which one might argue against such an assumption in advance, before comparing the results of the theory with the experiment.

The second tactical premise consists in the *axiomatic method* chosen by N.A.Kozyrev to construct his theory. In accord with it, causal mechanics starts from the postulates describing the properties of time and then they are used to derive the possible influence of time upon physical systems of our World. The use of the axiomatic method certainly cannot draw objections, it is in agreement with the general trend of exact sciences towards the logical perfection of their theoretical constructions and can be traced back to Euclidean geometry and Newtonian mechanics.

2. The postulates of causal mechanics

N.A.Kozyrev formulated the following three postulates about the physical properties of time (Kozyrev 1991, p.337).

Postulate I. *Time possesses a specific property distinguishing causes from effects, which may be called* ***directionality*** *or* ***course***.[1] *This property determines the difference between the past and the future.*

Postulate II. *Causes and effects are always separated in space. Hence an arbitrarily small but nonzero space difference* δx *exists between them.*

Postulate III. *Causes and effects are separated in time. Hence an arbitrarily small but nonzero time difference* δt *of a certain sign exists between them (the sign of* δt *is found from the condition that an effect always comes after a cause).*

Establishing the presence of an intimate connection between time and causality, postulate I immediately leads to the important conclusion that in practice a manifestation of the active properties of time should be searched in the cause-and-effect relations among the phenomena of our World. The adoption of this postulate as a starting point of the theory testifies that N.A.Kozyrev, while creating his theory, aimed to search concrete experimentally observable effects through which the properties of time manifest themselves in our World. The idea of connection between time and causality is running through all Kozyrev's theory. This is evident, in particular, from the fact that all the three postulates of the properties of time contain the terms "cause" and "effect". It is the scientist's conviction of the presence of such a connection that made him call his theory of the physical properties of time *causal mechanics*.

[1] We shall also call it *the direction of time*.

N.A.Kozyrev justifies the introduction of his first postulate in the following way (Kozyrev 1991, p. 337):

"The necessity of this postulate is due to the difficulties connected with the Leibnitz idea of determining the time directionality through causal relations. H.Reichenbach's (1956) and G.Whitrow's (1961) thorough investigations show that it is impossible to realize this idea strictly without tautology. Causality tells us about the existence of the directionality of time and about some properties of this directionality. At the same time causality is not the essence of this phenomenon but only its result."

Newton's classical mechanics does not make difference between cause and effect (since it postulates that the interaction forces between two bodies are directed along the same straight line, equal in magnitude, opposite in direction and act simultaneously). It is in this respect that classical mechanics is fundamentally limited. Overcoming this limitation is the aim of causal mechanics. The postulate under consideration asserts that time has just the property that creates a distinction between cause and effect.

The terms "directionality" and "course of time", being used as names of the postulated property of time, do not seem to be quite appropriate. Indeed, the first term is sometimes applied in science with a meaning different from that ascribed to it by Postulate I, while the second one is used in causal mechanics not so much to fit the above property of time as to describe one of its quantitative characteristics.

Postulates II and III do not require explanations, since their content is quite transparent and natural and is in agreement with all the experience of natural sciences related to causal properties. And even if some of the conditions $\delta x = 0$ or $\delta t = 0$ is valid in reality, this case can be expected to appear in the theory as a limiting version.

As mentioned above, in causal mechanics matter is modelled by material points. In such a model any process can be imagined as a sequence of separate cause-and-effect links. Therewith a smallest, *elementary* cause-and-effect link consists of two material points: a cause point and an effect point, which by Postulates II and III are separated in space and time and have no other material bodies between them. The quantities δx and δt which appear in Postulates II and III are considered to belong precisely to such an elementary cause-and-effect link (generally speaking, they may be different for different links).

Note that in causal mechanics the sense of the quantities δx and δt has not yet been clarified in detail. In particular, it is apparent from the relevant phrase: "these symbols denote the limits of infinitesimal quantities provided they never vanish" (Kozyrev 1991, p.338). This disadvantage does not, however, affect the following content of the theory because those quantities are not calculated in it and are not determined experimentally.

N.A.Kozyrev introduced the quantity

$$c_2 = \delta x/\delta t , \qquad (1)$$

which he called the *course of time*. In so doing, the researcher adopts that c_2 is a pseudoscalar, positive in a right-oriented coordinate system (in his early papers the opposite sign of c_2 was used, but in a more recent paper just this sign is adopted (Kozyrev 1991, p.367)). N.A.Kozyrev associates the pseudoscalarity of c_2 with the presence of a similar property in the quantity δt. However, the arguments justifying the pseudoscalarity of δt are not sufficiently convincing. Besides, this property of the quantity δt cannot be found anywhere in causal mechanics. Hence, in our view, it is reasonable to give up the assumption of pseudoscalarity of δt and adopt the following definition of the course of time.

Definition. *The pseudoscalar* c_2, *positive in right-oriented coordinate frames and equal in magnitude to*

$$|c_2| = |\delta x| / |\delta t|, \tag{2}$$

is called the ***course of time***.

The course of time c_2 has the dimension of velocity and determines the transition rate from the cause to the effect in an elementary cause-and-effect link. This quantity is a basic quantitative characteristic in causal mechanics. Based on the fact that an elementary cause-and-effect link contains no matter but only space and time between the cause and effect points, N.A.Kozyrev concludes that the quantity c_2 should reflect the properties of just space and time but not those of a specific physical system or process. In this connection he suggests that c_2 should be a fundamental constant, similar, e.g., to the velocity of light in vacuo. This proposition has not been singled out by the author of causal mechanics as a separate postulate, although it is indeed the case. Hence let us formulate it in the form of the fourth postulate.

Postulate IV. *The course of time* c_2 *is a fundamental constant.*

To emphasize the similarity between the course of time and the velocity of light, the two fundamental constants having the dimension of velocity, N.A.Kozyrev uses similar notations for them c_2 and c_1, respectively.

As regards the quantity c_2, one should point out the following. As mentioned above, this quantity characterizes the transition rate from the cause to the effect in an elementary cause-and-effect link. However, c_2 is not the realization rate of the whole cause-and-effect chain at the observable macroscopic level. It is related to the fact that the end of one elementary cause-and-effect transition and the onset of another one can be separated by a time interval required for the cause (or effect) point to be displaced from one position to another. Here a similarity with the interaction of gas molecules may be drawn. Two successive collisions of one molecule with the others are separated by a time interval during which the molecule moves freely, without interaction. This interval may far exceed the duration of a separate intermolecular interaction (in particular, in a dilute gas). Hence the rates of macroscopic processes in a gas, such as shock wave propagation and others, are not directly related to the realization rate of a separate intermolecular interaction. Likewise, a macroscopically observable realization rate of a cause-and-effect chain may not be directly related to the value of the course of time c_2. No contradiction is thus seen to exist between the postulated identity of the values of c_2 for any processes and the diversity of their macroscopic rates.

The next proposition of causal mechanics states that under certain conditions there arise forces in a cause-and-effect link which are additional to those predicted by classical mechanics. These additional forces are considered to be due to the influence of time. Let us formulate this proposition in the form of the fifth postulate.

Postulate V. *If in a cause-and-effect link there occurs a relative rotation of a cause point and an effect point, then the forces allowed for in classical mechanics are accompanied by certain additional forces. Therewith those additional forces applied to the cause point and to the effect one are equal in magnitude and oppositely directed, so that their principal vector is equal to zero. Besides, the lines along which these forces act, are allowed not to coincide, therefore their principal moment may be nonzero.*

For a real cause-and-effect link comprising two macroscopic bodies, the cause and effect ones, provided that (a) one of the bodies rotates while the other does not; (b) the shape of the rotating body is close to that of a perfect top (i.e. its entire mass is distributed approximately at the same distance from the rotation axis, with the centre of mass located on this axis); (c) the linear rotation velocity $\vec{v}$ *(having the same absolute value for all the points of the perfect top) satisfies the condition* $|\vec{v}| << |c_2|$*, the additional forces are described by the expressions*

$$\vec{K}_e \approx \frac{v}{c_2} F \vec{l}\,; \qquad \vec{K}_c \approx -\frac{v}{c_2} F \vec{l}\,, \tag{3}$$

where $\vec{K}_e$ *and* $\vec{K}_c$ *are resultants of the additional forces for the effect and cause, respectively, applied to their centres of mass;* $v = |\vec{v}|$; $F = |\vec{F}|$; $\vec{F}$ *is an interaction force between the cause and the effect taken into account in classical mechanics;* $\vec{l}$ *is a unit pseudovector parallel to the rotation axis and, in a right-oriented coordinate frame, directed to the side from which the rotation looks clockwise.*

From the condition $v << |c_2|$ and formula (3) it follows that $|\vec{K}_e| = |\vec{K}_c| << F$, hence $\vec{K}_e$ and $\vec{K}_c$ are small additives to the "classical" force $\vec{F}$.

Here we depart somewhat from the notation used by N.A.Kozyrev (1991). In particular, we have denoted the additional forces by the letter K after Kozyrev's name, and in contrast to (Kozyrev 1991), where v is a pseudoscalar and $\vec{l}$ is a (true) vector, we have adopted that v is a (true) scalar, and $\vec{l}$ is a pseudovector.

It is important that the additional forces involved in Postulate V do not change the resultant momentum of the cause-and-effect link and at the same time may change its angular momentum. (The reason is that their principal vector is equal to zero while the principal moment can be nonzero.) Since the additional forces are internal with respect to the whole cause-and-effect link, this may result in violation of the angular momentum conservation law, although the momentum conservation law remains valid. Let us discuss this issue from the standpoint of classical mechanics.

The momentum and angular momentum conservation laws belong to the fundamental laws of physics. Both of them are usually considered to be equally applicable to describing the behaviour of physical systems. However, if one refers to the foundations of these laws in classical mechanics, it can be seen that they are based on somewhat different assumptions. Thus, the momentum conservation law is derived directly from Newton's laws, whereas the angular momentum conservation law follows from Newton's laws provided that *the interaction forces between each two internal points of the system have the same line of action* (Polyakhov et al. 1985, p.137). This implies that the laws under consideration can be equally applicable to describing the nature as long as that additional assumption is also a general law of nature, to the same extent as Newton's laws are. Meanwhile, this assumption does not possess the rank of a fundamental law in classical mechanics. This indicates that classical mechanics allows, in principle, a possibility of violating this assumption along with the angular momentum conservation law at some conditions. This is just the case dealt with in Postulate V. By this postulate such a violation can take place in cause-and-effect relations.

The importance of Postulate V is determined above all by that it opens the way to experimental tests of causal mechanics. Having carried out the corresponding experiments, N.A.Kozyrev obtained (Kozyrev 1991, pp.367, 382)

$$|c_2| \approx 2200\text{km/s} \approx \alpha c \,, \tag{4}$$

where α is the fine structure constant ($\alpha \approx 1/137$) and c is the velocity of light in the vacuum. The fact that the quantity c_2 proved to be close to the product of fundamental constants serves as a certain argument in favour of the validity of Postulate IV claiming its fundamentality.

Postulate V was the first in physics to establish an objective distinction between causes and effects in the simplest mechanical systems. From (3) it follows that, using the cause-and-effect link containing a rotating body, one can say if the body is a cause or an effect by the direction in which it rotates as seen by the observer placed somewhere in the direction of the additional force vector. If the rotation seems to occur clockwise, then the body under consideration is an effect, if anticlockwise, then it is a cause. The distinction between causes and effects in causal mechanics is thus related to the distinction between the right and the left.

Let us dwell on the aspects of paper (Kozyrev 1991) connected with Postulate V, seeming to be insufficiently advanced.

N.A.Kozyrev writes (Kozyrev 1991, p.343) that there is no time lag between the forces of action and reaction, meaning, among others, the forces described by formula (3). This means that the cause and the effect are acting on each other simultaneously. Therewith it remains unclear how this statement can agree with Postulate III on a nonzero time lag between the cause and the effect.

In Kozyrev's paper (Kozyrev 1991) the weight of a body, for which a value of the additional force is determined, is adopted as the quantity F involved in formula (3). It is incomprehensible, however, why the reaction of the suspension keeping the body is not taken into account.

The experiments described by Kozyrev (1991) have shown that the additional forces arise in a mechanical system only provided that a certain causal action is introduced in it. (The latter was accomplished through mechanical vibrations, heating, or passing an electric current, with the source of action placed near one of the ends of the system acting as a cause, and the action itself transferred to the other end, the effect, in a natural way.) A surprising thing is that, although playing a predominant role in the effect, this action in no way enters in the relationships (3).

The value of the constant c_2 described by (4), has been calculated in (Kozyrev 1991) not by formula (3) themselves but by their modifications differing from (3) by the presence of the additional factor π in the right-hand sides of the formula (if it were absent, it would be $|c_2| \approx 700$ km/s). However, the arguments in favour of this modification (Kozyrev 1991, pp. 366-367) do not appear to be sufficiently convincing.

Let us express some considerations on possible methods of correcting the above shortcomings. The first one, the neglect of a time distinction between the forces of action and reaction, can be corrected, e.g., by the method presented in this book, in another article by the present author (see p.109). The next two shortcomings, those due to the neglect of suspension reaction and the causal action, may be eliminated in the following way: one should use just the interaction force between the cause and the effect as $\vec{F}$, according to Postulate V, instead of the gravity force as is done in (Kozyrev 1991). Then, for the cause-and-effect link, with one of the components connected with the external bodies and the other kept by the force $\vec{F}$ (as is the case in N.A.Kozyrev's experiments), this force will incorporate both the suspension reaction force and the one related to the causal action. Note that, if the force $\vec{F}$ proves to be proportional to the mass of the body, the corresponding formula will differ from the ones allowing for only its weight, by just a numerical factor.

As for the last of the mentioned shortcomings, namely, a possible invalidity of the additional scalar factor in formula (3), one should note the following. The need for such a modification of the formula may be related to a number of circumstances. For example, as we have written, a factor may arise in these formula due to the use of weight as the quantity F in the calculations. Besides, it is not improbable that a certain factor should be included in formula (3) *ab initio*. There are some reasons for that. First, the quantity c_2 was inserted in formula (3) evidently by dimensional considerations and by the hypothesis that additional forces are caused by properties of time required by Postulates I –€IV. However, apparently, for the same reasons any quantity kc_2 with a positive dimensionless coefficient k may be on equal grounds inserted in formula (3) instead of c_2 , which would result in the additional factor k^{-1} in the right-hand sides of formula (3). Second, formula (3) are not related to a microscopic cause-and-effect link comprising two material points but are applied to a macroscopic system. Hence it would be reasonable that in (3) there appeared a factor resulting from integration to be carried out when passing from the description of material points to that of a macroscopic system. Third, a certain factor may enter in formula (3) if there is a dependence of the additional forces on the relative orientation of the rotation axis and the cause-effect line (the possibility that such a dependence exists, has not been studied in (Kozyrev 1991), hence one cannot exclude it a priori).

Let us draw attention to the fact that if an additional factor is present in the right-hand sides of formula (3), then the experiment for determining the additional forces allows one to find only a ratio of that factor to the constant c_2 but not each of these quantities.

That is why to calculate them, additional grounds are required. The results obtained in another article by the author (p.109) may serve as such grounds. They indicate that the constant c_2 indeed takes the value described by formula (4). From this fact and N.A.Kozyrev's results on measuring additional forces it follows that the additional factor is equal to π, i.e., its value and that of the quantity c_2 coincide with those adopted by the researcher. Thus, formula (3) for the additional forces should be transformed to become

$$\vec{K}_e \approx \pi \frac{v}{c_2} \vec{F}; \quad \vec{K}_c \approx -\pi \frac{v}{c_2} \vec{F}. \tag{5}$$

Note that the similar formula in the author's paper mentioned above should be transformed in the same manner.

In Newton's classical mechanics, as well as in Kozyrev's theory, causes and effects are spaced, but in contrast to Kozyrev's theory there is no time lag between them in classical mechanics. This immediately follows from Newton's third law according to which the forces of action and reaction are applied to different bodies but act simultaneously. Hence in classical mechanics the ratio of a spatial distance between the cause and the effect to their time lag is infinite. Thus Newton's mechanics corresponds to the World with an infinite course of time c_2 and does not contain additional forces as described by formula (3) or (5).

This is not the case in quantum mechanics. Here particle interactions are realized by physical fields which may be superimposed on one another. Therefore the condition of spatial incompatibility of causes and effects, being valid in classical mechanics, ceases to hold. At the same time, in quantum mechanics there is a nonequivalence between the past and the future arising from the action of a macroscopic instrument on a microscopic object. This indicates that there is a time incompatibility between the past and the future. As a result, the spacing between a cause and an effect proves to be zero while the time interval remains nonzero. Thus quantum mechanics corresponds to the World in which the course of time c_2 equals zero. Consequently, the additional forces different from the classical ones should play a predominant role. (Formula (3) and (5), due to their approximate nature determined by the condition $v \ll |c_2|$, do not permit one to obtain the values of the additional forces when $c_2 = 0$ but confirm this conclusion qualitatively.)

Thus Kozyrev's causal mechanics incorporates classical mechanics ($c_2 = \infty$) and quantum physics ($c_2 = 0$) as the two extreme cases.

The next postulate can be formulated as follows.

Postulate VI. *Time possesses, along with its permanent property, the course* c_2, *also the variable property called* ***density****.*

N.A.Kozyrev has carried out a long series of experimental investigations of this property of time and obtained many results of interest (Kozyrev 1991). However, since he has not succeeded in introducing a quantitative characteristic of time density, it would be premature to discuss this postulate in detail.

The qualitative conclusions, derived by the researcher concerning the density of time, are as follows.

The density of time characterizes activity of time influence on systems and processes of our World. Since time acts on a variety of systems and processes, various objects may serve as detectors for recording its influence. (N.A.Kozyrev used detectors based on a nonsymmetric torsion balance, electric resistors, contact pairs of metals and others.)

The density of time at a given location in space depends on the processes occurring around it. The processes in which entropy increases, i.e. when there occurs disordering, increase the density of time around them, and vice versa, the processes with decreasing entropy decrease the density of time. It is safe to say that time carries order or negative entropy (negentropy), and it is either emitted by a system when its order decreases, or absorbed by a system when its order increases.

Since any process changes the density of time around it, it affects the course of other processes and the state of ambient matter by means of this property of time. Thereby the interrelation between all the processes occurring in nature is established through the density of time.

Let us pay attention to the fact that, since time is a characteristic of the fourth direction orthogonal to our World, both external and internal domains of any three-dimensional objects of our World are equally accessible to it. Each atom of matter, each cell of a living organism are equally open to the stream of time flowing throughout the World along the normal to it.

The above concept of time emission or its absorption by systems is justified by the nature of influence transmitted to the detector. Thus, the action on a detector subject to the influence of a process increasing the density of time around it, falls off according to the inverse-square-distance law, is screened (to a certain extent) by solids and liquids and is reflected from metallic mirrors. A decreased density of time near the process is something like entraining time from the ambient space into the domain where the process occurs. The action of this phenomenon on the detector is screened but not reflected by a mirror. It is of importance that the reflection effect allows one to focus the process influence with a parabolic mirror and provides a possibility to carry out astronomical observations with a reflecting telescope.

With this we conclude the discussion of the postulates of causal mechanics. As a whole, they essentially amplify and develop the modern scientific ideas of time and causality; at the same time some points call for further investigation.

3. Astronomical observations via physical properties of time

"Time is a whole world of mysterious phenomena which cannot be followed logically. The properties of time should be constantly clarified by physical experiments" — these N.A.Kozyrev's words (Kozyrev 1991, p.345) indicate that the scientist attached prime significance to experimental studies of the properties of time. For over 30 years he had been carrying out laboratory and (in recent years of his life also) astronomical observations of the properties of time. N.A.Kozyrev's prime merit is likely to be in that he was the first in world science to proceed from theoretical considerations on the existence of the properties of time other than duration to their experimental study.

An analysis of N.A.Kozyrev's experimental investigations is not our object. We would like only to note a specific feature of interpretation of his experimental data. In all experiments N.A.Kozyrev really registered changes of some characteristics of physical systems under certain conditions (such as torsion balance beam orientation, electric resistance of a resistor, weight of a body, etc.). N.A.Kozyrev treated these effects as a manifestation of the properties of time. Such an interpretation of the experimental data is justified from the viewpoint of N.A.Kozyrev himself. Really, he performed his experiments starting from definite concepts of time. Hence the experimental results that he had qualitatively anticipated served him as a convincing proof of this interpretation. However, the validity of this interpretation may not be self-evident from the viewpoint of a detached observer unaware of the circumstances that led N.A.Kozyrev to these experiments. He can reasonable put a question: "Why should the observable effects be due to the action of just time but not another, may be still unknown, physical field?"

The best way of solving this problem would be certainly to perform such an experiment in which time would be studied directly, then, having examined its physical properties in detail, one would be able to state with confidence whether the effects observed in Kozyrev's experiments are due to the action of time or not. However, so far there has not been elaborated an experiment in which time would be studied directly. It seems plausible that time cannot be studied directly at all but only indirectly by examining physical systems and processes occurring in them. If it is the case, then it is not improbable that an experiment allowing the physical properties of time to be proved without using a priori premises, cannot be performed under usual laboratory conditions.

At the same time, the effects that would be convincing proofs of the existence of peculiar properties of time are most likely to be revealed by astronomical observations. The results of N.A.Kozyrev and V.V.Nasonov's astronomical observations (Kozyrev 1991, pp. 363-383; Kozyrev and Nasonov 1978, 1980) provide strong evidence for that. They investigated different astronomical objects: stars, galaxies and globular clusters, using detectors of their own construction. For each of the observed objects they recorded signals coming from three locations on the celestial sphere: (a) from that coinciding with the visible position of the object, i.e. from the place where the object was in the remote past, (b) from that where the object was situated at the instant of observation and (c) from the place to be occupied by the object when a hypothetical light signal, emitted from the Earth at the instant of observation, could reach it. N.A.Kozyrev interpreted this result as a possibility of using the physical properties of time for communication with the past and the future along the corresponding light cones and with the present along a hyperplane of simultaneous events (Kozyrev 1980). Although such an interpretation appears to be too bold, it is not unreasonable. At least, it is not internally contradictory. Since the concepts of the past, the present and the future themselves are determined by the properties of time, they may be apparently defined, if only in principle, so that a communication with them via time be allowed. At the same time it is evident that any attempt to explain receiving signals from the future or the present apart from the properties of time should require a radical reconstruction of the foundations of physics.

4. The present state of the problem

In the recent years some publications have appeared which confirm the results of theoretical, laboratory and astronomical investigations performed by N.A.Kozyrev.

The authors of papers (Danchakov 1984; Danchakov and Yeganova 1987; Lavrentyev et al. 1991) have performed a long series of laboratory experiments using N.A.Kozyrev's procedure and obtained the results confirming and amplifying N.A.Kozyrev's data on distant action of irreversible processes on the states of ambient bodies.

The publications (Akimov et al. 1992; Lavrentyev et al. 1990a,b, 1992) describe the results of astronomical investigations using Kozyrev type detectors and those of biological type. A receipt of signals not only from the visible (i.e., past) positions but also from the true (present-day) and future positions of stars and other astronomical objects has been confirmed in complete accord with the results of N.A.Kozyrev and V.V.Nasonov's papers (Kozyrev 1991, Kozyrev and Nasonov 1978, 1980).

The paper by Arushanov and Korotayev (1989) explained on the base of Kozyrev's theory some geophysical facts uninterpreted conventionally, e.g., asymmetries of the Earth figure, geological structure, atmosphere circulation and distribution of the Earth's physical fields.

Japanese researchers carried out a weighting of right- and left-rotating gyroscopes with a vertical axis and revealed that when the rotational speed increases, there occurs a decrease of the weight of the right-rotating gyroscopes, close to that observed by N.A.Kozyrev (without referring to his works) (Hayasaka and Takeuchi 1989).

Later this result was tested and not confirmed in the subsequent papers of American and French researchers (Faller et al. 1990, Quinn and Picard 1990). An analysis of these publications carried out by R.Ya.Zul'karneev (JINR, Dubna) shows that in reality these papers are in agreement with N.A.Kozyrev's data. The point is that, in accordance with the views of causal mechanics, to change a gyroscope weight, it is necessary to subject it to an irreversible influence, e.g., vibrations; the latter were present in the set employed by Hayasaka and Takeuchi (1989) due to using a spring suspension of the gyroscope and are lacking in the sets described by Faller et al.(1990) and Quinn and Picard (1990).

A large number of correlations between lunar and terrestrial events as well as solar and terrestrial ones, unexplainable in the context of conventional physics, have been revealed by now (Middlehurst 1967, Vladimirsky 1991, Zilberman 1989, etc.), which makes N.A.Kozyrev hypothesis on interconnection of all the World's phenomena by the physical properties of time be treated with attention.

Thus some of the results obtained by N.A.Kozyrev have been confirmed by the works of independent researchers, which is an important step on the road to the recognition of causal mechanics as a competent physical theory.

In one of his last papers (Kozyrev 1980) N.A.Kozyrev concluded that the results of astronomical observations via the physical properties of time (Kozyrev 1991, Kozyrev and Nasonov 1978, 1980) correspond to the Minkowski space geometry. It should be added that in our papers in the present book (pp. 109 and 174) Heisenberg's uncertainty relations have been derived on the basis of the postulates of causal mechanics, and the development of the substantial conception of time is shown to result in the symmetry of our World coinciding with that dictated by the CPT theorem of quantum field theory. These results indicate that Kozyrev's causal mechanics is in agreement with special relativity and quantum mechanics, which serves as an additional argument in favour of its validity.

Note that the scientific literature does not contain any information on experimental studies ruling out N.A.Kozyrev's results (at least the author of the present paper is unaware of such publications).

5. On causality

In modern physics the concept of causality appears in the form of the causality principle, according to which the future cannot affect the past (which, with allowance for the views of relativity, also leads to the statement of the impossibility of superluminal motions in vacuo) (Causality principle 1983). Meanwhile, a philosophical comprehension of the causality concept leads to the conclusion that this concept is far richer in its essence and expresses one of the most important properties of nature (Bunge 1959, Causality 1983, etc.).

According to the philosophical views, *causality* is a genetic linkage between specific states of the sorts and forms of matter in its motion and development processes. The essence of causality is production of the effect by the cause. Causality is an inner link between a phenomenon and something being created by it, i.e. something only being formed. This is its fundamental distinction from the other forms of connections. In a causal process there occurs a transfer of matter and motion from the cause to the effect, hence it is accompanied by a change of the cause itself. The cause precedes the effect in time, but at the same time there exists a more or less extended stage when the cause and the effect coexist and actively interact with each other.

The exact sciences disregard most of the aspects of causality. As a result, as N.A.Kozyrev has written (Kozyrev 1991, p. 337), "...in a tireless search for the cause a naturalist is guided by his intuition rather than by definite recipes". N.A.Kozyrev was the first to indicate the necessity of including the concept of causality in the set of the basic axioms of mechanics, and in his causal mechanics he initiated a realization of this task. However, N.A.Kozyrev also failed to formulate an exhaustive physical definition of causality.

The first rigorously formalized definition of causality was apparently given in the papers by Arushanov and Korotayev (1989) and Korotayev (1992, 1993). This definition is based, roughly, on a comparison of the conditional probabilities of events: from the two events that one is considered to be the effect whose probability, provided that the other event occurs, is higher than a similar probability of the other event; the other event is thereby considered to be the cause. This definition has undoubtedly a right to exist. We believe, however, that a physical definition of causality should also incorporate the physical characteristics of causal action such as forces, energies, etc. Unfortunately, such a definition of causality has not been formulated yet.

One of the difficulties arising in the attempts to formulate the definition of causality as a physical concept, lies in that there exist physical systems for which the processes occurring in them (or available interactions) cannot be presented in the form of a sequence of causes and effects differing objectively from one another. Among such systems are, e.g., a perfect friction-free pendulum; a mass oscillating attached to a perfect spring; a system of immobile electrically charged particles interacting via the Coulomb forces; a pair of massive bodies rotating under the action of gravity around the common centre of mass, and others.

In our view, the above difficulty might be overcome if one assumes that not each process (or interaction) can be considered as a causal one from the viewpoint of physics. In particular, a thermodynamically reversible process cannot be treated as causal. While realizing such a process, the system may always be returned to the initial state exactly, with no change of the ambient bodies. In other words, in a reversible process both the system and its environment accumulate no irreversible change, hence this process is somehow equivalent to lack of a process. A reversible process can be treated as something similar to the ordinary uniform rectilinear motion or the oscillatory motion of a perfect pendulum, when the potential and kinetic energies alternately transform into each other without loss.

To all likelihood, it is only a thermodynamically irreversible process that may be considered to be causal. The positivity of entropy production rate in such a process, stated by the second principle of thermodynamics, allows one to introduce a process parameter varying strictly monotonically in the course of time. The existence of such a parameter provides a possibility to determine a causal order of events connecting it with their temporal order.

6. Conclusion

There is obviously a crisis coming in modern theoretical research of space and time. Its indication is that such investigations are now concentrated nearly exclusively on the situations which are unobservable in principle, namely, on the study of the domains of space-time close to the so-called cosmological singularities (the instant of birth of the Universe, etc.). In this connection it is appropriate to quote L.Brillouin that it is a pleasure to discuss the origin of the Universe, but it should be remembered that such discussions are no more than a pure fancy (Brillouin 1970). In contrast to that, N.A.Kozyrev's works are directly related to the reality. N.A.Kozyrev studied the properties of time, by A.D.Chernin's picturesque expression, "here and now", but not in the domains of the Universe inaccessible to study. Therefore N.A.Kozyrev's works are of utmost importance for the comprehension of the World structure.

The main conclusion at which N.A.Kozyrev arrives on the basis of causal mechanics (Kozyrev 1991, pp. 384, 393-394) may be briefly formulated as follows.

Due to its active properties, time can bring an organizing source into our World and, therefore, counteract the natural course of processes which lead to destruction of order and production of entropy. This influence of time is very small as compared to the natural destructive course of processes but it is distributed in nature everywhere, hence there is a possibility of its accumulation. Such a possibility is realized in living organisms and in massive cosmic bodies, primarily in stars. The ability of living organisms to conserve and accumulate this counteraction is likely the factor determining the great role of the biosphere in the life of the Earth. For the Universe as a whole, the influence of the active properties of time manifests itself in the prevention of Universe thermal death.

N.A.Kozyrev had no time to justify this conclusion in a rigorous way, therefore at the present state of the development of causal mechanics this conclusion is much of the world-outlook nature.

Summing up all the aforesaid, we can conclude that N.A.Kozyrev's causal mechanics amplifies the available picture of the World harmoniously, without contradicting the propositions of modern physics. So far it is not, however, a complete theory, and hence it is necessary to perform further theoretical and experimental studies in this field.

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