Chapter 2. The passage of time as a causal chain of events

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who came to us with the light of stars.

N.A. Kozyrev. Selected Works. Leningrad State University Publishing House, 1991, p. 409.

Kozyrev's last unfinished work is an introductory chapter to the book that he began to write. This work is called "Man and Nature," and it ends with significant words: "The experiments performed made an amazing, almost fabulous impression. Indeed, in the laboratory there was a reflection of the knowledge that comes to us with the light of stars" [6]. Now it is time to cover in detail amazing, fabulous experiments, the understanding of which would change our consciousness so much that it would become much easier for us to navigate the world simply because we would become closer to it. When reviewing the results of Kozyrev's astronomical observations, a completely natural question arises: why did a recognized observer astronomer begin to search for some phantoms of real celestial bodies scattered in time? In order to understand the essence of these unique experiments, one should turn to Kozyrev's earlier works devoted to theoretical and experimental study of the properties of time. In 1958, the scientist published the fundamental work "Causal or asymmetric mechanics in the linear approximation", where time is considered as an active participant in the universe [7]. According to this work, time is not an abstract philosophical category, but an objectively existing reality — the source of life in the Universe.

For Kozyrev it was obvious that "... in the World there is a certain deep principle, not yet discovered by modern natural science. This principle can hardly be invented, but it should be sought inductively, solving theoretically inverse problems. With such a study, we should not avoid issues that are difficult for the theory, but, on the contrary, focus our attention on them" [7]. He considered the problem of the thermal death of the Universe predicted by physicists to be such a difficult question. According to the second law of thermodynamics, heat transfers from more heated bodies to less heated ones. In order for the reverse process of heat transfer from a less heated body to a warmer body to be realized, it is necessary to do the work. In addition, in each closed system, an increase in entropy, or measure of disorder (disorder of the structure) occurs over time. This means that every closed system grows old over time and eventually ceases to exist - it completely degrades (dies). Due to the fact that the distances between stars in galaxies and between other structures of the Universe are quite large, each of them, including the Universe itself, can be considered a closed system. The application of the second law of thermodynamics to the body of the Universe leads to the conclusion about its inevitable thermal death, which will occur when the temperatures of its constituent objects, the elements of the body of the Universe, are aligned. "In the Universe, there are no signs of degradation that follows from the second principle. The world sparkles with an inexhaustible variety, we do not find in it even traces of the approach of thermal and radioactive death. Apparently, here lies the main contradiction — the contradiction is very deep, which cannot be eliminated by references to the infinity of the Universe "[7].

Kozyrev proposes to resolve this contradiction as follows: "... we must recognize that in nature there are constantly acting Reasons that prevent the increase of entropy" [7]. He considers them to be the same both for the Universe as a whole and for each fragment of it, for example, a star. To find these fundamental causes, Kozyrev suggests by solving the question of why the stars shine, including our Sun: "… we can think that having solved the problem of stellar energy, we will find the key to understanding the most important phenomena of the stellar World" [7]. Long-term theoretical studies of many stars with different characteristics — masses, radii, temperatures, etc. — led him to the following conclusion. "We have to conclude that the star is a machine that produces energy. However, this mechanism does not work under all circumstances" [7]. It turned out that there is a main direction in the space of physical conditions, "near which the energy mechanism can work in a huge range of states (from red supergiants to white dwarfs): B/n = const, where B is the density of radiant energy and n is the number of particles in cm^3" [7].

Some explanations should be made here, since the last quote is very important for further understanding not only the problem of stellar energy, but also the most fundamental problem of our material world — the condition of equilibrium between matter and the energy emitted by it. The value B is the density of radiant energy, i.e., its amount is 1 cm^3, and n is the number of particles of matter in 1 cm^3.Their ratio is equal to some constant value having the dimension of energy. If we represent it in the form const = $m_e c_2^2$, where me is the electron mass, then the quantity c_2, which has a velocity dimension, is approximately 350 km/s, which corresponds to the ratio of the quantities $e^2/\hbar$, where e is the elementary electric charge, $\hbar$ =

$h/2\pi$, h is the Planck constant, or quantum of action. The quantity h, having the dimension of the angular momentum, is a fundamental physical constant that plays a large role in the world of elementary particles. In particular, an electron moving in a stationary orbit around the nucleus of an atom has strictly quantized energy values proportional to h, and when moving from one orbit to another it acquires or gives off energy measured by strictly quantized (discrete) portions proportional to h.

In order of magnitude, the ratio B/n corresponds to the ionization energy of atoms. The ionization energy is equal to the energy with which it is necessary to act on the atom so that it begins to lose its electrons. This is possible under various external influences: strong heating, x-ray and radioactive irradiation, atom bombardment by fast electrons and ions. All these influences take place in the stars. Obviously, the *ionization energy* is equal in order of magnitude to the recombination energy, i.e., the energy that an ionized atom (which has lost one or more negatively charged electrons) needs to recover and become electrically neutral (the number of electrons of a nonionized atom is equal to the charge of its nucleus, i.e. the number of positively charged particles — protons).

It turns out that the mechanism of energy production in stars works best under conditions of equilibrium between two opposite processes: 1) ionization, tending to tear electrons from atoms and thereby bring the stellar matter into a degenerate state, when atoms lose all the electrons and the stellar matter is extremely dense a compressed mass consisting of "bare" atomic nuclei: 2) recombination (reduction), due to which atoms restore their electron shells, thereby preserving themselves as a structure urnye unity of the material world — atoms of matter.

The life of a luminous star is a balance between two states — total ionization, leading to the degeneration of matter, and complete recombination, which leads to the fact that the star ceases to be the luminous creature that we see in the sky. The fact is that a multi-colored glow of stars creates a plasma, heated to thousands and tens of thousands of degrees. And plasma is a partially or completely ionized gas in which free negatively charged electrons and positive atoms that partially or completely lose their electrons neutralize each other. The higher the temperature of stars, the higher the degree of ionization, i.e., the more atoms lose electrons, turning into positive ions. It turned out that the ratio

$$B/n \approx m_e c_2^2, \; c_2 = \alpha c/e^2\hbar = 350 \text{ km/sec}, \qquad (1)$$

where α is fine structure constant, c — speed of light, e — electron charge, $\hbar = h/2\pi$, h — Planck's constant, or action quantum.This relation holds best for stars belonging to the spectral class F (hotter than the yellow sun, greenish stars). Near this spectral type, most stars are grouped — from subgiants to sub-dwarfs. And among stars whose characteristics satisfy relation (1), the central place is occupied by stars in which the speed of protons (hydrogen nuclei), the number of which in stars significantly exceeds the content of nuclei of other elements, is equal to c_2.

It is interesting to note that in stars called white dwarfs, inside of which the substance is on the verge of a degenerate state, the temperature is also maintained, which prevents their degeneration. It turns out that a certain mechanism works in the stars, which allows generating luminous energy, and in this mechanism the value c_2, which has the dimension of speed, plays a decisive role. This value served as the cornerstone for Kozyrev in constructing the concept of time, which was most fully described in [7].

Kozyrev rightly believed that we live in a world in which nothing happens just like that, and everything is interconnected through causal chains. Even everyday life experience shows us with various examples that every event has its own reasons, although we do not always know about them. Scientists of the 18th century even tried to explain all the phenomena of life with the phenomena of mechanics. But this attempt failed completely. "At the same time, this mechanistic approach is not wrong in its essence, but only because the principles established by mechanics are incomplete and insufficient to explain the phenomena of the World" [7]. And Kozyrev sees the incorrectness of the fundamental principles of mechanics in the fact that "the laws of mechanics do not express the main property of causality, which consists in the fundamental difference between causes and effects. True mechanics should be causal mechanics, that is, contain a principle that allows one to distinguish a cause from an effect" [7], and this fundamental principle can be established by a complex theoretical and experimental method. Indeed, when it comes to the fundamental laws of the structure of the world, it is impossible to investigate them purely experimentally, without even representing, in general terms, what is at stake. On the other hand, formal theorizing can only lead to the construction of a purely speculative theory that does not advance the consciousness of people to a fundamentally new level of perception of the world.

The basis of causal mechanics is an axiom (truth that does not require proof): "In causal relationships, there is always a fundamental difference between causes and effects. This difference is absolute, independent of the point of view, that is, from the coordinate system "[7]. Causes and effects, according to Kozyrev, are always separated by both space and time. Otherwise, they are identical concepts. The spatial and time intervals separating cause and effect can be very small, but can never be equal to zero. In modern physics, laid down by Newton, time has only one (scalar or passive, in Kozyrev's terminology) property, called *duration*. It only allows you to set the duration of events or the length of the gap between events, but does not make it possible to distinguish between the causes of the event and their consequences. "From the existence of a difference in cause and effect, we are forced to conclude that time has some other special property" [4]. What is this property?

"This property of time is the difference between the future and the past and can be called a direction or a move. Our psychological sense of time is the perception of the course of time objectively existing in the World" [7]. Kozyrev formulates the following position: "Time has a special, absolute property that distinguishes the future from the past, which can be called a direction or a move. This property is determined by the difference between causes and effects, because the consequences are always in the future with respect to causes" [7]. This property — the passage of time — Kozyrev studied in detail through a variety of experiments, which are discussed before. However, before experimenting, always first you need to have an idea of what to experiment with and what to look for. Therefore, Kozyrev introduces a certain postulate (a principle that does not require proof), which consists in the following: "... the course of time in our world is determined by a certain constant of a certain sign. In a different course of time, this constant must be different and may even have a different sign" [7]. Kozyrev determines the course of time in relation to space in the form of the limit relation of the time interval δt, dividing the past from the future, to the gap between them δx. Obviously, the dimension of this ratio is the reciprocal of the dimension of speed:

$$\delta t = const\ \delta x \qquad (2)$$

As a constant coefficient, Kozyrev considers the value inversely proportional to the speed c_2. Thus, the ratio (2) takes the form:

$$\delta t = \delta x / c_2, \qquad (3)$$

where is the value $c_2 = ke^2/h = k{\times}350$ km/sec. It has been experimentally established that the proportionality coefficient k is approximately equal to 2. Then $c_2 = 2e^2/h$ is 700 km/sec, what is the speed of our galaxy. In addition, it is very interesting to note that, firstly, the value of c_2 determines the conditions for the formation of energy in stars, and, secondly, the ratio of the value of c_2 times π to the speed of light is numerically equal to the fine structure constant $\alpha = 1/137$. This value characterizes the intensity of electromagnetic interactions that take place between charged particles. Relation (3) can be rewritten in the form

$$\delta x / \delta t = c_2 \qquad (4)$$

This shows that c_2 is the transmission rate of spatial changes in time, more precisely, caused by time, or the rate of transition of a cause into a consequence (a measure of the course of time).

Now it's time to talk about why, as universal, that is, independent not only of the spatio-temporal coordinates of the points, but also of the physical properties of the interacting bodies of magnitude, it is precisely the speed c_2 that was chosen. Kozyrev cites the following arguments as an argument in favor of such a choice: "... the passage of time has a definite sign independent of the account system δx and δt. In other words, invariant sign matching is required in formula (3) δx and δt." But the signs of the temporal and spatial intervals are completely arbitrary and independent. In addition, time has a focus (flows from the past to the future), and in space all directions are equal. "Therefore, the consistency of the signs of δx and δt in formula (3) is possible only if, when the signs of δt and δx change, the sign of c_2 also changes. There is only one way to combine the change of sign c_2 when changing the sign of δx: the constant c_2 must be a pseudoscalar that changes its sign when moving from the right coordinate system to the left and back. In this case, *dt* must be a pseudovector" [7].

An explanation should be made here. In mathematics, along with scalars (invariants) and vectors, there are pseudo-vectors and pseudo-scalars [8, 9]. *A scalar*, or *invariant*, is a quantity whose value does not depend on the choice of a reference frame and can be expressed as a single number. *A pseudoscalar* is a quantity that does not change during the transfer and rotation of the coordinate axes, but changes its sign when the direction of each axis is replaced by the opposite. *A vector* is a quantity characterized, in addition to measuring it in certain units of a measure of number, also by its direction in space. An example of a scalar is an abstract (non-dimensional) number. An example of a simple vector is a straight line segment that has a certain length and a certain direction in space. Such vectors are called *polar* in geometry.

But along with polar axial vectors, or pseudovectors exist. A classic example of an axial vector is the vector product of two vectors *a* and *b*. It is a vector equal in size to the area of a parallelogram built on multiplicable vectors, perpendicular to the plane of these vectors and directed in such a way that rotation from *a* to *b* on the shortest path around the resulting vector occurs in the same direction as rotation from the *x* axis to the *y* axis around the *z* axis. The rotation of the vector can be carried out both clockwise and counterclockwise, depending on which reference frame we will use — left or right. The fact is that there are two kinds of rectangular coordinate systems, namely, left and right. In the left coordinate system, rotation from the *x* axis in the shortest possible way to the *y* axis around the *z* axis occurs clockwise, and in the right — against it. If, along with rotation from the *x* axis to the *y* axis, there is a movement along the z axis, then when using the left system, we get the movement of the screw with the left thread, and when using the right system, we get the movement of the screw with the right thread. For greater clarity, it is also convenient to use the rule of the right and left hand: we will direct the thumb, index and middle fingers along the *x*, *y* and *z*- axes, respectively; then the right hand will indicate the location of the axes in the right coordinate system, and the left — in the left.

Find out if the vector is axial or polar, as follows. We reflect the phenomenon schematically described by the vector in a plane perpendicular to the vector in question. If, in this case, the direction in which the phenomenon proceeds is reversed, then the vector is polar; if the direction of the phenomenon remains the same, then we are dealing with an axial vector. Polar vectors are displacement, speed, acceleration, force. If, for example, the velocity vector is reflected, then the direction of movement will change to the opposite — the phenomenon of motion will change the direction of flow, i.e., it will go in the opposite direction. If we reflect the phenomena of rotation in a plane perpendicular to the axis of rotation, then it is easy to make sure that the rotation will occur in the same direction, therefore the angular velocity vector of rotation is axial. Note that if we remain in the region of only right or only left coordinate systems, then there is no difference between polar and axial vectors. But during specular reflection (when one of the axes changes sign) and inversion (when all axes change their signs to the opposite), a transition occurs from the right coordinate system to the left. In this case, the axial vector changes its direction to the opposite, while the polar vector remains unchanged.

So, time is a pseudovector, and constant c_2 is a pseudoscalar. “The world course of time is determined by the universal pseudoscalar c_2 having the dimension of speed” [7]. The latter consideration is supported by the fact that numerically the value of c_2 is equal to $e^2/\hbar$, where e^2 is the scalar and *h* is the pseudoscalar. Indeed, the Planck constant *h*, having the dimension of the angular momentum (angular momentum), determines both the spin (angular momentum) of elementary particles and the external angular momenta of the electron in the atom around the nucleus. According to Bohr's second postulate, *an electron in a stationary state, moving in a circular orbit, should have quantized angular momenta satisfying the condition:*

$$m_n v_n r_n = nh/2\pi, \qquad (5)$$

where r_n is radius of the nth orbit, $m_n v_n r_n$ is angular momentum of an electron in this orbit, *n* is integer ($n \neq 0$). The state of an atom, in which it does not radiate energy, is called *stationary*. It corresponds to stationary orbits, along which electrons move that do not emit electromagnetic waves in this case, despite the presence of acceleration. The foregoing is the content of Bohr's first postulate. To understand the essence of causal mechanics, attention should be paid to the extremely important “coincidence” of the magnitude of speed included in formula (5) with the fundamental value of causal mechanics c_2, namely: **the electron velocity in the first stationary orbit (n = 1) in the hydrogen atom is approximately 2200 km/s, and the ratio of this quantity to the speed of light is numerically approximately equal to the fine structure constant α = 1/137. In this case, the velocity value of 2200 km/s numerically corresponds to the value of e^2/h multiplied by 2π.**

From what has been said, it is clear that the magnitude of the passage of time considered by Kozyrev, proportional to e^2/h, is associated with the deep properties of matter, manifested in structures of various scales — from the atom to the universe itself. Moreover, the universal course of time, i.e., the transition of a cause into a consequence, is fundamentally connected with the rate of stationary motion of an electron in an atom. This is not surprising if we recall that the atom is the main structural unit of our Universe. Of course, science also knows smaller (elementary) particles of which the atom consists — electrons, protons and neutrons. Moreover, modern elementary particle physics is already dealing with such concepts as quarks — multi-colored bricks from which particles and antiparticles are built.Nevertheless, the human body is a structure created from stable atoms assembled into molecules. Therefore, a person is aware of the world at the level of concepts embedded in the very structure of his body, so it is logical that the awareness of the elementary transition of cause to effect occurs for him precisely at the atomic level.

It is obvious that at every moment a huge number of different influences (causes) are caused on a person, causing no less huge number of consequences. The electrons in the atoms of the human body make their tireless whirling relative to their centers of attraction — nuclei. Obviously, they are spinning at the moment of influence of each cause, the elementary "brick" of which is an elementary "turn", which transfers the cause into the effect, the speed of which is proportional to c^2. Why exactly the turn? The fact is that in this chapter we are dealing with the concept of time, built specifically by Kozyrev, and he saw a simplified diagram of the world as such: "... time has two properties: 1) the scalar property, which is expressed by the existence of time intervals δt; 2) a vector property that is represented by pseudo-vectors of the passage of time $\pm ic_2$. The passage of time as a real physical process, leading from the point of view of the cause to the existence of a pseudovector of one sign, and from the point of view of the consequence to the pseudovector of another sign, is equivalent to the rotation of the cause relative to the effect with a linear speed c^2, or vice versa" [7]. The last phrase sounds very extravagant, nevertheless it is worth taking a closer look at it — after all, it was written by a person who demonstrated experimental evidence of some predictions that are incredible from the point of view of "common sense": he saw and photographed the eruption of the volcano crater Alphonse, located on the "lifeless" according to many the Moon; discovered the effect on the device of the (true) positions of celestial bodies invisible in the optical range and their reflections in time; showed that "time" can go either one way or the other, thereby causing the torsion balance to rotate clockwise or counterclockwise, etc.

Kozyrev considered his explanation of cause-effect relationships in the simplified world scheme to be formally correct, and he expected to understand his physical essence with the help of experiments, which will be discussed in the next section. And formally, he considered each elementary link in an infinite chain of cause-and-effect relations as two physical points1 located in relative rotation. He represented each point in the form of an ideal top — a body, the entire mass of which is located at some constant distance from the axis of rotation. "During rotation, the influence of such a body on a body rotating at a different speed can be realized through the material axis and material connections with this axis, the masses of which are so small that they can be assumed equal to zero. Then the interaction of these ideal tops will be equivalent to the interaction of two points having masses of tops" [7]. How legal is such an approximation to reality? In other words, are there real prototypes of these relationships in the material Universe?

The scientific picture of the world testifies in favor of the fact that at the present stage of the planet's development, the consciousness of those people who want a rational explanation of the world's structure is ready to accept Kozyrev's concept. Indeed, according to the scientific description of the macro- and microlevels of the Universe, the main structures of the hierarchical stage, extending from the atom to the studied part of the Universe, called the Metagalaxy, are collections of separate bodies (or their clusters), each rotating around its center. But it can be said in another way: the central body (Cause) rotates its space with its entire population (Consequences).

But it can be said in another way: the central body (Cause) rotates its space with its entire population (Consequences). "... Each point can be associated with a pseudovector of relative rotation $\boldsymbol{j}u$, where $\boldsymbol{j}$ is the unit vector perpendicular to the plane of rotation, u is the speed of rotation" [4]. The cause and effect in these examples can be considered point bodies. Indeed, the classical electron radius is of the order of 10^{-13} cm, and the radius of the first Bohr orbit (the distance from the nucleus to the nearest stationary orbit) is of the order of 10^{-9}, that is, approximately 10,000 times larger. So the atoms, and therefore the physical bodies built from them, mainly consist of emptiness. But what prevents our bodies consisting of atoms from turning into electromagnetic radiation? Why don't positively charged protons and negative electrons annihilate each other? Apparently, the elasticity of the "void", called the physical vacuum, does not make this possible, a detailed discussion of which will be in the next chapter.

Now let's look at the Sun – Earth causal pair. The radius of the Earth is approximately 6.000 km (more precisely, 6.370), and the distance from it to the Sun is 150 million km, that is, almost 25,000 times larger! So the solar system is also an "empty" space with rare material points — planets, asteroids, comets, etc. The sun attracts all the bodies of the solar system with its powerful gravitational field, but only those that do not have stationary orbits, for example, guests who have flown from outside, who do not have enough kinetic energy to withstand the gravitational force of the Sun. Even more "empty" is our Galaxy. Indeed, the distance from the Sun to the nearest star — Proxima from the constellation Centaurus — is about 4.3 light-years, and 1 light-year is 9.5×10^{12} km, or 9.500 billion km! And the distance from the Sun, whose radius is

1.391 thousand km, to the center of the Galaxy is equal to more than 20,000 light years. So the galactic center and the sun rotating around it can be considered a cause-and-effect pair.

Why does Kozyrev consider the speed c_2 to be the rate of transition of the cause to the effect, or the speed of the course (flow) of time? Indeed, in reality, any orbital velocity is the velocity of the passage of time — planetary, galactic, etc. Consider, for example, the planetary system, where all the bodies located in the gravitational field of the central star move in their orbits, and the orbital speed of each of the planets can be considered the rate of planetary time. For the Earth, it is 30 km/ . Similarly, for stars in the Galaxy, each has its own galactic time, etc. There is no contradiction here, just the Time of the Universe is the totality of all the times of the objects included in it — its population. And each of the orbital speeds is the speed of one of countless times. It's just that speed c_2 can be called an elementary link in an endless causal chain of events connecting the life of atoms with the life of any structure of the Universe, right up to its very structure.

And the speed c_2 is the pace of one of the times related to the most durable structures (electrons and hydrogen nuclei — protons), the lifetime of which is comparable to the lifetime of the Universe itself, and they are everywhere in it. In addition, hydrogen is the most common gas in the Universe, and all the atoms of other elements are built from it, like from brick. But in some of its parts, such as the planet, there are other more complex atoms, also built of hydrogen. Changes in the rotational energy of electrons revolving around the nuclei of hydrogen-like atoms (having one electron in the outer orbit) and having a rotation speed multiple of c_2 lead to a redistribution of electromagnetic energy in the space of the Universe, propagating with velocity c. We can say that the physical (material) body of the Universe is built mainly of hydrogen atoms. But in some of its parts, such as the planet, there are other more complex atoms, also built of hydrogen. Changes in the rotational energy of electrons circulating around the nuclei of hydrogen-like atoms (having one electron in the outer orbit) and having a rotation speed multiple of c_2 lead to a redistribution of electromagnetic energy in the space of the Universe, propagating with speed c. If we consider the material Universe as a single body, then the results of Kozyrev's experiments on instantaneous signal transmission from distant corners of the Universe become completely understandable: all atoms in the Universe - particles of one body of the Universe — are interconnected, therefore everything that happens in any of its corners immediately affects and on its other inhabitants. But for a more complete understanding of the concept of Kozyrev's time, one should also get acquainted with his other experiments, which will be discussed in the next section.