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MOTIVATIONS AND PROBLEMS OF STUDYING TIME

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1. Two images of time

Time is one of the undefined concepts in the paradigm of modern natural science. Any science is based on prerequisites like, in particular,

in geometry: a point, a line, a transformation;
in sets theory: an element in a set, an ordered pair of elements;
in mechanics: a material point, a distance, interaction, time...

In deductive sciences the fundamental undefined concepts (which are used as evident ones, and, by an implicit convention, as the ones understood in the same way by different scientists) are the basis for logical framework construction.

When we ask "What is time?", we are expecting an answer in at least two meanings. The first one is: what is the origin of the World's dynamic variability? Where does the sequence of events come from? Why is any instant followed by another one? Why does everything that exists change? Why is a totally stable World impossible?

The second meaning of the term "time" is the quantitative measure of object variability. How can one relate a number to a variation? How can one compare changes in different objects? The experience of scientific cognition prompts us that if we are unable to measure the manifestations of variability, we take a risk of being unable to gain insight into what is called its "origin".

An attempt to explicate the time concept should lead to its splitting into at least two sub-concepts:

a pre-time as an understanding of variability existing in the World and

a parametric time as a way of its quantitative description by comparison with the variability of a reference object, commonly called "a clock". Mathematically the pre-time is usually represented by the order relation on the set of events (the sequence of events), while the parametric time is just a metric on the set of events ("length" of the events).

Modern science does not contain a viewpoint upon the nature of time which could be understood as the existence of certain mechanisms creating the novelty and being the origin of changes in the World. In pre-scientific (or non-scientific) cognition such a role is commonly played by the Demiurge under whose control there are both the creation of objects and changes of their fate.

2. Motivations of studying time

2.1. Deepening of special scientific concepts

Natural science uses most readily the time concept which has been formed in the physical sciences. Time is always one of the initial, basic concepts, underlying all the dynamic constructions. Moreover, the latter, in general, gain a physical sense just due to the time concept. Thus the structure of time as a physical object is postulated to be as simple as possible from the very beginning from the viewpoint of its elementary physical properties (Akchurin 1974).

In physics time is identified with the set of real numbers. Their mathematical architecture is very rich: their construction involves closely interwoven structures of order and topology and several algebraic structures. Evidently the mathematical properties of a straight line should conform to the real properties of the physical time. The structure of order creates the succession of time instant. The additive group of number addition forms the metric to measure physical time intervals. The number multiplication group enables us to choose arbitrary units for measuring time. The real-number line topology induces the physical time continuity. However, physics does not contain a necessity and sufficiency analysis of the real line axiomatics (containing one and a half or two tens of postulates) for describing the actual properties of time. A reason for that is the usual absence of an explicit non-mathematical concept of time in physics. (Attempts to give a physical interpretation of the concept of time can be found in papers by N. A. Kozyrev (1991), Yu. I. Kulakov (1982), and also articles by Yu. S. Vladimirov and V. V. Aristov in this volume.) The physical "time of an event is the reading of a clock at rest, situated at the same place and simultaneous with the event..." (Einstein 1905, p.10), i.e., the properties of physical time coincide with the properties of physical clocks.

A number of operational methods of the time interval measurements able to play the role of clocks have been suggested in physics. These methods are based solely on physical objects variability standards.

The ability to measure a quantity does not guarantee an understanding of its nature. A classical example of inconsistency between the two is a thermometer which has been fine in measuring temperatures both in the flogiston epoch and after the appearance of the molecular-kinetic theory.

Natural scientists are not always pleased with the physical context of the concept of time measured by physical clocks and imagined as points of the real axis. Physics "specifies" time by excluding the formation, i.e., the property of time described using the concepts of past, present and future rather than the terms "before" and "after". In natural science where all the studied objects are frail, where the beginning and the end of each reality is so essentially inevitable, where the reversibility of phenomena is an exception rather than a rule, the "specified" image of time can drastically narrow the possibility of extrapolating the physical concept of time beyond the frames of special relativity. The interpretation of time as an intrinsic property of a physical system goes beyond the frames of the traditional physical description (Prigogine 1984). The question of whether the time of physics is the time of natural science, is so far unresolved, though repeatedly discussed (Bergson 1926; Vernadsky 1975; Meyen 1983; Prigogine 1984).

The natural scientists' dissatisfaction with the physical explication of the time phenomenon leads to attempts to introduce specific scientific concepts of time. In some fields of knowledge time becomes an essential rather than a background factor of the existence of natural objects. Above all those are certainly the objects of biology (Baer 1861; Vernadsky 1975). The specific biological time has appeared under the name of "organic" (Backman 1943) or "physiological" (Noüy 1936) time and continues to focus the scientists' attention (more detailed references can be found in the papers by A.M. Maurins, 1986). Only in the seventies about 25 books and 11 thousand journal articles, connected with the problems of time in biology, have been published (Study of Time, 1981).

The notion of specific time of geology (Neumayer and Pauli 1875; Vernadsky 1975) have become a working tool in geospheric studies (The Development of Time Studies in Geology, 1982; Simakov 1977; Onoprienko et al. 1984; Harland et al. 1982). As for psychological time, in the same period 35 books and more than a thousand of journal articles appeared (Study of Time, 1981), testifying the important role of the concept of time in the science of human psyche (see also a vast bibliography in the papers by Doob (1971), Golovakha and Kronik (1984)). Sometimes also geographic (Markov 1965, Rychkov 1984), economic and social (Study of Time, 1972, 1975, 1978, 1981) times are also mentioned.

In modern natural science, along with the studies of the scientific times, temporal characteristics of objects in different branches of rhythmology are frequently investigated, specifically, their variability with respect to astronomical cycles, synchronous with them or their multiples. However, there exist acyclic variability, irregular and unique temporal characteristics which also play a significant role in natural science. They are not covered by rhythmology but are studied within a wider investigation programme, namely, temporology (Maurins 1986). The concepts of time acquire unequal senses in the intuition of scientists studying different fragments of the reality. Therefore as far as time is one of the undefined categories in the conceptual framework of science, temporology cannot be the field where a consistent discussion of the concepts of time would be possible.

Unlike many natural sciences, the field of human activity connected with the construction of computer "knowledge bases" and "artificial intelligence" inevitably requires an algorithmable construction of real time (Kondrashina et al. 1989).

2.2. Measuring the age of natural systems

A "true" age of a system can be measured only using the system's proper time scale rather than the astronomical one. To achieve that, a "proper scale" must be found and constructed.

Applied gerontology needs markers of the body's biological age. When temporal bounds of a person's professional fitness are to be determined, the characteristics of biological rather than astronomical age are of importance. The solution of the basic problem of gerontology is now moved towards the attempts to achieve big astronomical ages to the methods of broadening the bounds of fruitful biological age.

Each economic or social system has its own age and its own development stages. Knowledge of natural functioning durations for social systems is necessary for planning the development of economic systems. An alternative to scientific studies of the temporal structure of social systems is a voluntaristic determination of the beginning and termination times for different stages of the development. If markers of a person's spiritual development stages are absent, a realistic conception of education is impossible, as well as a model of the school adequate to the temporal characteristics of the objects of education. (The present model is oriented at the education stages which equalize the students in the astronomical time scale rather than take into account the individuals' natural development stages.)

2.3. Scientific forecasting

Forecasting is one of the basic functions of science. The scientists' helplessness in forecasting the ecological consequences of human activities, seismic and climatic disasters on the Earth, the society's scientific, technological and social development aggravates the survival problems for the whole humanity. From A.M.Maurins point of view (1986), the most common factor exciting the humanity's interest to the problems of time, is a sharp acceleration of the social processes creating "a shock from a collision with the future" (Tofler 1972). Any scientific forecasting methodology implicitly contains the scientist's conception of time.

Here is the way in which R.Rosen discloses this implicit content using the modelling method as an example: Dynamic models include time as an essential variable and serve as a crucial factor for forecasting-based control. However, for studying them a neat investigation of the very notion of time, along with everything hidden under that notion, is necessary. Time itself turns out to be a complicated category since it admits many different models and images for its understanding. Thus in classical mechanics time is implicitly defined by a classical Hamiltonian set of differential equations... and this form is drastically different from that used when stochastic processes are described. Thus time as it is found in statistical thermodynamics is quite incomparable with that in the Hamiltonian formalism. There is another aspect of time, the so-called logical time, connected with the concept of logical preceding. The interrelations existing among all these various forms of time, are of extreme interest. They find its fundamental manifestation in the dynamic model treatments and in the nature of forecasts obtained using these models (Rosen 1980).

The forecasting problem can be formulated in a much more general scientific context. One could speak of searching the causes creating the very dynamics and evolution of the World's objects, i.e., the principles of event determination or causality.

2.4. Manipulations with time

Stressing the necessity of studying the problem of time, I. Prigogine (1984), referring to the fundamental work of J.Needham (1969), noted that even Chinese alchemists' supreme purpose was to be able to manipulate with time, namely, to make the biological time of their bodies obey their will. Knowledge of the origin of systems' temporal characteristics can make it possible to solve applied questions concerning time control and mastering, more precisely, to scientific ways of acceleration or deceleration of the systems' natural development. The proper development rates of natural objects vary significantly. The studies of time should explain the causes of the differences and reveal the possibilities to render influence on the proper time of the objects (the bounds of age, development rates, relative proceeding rates of different stages). If the temporal characteristics of a system cannot be affected, the very understanding of that could apparently be a significant scientific achievement.

In the seventies there appeared a hope that experimental studies of time might become part of normal physical studies. N.A.Kozyrev, led by his own conjecture on the substantionary nature of time, discovered the influence of irreversible processes, both on the Earth and in space, on the weight of nonrotating and rotating bodies and on some properties of matter, such as density, elasticity, viscosity, electric conductivity, etc. and on the conditions of living systems. N.A.Kozyrev connected the active factor of the irreversible processes with the active properties of time, with causality and with so far unknown physical energy sources (Kozyrev 1982, 1991; Yeganova 1984). At present a certain doubt still remains on whether all the traditional causes of the observed phenomena have been taken into account. The absence of observation of N.A.Kozyrev's effects in regular precision measurements and other experiments in the laboratories of the world also requires thorough explanation. For instance, Shaw's experiments (Piragas 1971), where the influence of the nonequilibrium process of heating on the value of the gravitational constant was investigated, demonstrated that the reading of a torsion balance was invariable up to 1.6×10^{-6}, while Kozyrev's effects are of the order 10^{-4} - 10^{-5}. However, an explanation of N.A.Kozyrev's experiments by more prosy conjectures than the active properties of time, was absent as well. The second part of this book contains a detailed discussion of the "active" properties of time according to N.A.Kozyrev.

The applied problems of time studies can be solved adequately only with the development of theoretical knowledge for which elaboration of the constructive notions of time is in my opinion of top necessity.

2.5. Time as a component of theoretical knowledge

A task of the scientific approach in natural science can be formulated as the ability to forecast the variety and variability of natural objects.

In my opinion, the basic motivation in studying the time phenomenon is a hope to discover the ways of finding the laws of variability. One of the basic objects of science is to obtain these laws, otherwise it becomes impossible to fulfil the forecasting function of the cognition. Apparently it is impossible to find the laws of variability without having the correct causal and parametric descriptions of time.

A dynamic theory describing any fragment of the reality inevitably includes a number of components whose development forms, deliberately or, more frequently, implicitly, the stages in the process of creating a theory. (I.A.Akchurin (1974) is the one who clearly revealed the inevitability of solving some of the classes of methodological problems listed below.)

- The O component is a description of an idealized structure of the theory's elementary object.

- The S component lists the possible states of the objects. In other words, the

S component is called the space of states of the studied system.

- The C component fixes the ways of object variability and corrects superfluous idealization connected with object selection, since there are no objects in the real world, there exist processes whose abstraction leads to the notion of objects. The C component inserts processes, variability, i.e., the "pre-time", to the theory.

Instead of rigorous definitions, I would like to give some examples of elementary objects and their variability.

In classical mechanics the elementary objects are material points with their positions and velocities in the physical space. For instance, the planets of the Solar system. The variability is determined by trajectories of the points. The space of states is the six-dimensional phase space, the product of the three-dimensional Euclidean space and the three-dimensional space of velocities.

In quantum mechanics the elementary objects are the probability amplitudes of the states of micro-objects (for instance, the energy states of an atom). Variability in the space of states is determined by trajectories of vectors in the infinite-dimensional Hilbert space.

In nuclear theory the elementary objects are nucleons and some other elementary particles with their specific sets of quantum numbers. The variability consists in mutual transformations of particles and radiation. The space of states is confined to the combinations of quantum numbers for the transforming particles which satisfy the conservation laws.

In embriology the role of an elementary object is played by a living cell, while the variability is the process of cell fission. The space of states is described by archetype morphological indications in zoological taxonomies.

In ecology of communities an elementary object is a population of organisms. The variability consists of births and deaths of individuals. The space of states can be described as a set of all possible vectors $\left(n_1, n_2, ..., n_k\right)$ where n is the number of individuals of the i-th species - member of the community. The numbers are limited by the available resources of the environment.

- The T component of a theory consists in the introduction of clocks and parametric time into object description. The parametric time can be understood as an image of changing objects when the variability process is mapped into a linearly ordered set with a metric (generally a number set). The variability of a selected object is usually taken as a standard to be used in the measurements of other variabilities. A clock is just a natural object whose variability is a standard and an operational way of the above mapping.

Traditionally in natural science the clocks are based on physical processes, such as constructions with an elastic or gravitational pendulum, and on astronomic devices fixing the Earth' s rotation around its own axis or around the Sun. Modern clocks use caesium or other sources of electromagnetic oscillations; from recent years the pulsar standard of hyperstable periods is widely discussed; radioactive decay can also be used. Here is A. A. Friedmann' s (1966. P.50-53) description of the emergence of physical clocks: "Let us relate... a certain basic motion to each physical point and define a clock of the given point M as an instrument showing the length t of an arc covered by the material point in its basic motion along the trajectory... Let us call the quantity t the local physical time of the point M. Consider first the stellar time... Define the basic motion to be the motion of the end of an arrow of a specified length, directed from the center of the Earth to a selected star. The stellar time t will be measured by the length of the arc stroke by the above arrow end. The stellar time t will be the same in all the points of the space, it will be a universal time... Now let us consider another time, called for brevity the gravitational time... Let a material point fall in a constant gravitational field and let us take this motion to be the basic one; the clock shows the length of the path, t , passed by the point. This quantity is the one to be called the gravitational time. The stars move non-uniformly with respect to the gravitational time... Let us introduce also... the pendulum time. Let us build a large amount of equal clocks with a pendulum and define the basic motion to be that of the end of the second arrow of the clock at each point. Denote its path from a fixed initial position by t which will be called the pendulum time. Unlike the universal stellar and gravitational times, the pendulum time will be local and different at different latitudes".

Variability parametrization using physical clocks pierces through nearly all the human existence controlled by consciousness, including science, culture and everyday life... However, the changes occurring in the world, cannot be reduced to mechanical motions: there exist, for instance, chemical transformations of matter, the geological history of the Earth, the development and death of living organisms and whole communities, non-stationarity of the universe and social genesis... Would it be incorrect to recognize that the clocks which we pose in different frames of reference to describe the variability of natural objects, can be different? Can one assert in these conditions that some of the clocks, for instance, physical, are "good" while the others are "bad" ?

Such an estimate would be understandable if it concerned, e.g., Galilei, who tried to determine the law of motion of the physical pendulum, the temple chandelier, using his "physiological clock", the rhythm of his own heart.

A. Poincaré stressed that "... a way of measuring time which would be more correct than another one, does not exist. The one adopted is just more convenient than the others. Comparing clocks, we cannot say whether one of them operates well or not, we can only say that one of them is preferred" (Poincaré 1898). In the nonphysical branches of natural science more and more frequently there appears the need to use a clock unsynchronized with the physical standards but more convenient and adequate than the latter when unphysical phenomena are to be described.

In embriology the development of different organisms is effectively described using the biological time unit equal to the interval between the same fission phase (Detlaf 1982; see also the corresponding chapter of the present book). The above unit ("a detlaf") depends on the temperature and the species, therefore the laws of development revealed using the description in detlafs, remain undiscovered when the astronomical time is used. The populational time in ecology (Abakumov 1969), ethnography (Alexeyev 1975) and genetics (Svirezhev and Pasekov 1982) is conveniently measured by the number of changed generations. The chronostratigraphic geological time scale is formed from a sequence of rocks with standard points selected in open-casts with the best preserved boundary layers (Harland et al. 1982). For biology-based stratigraphy the geological epoch durations can be measured by the vertical thickness of the layers where the corresponding species are met (Simakov 1977).

In a psychological time model (Golovakha and Kronik 1984) the durations of time intervals between the events significant for an individual are measured by the number of connections between the events.

The L component of the theory is the formulation of the variability law which selects the real generalized motion of the objects in the space of states among all the possible motions (the term "generalized motion" is used as a synonym of object variability).

In mechanics and field theory such a law usually has the form of the "equations of motion" which are postulated in the theory, for instance, Newton' s equations for motions of macroscopic bodies with small velocity and weak fields, or the Schroedinger equations of non-relativistic quantum mechanics, or the Maxwell, Einstein, Dirac equations, etc. The law can be formulated in a form other than equations, such as, for instance, an extremum principle, like the minimum action principle (only those trajectories are real for which the temporal integral of the difference between the kinetic and potential energies is the least). The formulation of the variability law using the equations of motion is equivalent to that of the extremum principle. The "derivations" of the functionals used in the extremum principles often include considerations connected with the invariance properties of the space-time or field variables.

If the action functional of the studied system is known, the dynamic equations, e.g., in quantum mechanics can be obtained using the Feynman path integral method (Feynman and Hibbs 1965). The least action principle turns out to be a specific case of the Feynman principle.

An unusual method of variability law derivation, in particular, in the form of the Newton and Dirac equations, appears in the physical structure theory and binary geometrophysics (Kulakov et al. 1992; see also the chapter by Yu.S.Vladimirov in this book). Formally the laws follow from the requirement that a certain specially constructed Gram determinant should be zero.

For many fields of natural science (in particular, for the already mentioned nuclear theory, embriogenesis and ecology) the variability law formulation is the aim of theory construction. This aim cannot be achieved if the classes of problems forming the O, C, S, and T components of the theory, are not solved in a consistent way. In natural science methodology the C and T components are elaborated less than the others. There is a close connection between the choice of these components and the way of obtaining the L component. According to A.A.Sharov (see the chapter in this book), the law of motion is a description of the variability of the studied object in terms of the variability of the standard clock, therefore the ability to discover the variability law can depend on the adequacy of the standard clock selection to the studied processes. The laws of motion affect the ways of measuring time in the domains where the T and L components agree with each other (Le temps et la pensee physique contemporaine 1968), for instance, "...simultaneity of two events or their sequential order, and the equality of two durations, must be defined in such a way that the formulations of the natural laws would be as simple as possible" (Poincaré 1893).

It seems that the difficulties in obtaining the equations of motion in many fields of science are connected with the disagreement of the physical methods of time measurement with the unphysical nature of the studied laws.

Finally, the I component of the theory is formed from the set of interpretation procedures. Firstly, that is the procedure of relating the mathematical constructions of the theory, which have, as a rule, a formal character, to the abstract notions of the reality; secondly, those are the rules of how these abstract subject notions are related to the quantities measured in the experiment.

Thus the formalism of quantum mechanics uses the complex-valued wave functions and the operators acting upon them as the above formal objects. A transition to the concepts of the macroscopic reality is carried out by certain postulated rules: the absolute squared value of the wave function is the probability of finding the particle in the specified point of the space at a given time instant, while an eigenvalue of an operator is a numerical value of the corresponding physical quantity. Observation of the probability distributions requires, for instance, interference experiments with particles penetrating through barriers. The energy characteristics of an atom are determined via spectral line spacings in the experiments with radiation emission and absorption by the atoms.

The I component is a necessary ingredient of a theory. It is the interpretation procedure that turns a formal theoretical scheme into a science studying the reality. The possibility of developing the I component depends not only on the advantages of the theoretical scheme, and often not even as much so, but also on the "technology sum" achieved by the whole civilization.

Democritis' conjecture on the atomic structure of matter required a millennium to become a verified theory.

The enormous experience of the X-ray structure analysis has turned out to be necessary to transform the discrete heredity substance conjecture, the one put forward nearly a century before, into a consistent model involving a double spiral of the deoxyribonucleic acid.

3. The basic tasks of the studies of time

A consistent solution of the theoretical and practical problems connected with the studies of time is impossible as long as time remains among the basic undefined concepts of science. In the modern scientific paradigm the time phenomenon is implicitly present in the explanations of practically all the manifestations of the reality. Apparently natural science lacks the entities and (or) elements of the conceptual basis to explain the existence of time. In my opinion, the main problem in the studies of time is to create an explicit construction of time which could yield a sufficiently rich language for discussing the intuitive notion of time inherent to the scientists investigating different sides of the reality. At present the main hing in the posed problem is to realize that the problem does exist.

M.Ichas (1969, p.23) stressed that such an understanding is nontrivial, on the example of the genetic code: It has been the most difficult in the "code problem" to gain the understanding that the code does exist. It required a whole century.

The work aimed at creating such a construction of time that would meet all the requirements, is apparently unfinished. Summing up the viewpoints of the investigators of time, Prof. J. T. Fraser, founder of the International Society for the Studies of Time, was very optimistic: "But a universally acceptable framework that could accommodate the multitude of views about time, one which could serve as a guide for critical studies, does not exist. It may never be possible to consider physical, biological, psychological, historical, literary, and philosophical notions of time under the same heading. Yet, a survey of the literature of time does not leave one with the impression of complete incoherence, but rather with a kind of feeling that researchers often have while examining unreduced data. Surely there is a design to be found; surely there is universal truth to be discovered; there must be a pattern hidden somewhere among the multiplicity of facts, utterances, and fiction" (Fraser 1981, p.XIV).

The views of time are closely connected with the concepts of motion, space, interaction, energy, entropy, etc. Thus a construction of time must be in agreement with these and many other constructions of general scientific concepts. A replacement of the time postulate in the conceptual ground of natural science would imply a significant revision of the whole conceptual framework of science. The experience shows that, despite the complexity of the problem, revisions of the conceptual grounds of separate branches of science occur rather frequently.

Beginning with the publication of G.Kantor' s works, till the sixties-seventies of this century, sets theory was considered as the basis of modern mathematics (see the treatise "Foundations of Mathematics" by N.Bourbaki, 1965). The concept of extreme significance for mathematics, that of mapping, is constructed in sets theory from such undefined concepts as an element, a set, an ordered pair, etc. In the recent decades the mathematical literature becomes more and more oriented on the theory of categories and functions as conceptual basis of mathematics. In category theory the morphisms (analogs of mappings) with the necessary associative composition properties appear in an axiomatic way as initial undefined notions Category theory makes it possible to construct rather than postulate the categories of sets consisting of analogs of elements. category approach leads to a very natural formulation of the concept of a mathematical structure. The language of category theory is perhaps more adequate to the problems of natural science than the language of sets theory.

4. The properties and problems of time

Evidently, different versions of the construction of time are possible. What are the plausibility criteria for those constructions? The problem approach to reviewing the developed models is suggested: to be adopted, a suggested model must describe certain properties of time, it must solve the prescribed set of problems and, as much as possible, it must give a key to the derivations of the laws of natural object variability or open a way to experimental studies of time.

An a priori selection of the verifying criteria certainly depends on the intuitive views concerning the content of the time phenomenon. I would like to suggest to the reader a set of the properties and problems of time formulated by the initiative group of Moscow Interdisciplinary Seminar on the Studies of Time in Natural Science (M.A.Arkadyev, A.D.Armand, D.A.Cherepanov, A.A.Kronik, A.P.Levich, G.E.Mikhailovsky, V.M.Sarychev, V.A.Volodin and A.A.Sharov).

4.1. The properties of time

- Is time universal or specific for different systems? If the latter is true, what is the sense of the assumed specific character of natural-scientific times, e.g., biological, geological, physical and others? What are the subordinations and connections of those specific times with each other?
- Is time discrete or continuous?
- Is time homogeneous or qualitatively alternate?
- Is it bounded or boundless?
- How can one describe the inhomogeneity of the proper times of different systems?

4.2. The status of time

- Is time a reality or a convention?
- Is time a substance or a relation?
- Does time depend on matter? In other words, does the variability require a sort of external cause or is it a consequence of the inherent, independent activity of matter (Prigogine and Stengers 1986, p.362)?

This problem can be put in another way. M.A.Arkadyev unites the concepts of matter and time saying that when we study the world, we study the "matter-time". A unification of these two concepts into a single one is justified by the fact of fundamental significance that matter cannot be observed without its inherent processuality while the latter, within natural science, cannot be observed apart from matter.

- How do the natural systems "organize" or "produce" time?

4.3. The problems of time

-What is the origin of the appearance and the course of time? What is the cause of the World' s variability? Why is the totally stable World impossible?

-Why is it that all the events throughout the World do not occur simultaneously (Whitrow 1961, p.352)? Where does the sequence of events come from? Why is any time instant followed by another one?

-Why is the present moment unique?

-Is an existence outside time possible?

I would like to note that the latter problem is in close connection with the constructions of time: "Let us make a small excursus to cognition theory and ask ourselves, what is available for direct observation? The answer is - the boundaries of the objects rather than the objects themselves. We can see the water of the sea and the sky over the ground because of the boundaries they have with the shores, the air and the mountains. But the pelagic fishes could conjecture the existence of water only in case they were caught and extracted to the air. Thus, we know that time exists as a category, but without seeing its boundaries we cannot give it a definition to be adopted by everybody. And the stronger the contrast, the clearer for us are the objects which we cannot see but surmise..." (Gumiliov 1979, p.41).

- Why is everything that exists, perishable?
- What is the relation between time and causality?

In D. A. Cherepanov' s opinion, natural science, whose spirit is close to that of the idealized views of classical physics, treats all the processes as deterministic ones, thus extracting the formation of everything new from the scientific picture of the world. Therefore time only plays the role of a parameter characterizing a sequence of the unambiguously connected events following from one another. However, the development of natural sciences led to an understanding that such a view of time and causality is no more than a convenient idealization and that our intuitive feeling of the qualitative difference between the past and the future, the feeling of a specific markedness of the present moment, must be explicitly introduced into the scientific description. Quantum mechanics and relativity theory, statistical physics and information theory, theoretical biology and geology are intrinsically ready for such a revision of the "Newtonian" time. Evidently, a consistent transition to a new time concept is very difficult to perform; however, even a negative result, a determination of the possible boundaries of the deterministic description of the reality, would be of extreme significance for further development of natural science. An example of that kind of changes in our views about the relations between causality and fortuity can be found in the rapid development of nonequilibrium statistical physics and nonlinear thermodynamics (Prigogine 1984). Thus one of the aspects of the studies of time is a revision of the classical views of causality.

- In what way is time included in the conceptual basis of natural science? Namely, in which way is time related to the other natural-scientific constructions such as space, motion, structure levels of matter, life, energy, mass, entropy, interaction, etc.?

Essentially, thinking of a definition or the nature of time, we have to re-construct the whole world outlook. Here are the words written in this connection (in a private correspondence) by one of the deepest investigators of time in natural science, our contemporary, S. V. Meyen (see A. A. Sharov' s chapter in this book): "Each time when I read the words "what is that" or "what is happening", a question occurs: what is the meaning of these words? What answer does a person want to get? Just a definition? But definitions are impossible as far as the philosophic categories or natural taxons are concerned. I have a strong suspicion that an answer to the question "what is that" about consistent concepts must mean a description of a large fragment of the world (or world outlook), including the object to be characterized. Thus, one cannot give a definition to the Moon, a sunflower, the force of gravity, etc. One should present large fragments of astronomy, or botany, or physics, and insert the corresponding notions to these fragments, indicate their places there. The same story goes with time. To answer the question "what is time?", it is necessary to describe a piece of the world outlook (general, or specifically scientific, etc.), with time included there".

Yu.S.Vladimirov (1982) depicts the alternative concepts of constructing the physical picture of the World in the following way:

-The common concept assumes the elementarity of the three physical categories: space-time, the physical fields-interaction carriers and the particles of matter.

A purely geometric concept is based on the understanding of the space-time manifold as the substance on which all the forms of matter appear as manifestations of certain geometric and topological properties. This approach is claimed in the most extreme form by Wheeler' s colleague (Wheeler 1962): to build "matter without matter", "charges without charges", etc., i.e., in the geometric paradigm the elementary entities are the space-time and the interaction carriers while the particles of matter with nonzero rest masses must be constructed within the theory.

According to the concept, more precisely, theory of direct particle interaction, the space-time and particles are postulated, so that particles interact directly rather than through the fields. The category of fields - interaction carriers in this theory has an arbitrary character.

The fourth concept also has the right to exist, in which the particles and the interaction carriers are chosen to be elementary categories while the space-time relations must appear as consequences of the above two elementary categories.

In a paper published in 1992 (Kulakov et al. 1992, pp.142-147) Yu. S. Vladimirov has already described as many as ten research programmes with different sets of the fundamental physical entities.

- What are the relations between the coordinate time of the systems (the sequence "earlier - later") and the "proper" time (the sequence "past - present - future")?

- What determines the variety of the "proper" times of the systems and processes (the times of existence, relaxation, development...)?

It goes without saying that these lists can neither exhaust the existing properties nor the possible problems of time. An inquisitive reader can apply to the fundamental works of J.Whitrow (1961), Yu.B.Molchanov (1977, 1980), J.Fraser (1978) and V.P.Kazarian (1980). As for the problems themselves, they challenge the natural scientists: which construction of time is able to solve them?

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