

FIGURES OF TIME IN EVOLUTION OF COMPLEX SYSTEMS

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SUMMARY. Owing to intensive development of the theory of self-organization of complex systems called also synergetics, profound changes in our notions of time occur. Whereas at the beginning of the 20th century, natural sciences, by picking up the general spirit of Einstein's theory of relativity, consider a geometrization as an ideal, i.e. try to represent time and force interactions through space and the changes of its properties, nowadays, at the beginning of the 21st century, time turns to be in the focus of attention. It turns to be possible to represent space through time, because synergetics shows that historical and evolutionary stages of development of a complex structure can be found now, in its present spatial configuration. A whole series of paradoxical notions, such as "the influence of the future upon the present", a "possibility of touching of a rather remote future today", "availability of the past and the future now, *in praesenti*", "irreversibility and elements of reversibility in the course of evolutionary processes in time", "discrete unites, quanta of time", appear in synergetics.

Key words: complex systems, future, irreversibility, nonlinearity, pre-determination, self-organization, space and time, synergetics, tempo-worlds, topological properties of structure-attractors

1. DIFFERENT ASPECTS IN STUDY OF THE PROBLEM OF TIME

The problem of time can be discussed in different aspects, viz. the physical time, the psychological time (time perception), the images of time in the history of human culture, including the images of time in myths of the Eastern and Western cultures, the historical time (temporal characteristics of the flow of human history). In this article, I touch upon the first two aspects: the physical time and the psychological perception of time. My attention is concentrated on the question how our notions of time change in connection with the rapid development of the theory of self-organization of complex systems, named also synergetics after Hermann Haken (Haken, 1977). This is first of all the physical aspect of time. Since the models of synergetics are physical by their origin (the models of formation of a coherent laser radiation by H. Haken) or physicochemical (the model of

brusselator for the description of the periodical chemical reactions by I. Prigogine). But we should add a proviso here, inasmuch as synergetics is an interdisciplinary, or better to say *transdisciplinary*, theory. And in transdisciplinarity, there are both the aspect of *inter-*, i.e. of interaction of different branches of science, the aspect of *meta-*, i.e. of going out beyond the fields of physics, chemistry, biology etc. on a certain metascientific method of research (because some patterns of complex behavior in general, of the complex both in nature, in society and in human mind are being discovered), and the aspect of *trans-*, i.e. of transition through disciplinary boundaries, of transfer of cognitive schemes from one research field to another. When revealing general patterns of complex behavior, synergetics is able to say something not only about time in the physical sense, but also about time in the most general, metaphysical sense.

The psychological aspect of time is not of less importance. The problem of time perception is under consideration since Edmund Husserl's time. In 1905 he delivered a course of lectures on the phenomenology of the inner perception of time (Husserl, 1966). The texts of these lectures were originally published in 1928 by Martin Heidegger. The lectures contain some profound ideas which are until now a subject of interpretations and discussions. The problem of time is touched upon from different sides in the modern cognitive science as well that involves a whole series of scientific disciplines (psychology, neurophysiology, biology, computer science, artificial intelligence) which study how the human brain works, how the human psyche functions, how the human mind is arranged and how it works, how a human being cognizes the world. A dynamic approach is under development now in cognitive science. The approach is based on the application of models of nonlinear dynamics and partly synergetics (Varela *et al.*, 1991; Port and Gelder, 1995). Some notions of discreteness and nonlinearity of time arise in the frames of the dynamic approach. The notions are similar to synergetics and will be discussed here.

To begin our consideration of the physics and metaphysics of time, I would like to recall an almost poetical image of time which is given to us by Heraclites. The world was, is and will be an eternally living fire which lights up according to a certain measure and goes out according to a certain measure, i.e. the world undergoes permanent changes, the switching of different regimes of evolution going on. The world doesn't change in a linear and monotonous way. The change of the world is subordinated by certain cycles and rhythms, but it is a realm of random and emergent events as well. According to Heraclites, time is not a clock that is winded one and for all, it is neither a machine with a monotonously working mechanism nor a blacksmith automatically counting out blows, when letting down his hammer on an anvil, it is rather "a child playing pebbles". This image of a playing time and of a constant trial of possibilities of the world is very

close to the spirit of synergetics. The world is open and overcrowded with possibilities and with structures-attractors until not realized, the world is a fount of possibilities. The implementation of a part of these possibilities, the test of what can be implemented and realized in the world *here and now* and what cannot, what is feasible and desired for implementation in the given situation which has a certain space-time configuration is exactly a *nonlinear image of time* what can be elicited from the synergetic knowledge.

And one more preliminary note. At the beginning of the 20th century, natural sciences, by picking up the general spirit of Einstein's theory of relativity, consider a geometrization as an ideal, i.e. they try to represent time and force interactions through space and the changes of its properties. According to Einstein's views, time was spatialized, as it was a fourth dimension of space. And nowadays, at the beginning of the 21st century – due to the theory of self-organization of complex structures (synergetics) – time turns to be in the focus of attention. The emphasis is placed on evolutionary and temporal, emergent and random characteristics of appearance of ordered structures in natural, human and social systems. It turns to be possible now to represent space through time, because synergetics shows that the historical and evolutionary stages of development of a structure are represented and can be found out in the present spatial configuration of a complex structure-attractor. The spatial configuration can be treated as a unification of fragments of structures of “different ages” that carry in themselves elements of “memory of different depth”. The very space can be considered as a hierarchy of structures of “different ages”, of different temporal distinctness. Thus, the turn from a spatialization of time to a temporalization of space obviously occurs at present.

2. NON-LINEARITY OF TIME

What sense is put by synergetics in this new, nonlinear image of time? Paul Valéry says in his diaries that “time has its figures” (Valéry, 1974, 1113). According to Ilya Prigogine, time becomes a “nascent” property (Prigogine, 1997). This is not time of being, but time of becoming of organized, ordered structures in dissipative media (systems). This is time of morphogenesis of structures. This is also time of natural and, as a matter of fact, inevitable periods of catastrophes, a periodical falling out into chaos.

A whole series of paradoxical notions which suggest the nonlinearity of the course of time in the processes of evolution and co-evolution of complex structures appears in the modern theory of self-organization. They are as follows:

- a) pre-determination, the influence of the future, structures-attractors of evolution, when “the wind insensibly blows from the future” (F. Nietzsche);
- b) the past and the future are presented in the present, “the moment of ‘now’ retains all the preceding stages of development as well as all the subsequent ones” (E. Husserl);
- c) irreversibility and elements of reversibility of the course of time, the change of regimes which are opposite by implication but mutually complementary (the regime of rapid growth and localization and the regime of activity decay and of spread over old traces) as a way of maintenance of functioning of a complex organization; rhythms of the flow of time, “a rhythm lays a hazy coverlet on reality” (F. Nietzsche);
- d) acceleration and slowing down of the course of evolutionary processes, the similarity of slow processes (on a quasi-stationary stage) and rapid ones (close to the moment of blow-up) in the case of automodel, i.e. self-similar, description by a power law; “time has its density” (G. Bachelard);
- e) discreteness of time, quanta of the biological time (metabolic cycles of living creatures), of the cognitive time (frames of perception), of the historical time (life time of one generation amounting to about 40 years); “duration consists of moments devoid of duration”(G. Bachelard).

Ilya Prigogine (1917–2003) over the time of his whole life aspired to implement his dream which was expressed as far back as in 1937 in three short notes for a student journal. The dream consisted in the unification of natural sciences and philosophy through solving the riddle of time (Prigogine, 1997). He frankly spoke about the non-linearity of time:

Chaque être complexe est constitué par une pluralité de temps ‘branché les uns sur les autres’, selon des articulations subtiles et multiples. L’histoire, que ce soit celle d’une être vivant ou d’une société, ne pourra plus jamais être réduite à la simplicité monotone d’un temps unique. (Every complex being is constituted by a plurality of times branching one over another, according to their subtle and multiple articulations. The history, would it be the history of a living being or of a society, cannot any more be reduced to the monotonous simplicity of a unique time) (Spire, 1999, 25).

Of course, this image of a bifurcating, branching time is metaphorical, but the inner spirit of our age of bifurcations is reverberated in it. As regards the philosophical notions of time which are close to this vision of time initiated by synergetics, in addition to Edmund Husserl, Friedrich Nietzsche and Gaston Bachelard, it is worth to mention the names of Nicolai Hartmann, Henri Bergson, Maurice Merleau-Ponty, Alfred Whitehead, and Martin Heidegger.

3. PARADOXICAL IMAGES OF TIME

3.1. *The Influence of the Future*

The most paradoxical synergetic idea is an idea of the influence of the future upon the present (Haken and Knyazeva, 2000). It is disclosed in synergetics in two aspects. Firstly, when a system fall into the cone of an attractor, the latter becomes determinative for behavior of the system; the system begins to build and to complete itself from the future, in accordance with its structure-attractors, with its future form. Secondly, when structures of “different ages” being resonantly unified in a common integrated structure, more developed stages (higher levels of development) of a structure which are drawn to a more degree near the moment of peaking (i.e. the future) have a direct influence upon less developed structures (i.e. the present).

But what is new here? After all, the whole human activity is based on the fact that a human being is able to build his activity in a purposeful way and to consciously correct it depending on an arisen situation. He can change his purposes and can achieve a full success, can completely fulfill his plans. The new here lies in the understanding that the influence of the future, predeterminations and quasi-purposes exist not only in the human activity but also in complex (natural and made by men, artificial) systems. Besides, the synergetic idea of the influence of the future differs radically from the notions of attitude, anticipation, advanced reflection which is known in psychology and the study of behavior of animals (a frog sees a moving object and jumps to catch it, to eat up an insect). An attitude is a possibility desired for realization a bigger or lesser degree, feasible a bigger or lesser degree. As opposed to it, a structure-attractor, in the case of falling of a system into a cone of attraction, cannot remain unrealized and incomplete, cannot be constructed only partially; this is already reality, the direct and immediate availability of the future, of a future form, exactly in such a shape as it will be in the future.

Leibniz wrote that “the present is always pregnant with the future”, it carries the future in itself, in its bosom, although he denied chaos, the whole course of development is predetermined towards a certain harmonious state.

When discoursing on a superman, Friedrich Nietzsche said: “Von der Zukunft her kommen Winde mit heimlichem Flügelschlagen” (“Winds blow from the future by inaudible flappings of wings”) (Nietzsche, 1943, 83), or elsewhere: “Die Zukunft und das Fernste sei dir die Ursache deines Heute: in deinem Freunde sollst du den Übermenschen als deine Ursache lieben” (“Let the future and the most remote be a reason of your today: in your friend you should love the superman as your reason”) (Nietzsche, 1943, 65), i.e. the future defines how the present is built.

Edmund Husserl spoke about protentions as threads stretched themselves from the future (running ahead) as well as about “the depth of time”, the moment of now that retains all the preceding and subsequent stages of development (Husserl, 1966, 111–114).

And his disciple Martin Heidegger wrote that “Die ursprüngliche und eigentliche Zeitlichkeit zeitigt sich aus der eigentlichen Zukunft, so zwar, daß sie zukünftig gewesen allererst die Gegenwart weckt” (“The original and authentic temporality is hurrying itself from its own future, that is it awakes the present”) (Heidegger, 1986, 329).

Matters stand so as if – from the standpoint of synergetics – we could understand the teaching of Aristotle of final and formal causes in a materialistic way. According to Aristotle, forms don’t emerge in the process of giving shape to a thing, they are something pre-given. And if a blacksmith makes a copper ball, he makes neither copper nor a ball as a certain form, he simply gives to copper a form of ball. The form of ball exists *before* the very process of giving a shape of ball to a piece of copper. Analogously, we understand patterns of self-organization as if they would precede to the very processes of self-organization: both nature and society are drawn up in certain forms, for instance they build themselves over regular hexagonal cells which are called the Benard’s cells in the case of physical convection and are called the Cristaller’s cells (central places) in the field of geography where phenomena of urbanization are studied.

The Aristotelian notion of *entelechia*, the inner energy contained in being that impels it to finding of a certain form, is of great importance as well. Jean Petitot, the French epistemologist, disciple of René Thom who made an important contribution to the elaboration of the theory of catastrophes (or singularities), reformulates this notion. He explains one of René Thom’s major theoretical notions of “richness of content (*prégnance*), of gorgeousness of the inner sense of forms, i.e. significant value of the inner sense of forms for subjectivity (this is what was called by Kant a ‘formal subjective finality’ of organized natural forms which was opposed by him to an ‘objective inner finality’)” (Petitot, 1994, 509–510). He argues that on this basis a materialistic theory of finality can be developed. The idea of morphodynamics is a core one in the theoretical notions of René Thom. Morphodynamics is study not only genesis and appearance of forms, but also their development and completion, transmutation of forms as a manifestation of qualitative discreteness of processes in space and time, a passing of processes through the points of singularity (the phenomenon of criticality). Morphodynamics is investigation of the inner sense and the inner side of being. Physics changes thereby into geno-physics, i.e. into a science studying the genesis of physical processes.

At the synergetic models developed at the Keldysh Institute of the Applied Mathematics of the Russian Academy of Sciences, automodelity

(self-similarity) of description testifies to the unity of the whole process – both of its slow, quasi-stationary stage and its rapid stage near the moment of peaking. Both the past and the future are accessible to the unified description, can be grasped by one mathematical law, moreover the inner similarity of stages of development – of rarefaction and thickening of events – exists. If this is the case, the process would develop according to a program laid from the very beginning.

On the basis of the notion of structure-attractors as own forms of self-organization of open nonlinear media, it is necessary to highlight other key points in our vision of selection as a mechanism of evolution. When the processes of evolution of complex structure formations are considered, it is usually supposed that it is selection that leads to their perfecting and complexifying. But, from the point of view of synergetics, there are some inner laws of development. In other words, selection works only on the field of pre-given possibilities, only forms laid in the very nonlinear medium are liable to selection. These forms (purposes) do not created by selection, they are determined by own properties of the medium.

3.2. The Future and the Past are Presented in the Present

One more paradoxical idea is an idea of availability, co-existence of the past and the future in the present. Complex (by their configuration) spatial structure-attractors contain information of their past and the future. Where does it follow from? From the fact that these are steady, automodel processes, hence they are described by spatio-temporal invariants, and as invariants, as it is well known, time and space are not free but are connected with each other in some way. However, they are not connected in such a way as in the theory of relativity, they are connected with each other otherwise. And from this intrinsic connection of spatial and temporal characteristics of structures at the developed, automodel stages of evolution, a possibility of penetration in their past and the future supposedly appears. Information of the past and subsequent temporal stages of evolution is contained in a spatial configuration of a structure at present, and if we would learn how to read this information, we could penetrate not only in a plausible future that we are able to predict, but in the real future (what will actually happen to the structure) as well as not in a past reconstructed, restored by crumbs but in its real past (what was really took place). Then, everything is already available in the present, the past and the future of a structure are retained in its present, in its today's spatial configuration. This is a paradoxical idea indeed.

From the point of view of synergetics, a complex, hierarchically organized structure can be represented as an assemblage of different stages of evolution. Its hierarchy is directly connected with its evolution, with a

degree of its advancement towards the moment of peaking. For example, if we as observers are placed on some medium structure, at a certain middle hierarchical level, then structures with a lower maximum of intensity of processes seem to be structures from the past, and structures with a higher maximum seem to be structures from the future. Inasmuch as these structures are connected together in an integral structure, i.e. they are coherent and develop consistently, we as inhabitants of the middle level feel an immediate influence of the past (from lower structures) and an immediate influence of the future (from higher structures which move ahead towards the moment of peaking). Their coherence signifies the falling into one and the same tempo-world, figuratively speaking the finding of a consensus, and it is possible to come to an agreement not with everybody and not always, but only selectively and when sticking to certain rules.

A similar bond between the past and the future was named by Gaston Bachelard “une viscosité de la durée” (“an adhesiveness of duration”) (Bachelard, 1936, 10). Paul Valéry spoke about the present as a co-existence and reciprocity (Valéry, 1973, 1337). Maurice Merleau-Ponty noted that “the living present contains in itself, in its thickness the past and the future” (Merleau-Ponty, 1945, 318), that the present has a temporal depth.

Let us give an example. As it is well known, a human being is one of the most complex hierarchically organized structures. One of main purposes of social development is connected nowadays with the solving of a problem how to radically change a man in order to change for the better the social life. A man is an elementary cell of society, therefore when transforming a social medium at the level of its elements, changing own properties of this media, we can change the field of possible paths of development of the medium as well as to facilitate the attainment of preferable future states of society as a complex system. This important purpose was often formulated and is still formulated conversely: one needs to change society and the social condition of life in order to change a man himself. From the standpoint of synergetics, it is obvious that the target setting of this kind and such a formulation of purposes of social transformation are doubtful and even, perhaps, dangerous. The nature of complex structure formation in the world is like that; their complexity is connected not only with large number of elements and subsystems embedded in them, not only with the complexity of interactions between them, but also with a complicated unification, synthesis of previous historical states (stages) of development in them.

According to synergetics, a human being as a microcosm represents a synthesis of preceding stages of development, maybe even both of ontogenetic and phylogenetic development. Everywhere in nature, the coming into being of a complex evolutionary whole is accompanied by the accumulation of preceding stages of development, by their proper resonant inclusion

in a unified structure of “burning” of a human being, not by their exclusion and cutting off. Memory doesn’t disappear but retains and proceeds with working. A new world is formed from pieces of the past, from stratifications, deposits, layers of the past, from its ruptures and shifts. According to Henri Bergson, “an uninterruptedly acting past swells endlessly with an absolutely new present” (Bergson, 1945, p. 208). Of course, it doesn’t signify that all (without exception) historical stages of development are get in a complex developed structure and that they get in it in an invariable, historically fixed form. When assembling a complex whole, some preceding stages of development may naturally fall out of it, but other essential stages of development fall into the whole in a converted, transformed state. The construction of the complex whole leads to the alteration of parts, elements, subsystems belonging to it.

From such a theoretical position, we arrive at a conclusion that, with the purpose of changing a human, one should not simply displace all the old, savage and injudicious, bodily from him, from his psyche, one should not cut off his history; something from the old, from a burden of his historical path should be included, resonantly integrated, transformed in him. The falling out of some substantial elements of a complex evolutionary structure can make the further development of this structure unstable. And a management, educational, pedagogical effort aimed at the elimination of allegedly undesirable elements of savagery, unreasonableness, bodily determinacy in a human turns out simply to be ineffective.

The main principle of holism consisting in the statement that ‘*the whole is more than the sum of its parts*’ may be traced back to the ancient philosophical studies. One of the earliest formulations of it may be found in Taoism, in the philosophy of Lao Tzu. However, a complete and profound sense of the principle has been revealed only in such theories, as gestalt-psychology, systems theory, and synergetics.

The principle of consideration from the whole to its parts, of analysis of behavior of parts from the position of the whole, is quite unusual and non-traditional for the classical science. The latter moves in the course of analysis mostly from a phenomenological whole to its taking apart and studying behavior of its separate parts, and this reductionistic path of analysis isn’t supplemented by a reverse movement from separate parts to the whole, and it isn’t concluded with the construction of an integral picture.

The classical principle of superposition becomes invalid in a complex and nonlinear world we live in: the sum of partial solutions is not a solution of equation here. The whole is not equal to the sum of its parts. Generally speaking, it is neither more nor less than the sum of parts. It is qualitatively different in comparison to parts which are integrated in it. Besides, an emerging whole alters parts. The co-evolution of different systems means the transformation of all subsystems becoming parts of a

co-evolutionary whole by mechanisms of establishment of coherent connection and coordination of parameters of their evolution. The nonlinear synthesis is not at all an assemblage of rigidly adjusted, fixed structures. This is a resonant and meta-stable unification of structures of “different ages”, i.e. structures being at different stages of development. This is a combination of elements of memory so that this memory is of “different depth” (Knyazeva and Kurdyumov, 2001, 2002).

Main principles that govern the integration of such structures of “different ages” are revealed in synergetics. The integration of relatively simple structures into a complex co-evolutionary whole structure occurs by the establishment of a common tempo of evolution in all unified parts (fragments, simple structures). Structures of “different ages” start to co-exist in one and the same *tempo-world*. Moreover, if a complex co-evolutionary structure is organized from more simple structures in a right topological way (if there are a certain degree of interaction of substructures and a certain symmetry of architecture of an originating united structure), an exit to a new, higher level of hierarchical organization occurs, i.e. a step towards a super-organization is taken. Thereby the rate of development of structures which are integrated into a complex one is being picked up. The rapidly developing structures “pull to themselves” by the tempo of life the slowly developing structures. If an evolutionary whole is rightly organized, the whole begins to develop at a rapid pace which is higher than there was a pace of the most rapid developing structure before the unification.

3.3. *The Arrow of Time: Irreversibility and Elements of Reversibility of the Course of Evolutionary Processes*

It is worthwhile considering one more important synergetic idea – the idea of irreversibility and partial reversibility of the processes of evolution in complex systems. In his works, Ilya Prigogine laid always emphasis on the idea of irreversibility, of the arrow of time. He built diagrams of bifurcations and spoke about cascades of bifurcations and microstructures of events what makes the future principally unpredictable, open for us, the uncertainty concerning both the future and the past (Prigogine, 2000, 17–19). “Is Future Given?” – questioned he and gave an answer: “It is not”. Recently Sergei P. Kurdyumov and me have arrived to a conclusion about the importance of partial reversibility of evolutionary processes. In evolution, there is not only irreversibility but also reversibility.

What are grounds for such a conclusion? The grounds lie in our understanding of switching of different types of evolutionary regimes: a regime of rapid development of structures, of localization of processes and approaching the moment of peaking and a regime of recession of activity and of spreading out, “cooling”, “sleep” or “rest” of a complex structure

(organization). And why is such a switching necessary? It is necessary because a rapidly developing structure – and we live in a nonlinear world where rapid, avalanche-like processes play a significant part, – when approaching the moment of peaking, becomes unstable and synchronization within it can get broken as a result of small fluctuations that always exist in nature, and in the upshot it can fall to pieces. The structure is threatened with danger of destruction, and to avoid the destruction it needs to switch over another, opposite regime, the regime of recession of activity when this structure (organization) would “take a rest”. Hence, the meaning of reversibility, of a partial return to the past is maintenance of life of a complex structure (organization). A complex organization lives, but it is mortal, near the moment of peaking it is threatened with danger of a decay, and a switching over another regime gives a possibility for this organization to live a little bit longer, to live at least during a following cycle, to turn into another state in order to keep up a living fire in its hearth.

The synergetic idea of irreversibility and reversibility, of switching of cycles of life is very close to the idea of *autopoiesis* what literally means *self-production* (from Greek: *αυτο* – oneself + *ποίησις* – production, creation, creative work). Remarkable scientists Francisco Varela and Humberto Maturana originated in the early seventies the theory of autopoiesis that reflects the essence of the living and, in particular, as it turned out, of a complex organization in general. In the nineties Varela applied the idea of autopoiesis to cognitive systems and elaborated an original and profound conception of enactive, embodied or situated cognition that is nowadays very popular in cognitive science.

According to Francisco Varela, the essence of life consists in maintenance of its identity, in its ability to self-completion. The daily activity gives place to the rest, the sleep of an organism. As Hindus say, the sleep puts everything back in its proper place. But at the same time, the sleep is not simply the rest, not simply spreading out along old traces but also, as Varela showed us, an activation of creative potencies of the human consciousness. In the state of sleep, especially in the phase of paradoxical sleep accompanied by rapid eyes movements (REM), “the sleep grants us a space where we should not make use of things at once and immediately, but where we can train our ability of imagination, can reconceive and reformulate. This is a form of repetition that allows us to test new possibilities” (Varela, 1998, 53). As Frenchmen say, *reculer pour mieux sauter* (to recede in order to jump better). A return to the old is a way of break-through to the new.

The essence of a living being (and a complex organization in general) consists in, as Varela said, in autopoiesis, in a permanent reproduction of itself, in completing of itself, in searches of defects (whether something is destroyed) and in the elimination of these defects. Of course, the world

evolves irreversibly, it goes through cascades of bifurcations, goes towards more and more complex structures (organizations), but such a progressive motion forward isn't possible without partial and periodical reversions to the past.

Everything completes itself in the world of animate nature: out of a piece of a hydra, the whole creature grows again; a lizard grows its detached tail, and so on. Wounds on the human body are healed over, a man makes a complete recovery from illnesses, and, what is more, he can rid himself off fatal illnesses, for instance off cancer, as it was described by A.I.Solzhenitsyn in his novel "Cancer Ward". A human being restores himself continuously and maintains his identity both in biological and spiritual aspects. A complex organization of mind-body of a human being is poised "at the edge of chaos", on a fragile boundary between life and death. An irreversible bodily and spiritual growth, going upstairs in life and rising over oneself are impossible without returns to the old, without looking back, without switching to another regime when spreading out along the old traces occurs, without coming downstairs along some footsteps. One needs to descend at least a little so as one day not to roll along the whole stairs down, not to break away in a final and irreversible falling, not to die.

The processes of complication and degradation, of compression and dispersion play a vital part in evolution of stars. It may well be that, after the present epoch of expansion of the observed universe, a stage of its compression and cumulating will follow. At the same time, in the course of intensification of cumulative effects, some qualitatively different processes (chaos, a possibility of going out on a strange attractor) are apparently engaged; these processes prevent from the cumulating. Matters stand so, as if another, shady side of the world would exist. There would be something that strives for converting the course of evolutionary processes to an opposite direction. To all appearance, there exists something in nature that impedes the attainment of infinity (infinite density, infinite temperature, etc.).

As it is shown by Sergei P. Kurdyumov and his disciples, complex structures in plasma physics are also able to complete themselves and to restore themselves, they show stability in respect of fluctuations, in respect of insignificant disruptions of their organization. A renewal of processes is spreading out along old traces (former channels), simply because temperature is higher in them than in the rest of a medium. Therefore, when repeating the processes, when switching over regimes of recession of activity, these channels become more and more deep. It becomes easier and easier to spread out along old traces, and a more and precise spreading out along them is apparently taking place. And how does such a switching over turn out? Perhaps, complex structures seem stationary to us, simply because the switching over one evolutionary regime to another occurs very

rapidly in them. Such a rapid switching over, a rapid change of activity may look for an observer like stationarity. But, in reality, this is not stationarity but a rapid change of regimes.

3.4. *Acceleration and Slowing Down of the Course of Evolutionary Processes*

The notion of nonlinearity of time which is under discussion here contains also an idea of acceleration and slowing down of the flow of time. The acceleration of the flow of time occurs in the regime of rapid growth and of localization of a structure, and its slowing down occurs in the regime of recession of activity and of smearing of the structure.

The acceleration and the slowing down of the course of development have been studied by Sergei P. Kapitza in the historical aspect. He has shown that development of a global system of mankind, first of all the growth of population in the world, occurs in a blow up regime (Kapitza, 1996, 1999). There is a prolonged quasi-stationary stage in this process, and then an explosion takes place. The population explosion has started in the sixties of XX century. This explosion and a demographic transition, which is observed nowadays and is connected with stabilization of world population and even with a decrease of population in the developed countries of the West, exert a significant influence upon instability of the whole social development on the Earth at the boundary of millennia. Kapitza shows that, in the course of history of mankind, time dilation and time compression in dozens, hundreds and thousands of times take place. The scale of the historical time changes, and this scale has a logarithmic character, i.e. each following historical period is shorter than a preceding one approximately in 2,5-3 times, more precisely in $e = 2,7$ times (Kapitza, 1999, 89).

The acceleration of the historical time can be explained by giving such an example. Whereas the ancient civilizations were in existence over thousands years (for example, the history of the Ancient Egypt counts three thousands years), and the flourishing and decline of the Roman empire lasted over one and a half thousand years, the modern empires were created during hundreds years and came apart during some decades (Kapitza, 1999, 97). The acceleration of the flow of the historical time is quite evident. A “quantum” of the historical time is a scale of time to what one must refer the processes that occur in the global system of mankind. At present the history reaches the inner limit ability of the system of mankind to the quickness of development, to a quantum of the historical time which is equal to life time of one generation, which is about 45 years. The scale of time cannot be squeezed any more, everything turns on the inner discrete unite of the historical process.

The modern researches in the field of cognitive science also lead to a discovery of discreteness of time as well as of acceleration and slowing down of time perception by the human consciousness. Under the maniacal-depressive psychosis in its maniacal phase as well as in the state of stress or in altered states of consciousness when taking up the LSD, an increase in speed and intensity of the psychical and physiological processes is manifested most distinctly; a man perceives everything in an accelerated way, he himself is excited and it seems to him that all the people move very quickly. On the contrary, at a depressed stage of the maniacal-depressive psychosis, all the psychical reactions of a man are slowed down, and surroundings appear before his eyes the same, slowed down.

There exist discrete unites, “quanta” of the psychological time as well. I am based here on a hypothesis put forward by Francisco Varela. These are certain frames, i.e. limits or shots, of the human perceptual activity; their duration amounts about to 0.1–0.01 seconds. Varela supposed that such duration is assigned by rhythms of neuron discharges which are inherent to cerebral cells and by utmost temporal possibilities of summation of signals and of synaptic integration (Varela, 1997, 273). The essence on the mechanism that allows to maintain a stable frame – as it would be frozen, firmly established – in a certain time gap, as it was perceived by Varela, consists in the fact that a certain multitude of neurons from functionally and locally different areas of brain fire synchronously, the phase coincidence of their cellular activity taking place. A temporal constellation of cerebral cells is formed. The constellation stands out against the rest massif of cells because cells within it are phase-locked. “The hypothesis of synchronization of neurons postulates that it is an exact coincidence of the moments of discharging that constitute the unity of mental and cognitive experience” (Varela, 1997, 275).

The essence of framing of perception is so that nothing happens within the frame. Time stands still within the frame of perception. And matters stand as if time would consist of moments of timelessness (as Gaston Bachelard wrote in his work “L’intuition de l’instant”, “duration consists of moments devoid of duration”, so as a right line in mathematics consists of dimensionless points).

Thus, in consequence of the intensive development of synergetics during last three decades, profound changes in our notions of time occur. Time is rather non-linear than linear. Since complex structures appear out of chaos in emergent way, undergo bifurcations and cascades of bifurcations, become transformed and complicate their forms, develop in a non-monotone and non-uniform way, pass through natural stages of crisis when they are threatened with danger of destruction or they are even be destroyed partly or completely. Complex structures are autopoietic ones,

they are able to withstand corroding influences of internal and external fluctuations, reestablish their integrity, produce themselves.

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