

Creating chaos and the Life

Boris Chirikov

Budker Institute of Nuclear Physics
630090 Novosibirsk, Russia

Abstract

In this short report the first attempt of a new approach to the still mysterious phenomenon of the life, and its peak, the human being, is presented from the view point of the natural sciences, i.e. of the physics in the broad sense of the word. This idea has come to my mind about 10 years ago when doing a completely different problem I suddenly have noticed to my surprise (see [1], p.20) a wonderful relation between a very complicated human (physical) conception *creation* and the relatively simple mathematical theorem due to Alekseev - Brudno (see for instance [2]) in an almost unknown for physicists field of the so-called *symbolic dynamics* and *algorithmic chaos*, which one I have immediately christen *the creating chaos*.

Unfortunately, realizing very well an incredible complexity of all the life and especially the present human being, homo sapiens, as well as my own complete ignorance in this field, I had to put aside any farther studies of my "creating chaos" for indefinite time.

However, to my surprise, it gradually turned out that not only me, a curious physicist, beginner in this field, but honourable psychologists as well can neither understand, nor explain what is after all the principal distinction between the human being and the ape (as a generalized representative of the common highest primates) in spite it is really striking. This problem is well known to experts, yet it is not only remains unsolved but, to the contrary, is beclouding by somewhat misty hints on a possible wisdom of the ape comparable with human talent (see, for example [3]) !

Here I had just wised up, that the time of my *creating chaos* has come. Certainly, some conception of chaos, probability and statistical laws have been known since long ago, as the random mutations of genes, for example. Yet, that was not the chaos which could explain the laws of the life, so different from anything else (see for example [4,5]).

1. Creating chaos in classical dynamics. A relatively simple and detailed physical description of the symbolic dynamics is presented in [1], including the most interesting, in the problem under consideration, mechanism of *random symbolic trajectories*, or *the algorithmic chaos*. For this problem the most important peculiarity of the *algorithmic chaos* is in the statistical properties (fluctuations) of *individual trajectories* of a single particular system instead of averaging over an arbitrary ensemble in which the largest and most important fluctuations are hopelessly lost. To avoid this one can make use instead of the "true" continuous trajectories the so-called *symbolic trajectories* which are presented by the projections of the former on a certain discrete lattice in the system phase space, and moreover, in the particular, also discrete, instants of time. A finite time step of the trajectory allows to introduce a specific conception of the *complexity of symbolic trajectory* (after Kolmogorov) which, under the certain conditions, serves as the ideal *algorithmic information* (after Chaitin [6]), the main statistical characteristic of the symbolic dynamics, at least for physicists.

Most interesting and surprising here is that under the certain conditions the dynamics of such system becomes extremely chaotic in the sense of absence of any correlations in time. In other words, almost any individual symbolic (discrete) trajectory of such a system becomes absolutely unpredictable, i.e. it is impossible in principle to calculate almost any of its (discrete) values, even if all the previous as well as succeeding discrete values are known exactly ! Such is the effect of incommensurability of the dynamical scales for the continuous trajectory and its discrete symbolic projection.

In a reduced form *the symbolic dynamics* is described by a rather simple equation (see [1], Eq.(2.19)), which can be represented as

$$\lim_{|t| \rightarrow \infty} \frac{I(t)}{|t|} = h = \Sigma \Lambda_+$$

where Λ_+ are the positive Lyapunov exponents, characterizing the local instability of the limiting continuous trajectory and their sum h stands for the metric Kolmogorov - Sinai entropy. The latter characterizes the most important in the problem parameter, the complexity of a single symbolic trajectory, or *the density of algorithmic information* about trajectory on the time interval $|t| > 0$.

This is still some simplified mathematics. The physics appears in my hypothesis [1], that the algorithmic information is just the qualitative char-

acteristic of creation. The latter is always present in one form or another for any model parameters. However, a continuous unrestricted creation requires extremely strong, exponential instability of the system:

$$h = \Sigma\Lambda_+ > 0$$

On the contrary, any regular sorting out any parameters of the system, including any external interactions is going to certainly suppress any creation after all.

Moreover, for application of the mathematical method of symbolic dynamics in physics the complete absence of correlations in algorithmic information is required, at least in the limit $|t| \rightarrow \infty$.

This is just the end the discrete symbolic trajectories are used which, in the chaotic regime $h > 0$, produce the complete *indeterminism* of individual trajectories, i.e. rule out any systematic repetition of the algorithmic information, which would be a contradiction with our intuition of unrestricted creation.

In spite of unusual terminology for physicists, the physical meaning of symbolic dynamics is actually very simple. This is just a specific observation (measurement) of system motion by a human being, human itself or its special device which results only human can use for its own purposes, particularly for the science, discovered and developing by the human itself.

2. Creating chaos in quantum dynamics. Until now only classical models have been mentioned for simplicity. However, by the first look, the biological systems seem to be essentially quantum ones. If so, is there any physical meaning in the study of classical models? As a hypothesis it is not completely excluded since in both cases the main point remains the same, the external with respect to a living system measurement by the macroscopic observer, the human being. Importantly, that in this case it is not at all the object to study. On the contrary, it plays a purely ancillary role, absolutely necessary but still an ancillary one. Without direct continuous participation of the human it would be impossible to develop any science, any natural science (= physics, see beginning of this report), even though the human itself does not directly appear. Otherwise, one can say that the human being plays in science a double role:

(1) as a certain particular physical system, the extremely specific and complicated "mote" in our Universe, the mote of paramount importance for

us as human beings but not as physicists since this "dust" does not at all influence any physics of the World in spite of the so-called *anthropic principle* in the physics itself (see for example [7]) which is essentially correct but rather misleading in formulation, and

(2) as unavoidable "construction" of the whole physics irrespectively of the existence of human being itself, particularly before its appearance (!) during the evolution of the life (see for example [1] and Section 3 below).

It is just this second "hidden" role of the human being, particularly the future human, which still brings some physicists to an "evident" confusion, especially in quantum mechanics (see for example a detailed discussion in [8]). In any case, a serious question arises as to an ambiguous human construction of science, that is well known in practice of the science creation (see for example [9]). Moreover, if the creation itself turns out to be chaotic indeed, the "construction of science" becomes completely indefinite ?? This important question will be also considered in Section 3. So far, one can only remark that in mathematical language there is no serious cause to expect any considerable discrepancy between classical and quantum model which corresponds to the same method of symbolic dynamics in both cases. Perhaps, this is just the reason why physicists don't like this mathematical invention, which may look for them "suspicious". The point is that until now the characteristic quantum indeterminism, related just to the measurement, is regarded as an exclusive peculiarity of the quantum mechanics only.

And suddenly, the unexpected discovery: a complete classical model of quantum measurement ! The discovery has been made recently [10,11] by famous soviet (american since the end of 80th, expelled from USSR [12]) physicist Yuri Orlov .During many years, in unbelievable soviet conditions he was theoretically studying, in the frame of quantum mechanics, the physics of human psychics, i.e. the physical processes, designating the behavior of human both a single one as well as in a collective. One of the main problems of his studies was the so-called *human freedom of will*, its mechanism and ability. Already half a century ago Schrödinger was fantasizing about this still unsolved mystery of the life in his remarkable book on the physics of a living cell [5]. This is how he determined his curiosity to this problem in the closing chapter of his book

On determinism and the freedom of will

"In reward for the work in presentation of the purely scientific side of our problem...I beg now for permission me to express my own, inevitably

subjective view at the philosophical value of the question...I beg the reader to give up, for a time...some particular opinions, and to consider an essential point..., what could be the contribution of biologist, trying to prove in one strike both the existence of god and immortality of psyche”.

Orlov’s problem was and remains an incomparably more complicated: to prove within the physics, not a philosophical fantasy, a possibility of indeterminism and the freedom of will in human being and only the human being. And he has got the interest not simply to a problem of the fundamental science but also as an application to the politics (!): what is the freedom of will ?? the freedom of choice or ”the realized necessity” ? - a standard slogan of the soviet philosophy, attributed to Lenin even though it has been used and much earlier in the world philosophy but certainly not in such a categorical form (”old wives’ tale on the freedom of will”).

Generally, it is very important to clearly separate the truth of science (physics) which is ”ratified” by the experiment only and remains forever from various ”surmises” of the so-called ”humanitarian sciences” (see next Section), very diverse in content and strongly fluctuating in time. True, all these fantasies may turn out to be extremely useful prompts for the development of physics, yet they never are deciding because of their undetermined nature. A fresh example is the second, auxiliary, role of the human in symbolic dynamics where the human being represents not the content of the physical law but its symbolic construction only (a pun in symbolic dynamics, see Section 1).

Curiously, a prompt here could be (?) the final (critical) Kant philosophy on the ”thing-in-itself”, unobservable by the human, that almost literally corresponds to the present mathematics and physics of symbolic dynamics under conditions of chaos and indeterminism (see for example [1], p.20). Thus, philosopher Kant had got ahead of mathematician Hadamard by more than 100 years and of contemporary physicists, in the best case for them, by 200 years ! Remarkably, that even though Kant’s aim was some (any ?) justification of demand on human for the moral (which one ? any ??), he intuitively understood the necessity of ”freedom-of-will/indeterminism” combination for the human moral responsibility.

On the other hand, Orlov was the first who really has *proved*, in the frame of present physics, the principal possibility of such a combination [10,11]. Strikingly, he did this fully independently of the well known mathematical method of symbolic dynamics ! Naturally, he was using a rather different

terminology, including, particularly, and some strange expressions like, for example "indeterminism without chaos" [11]. Only after fairly prolonged discussions during the Novosibirsk conference [11] we both (I believe !) have managed to understand the very important correspondence between Orlov's physical theory and the mathematical method of symbolic dynamics .

Mathematically, both models are equivalent, that justifies using the classical model of symbolic dynamics, at least at the initial stage of studying the creating chaos of the life. Such a mechanism, classical and quantum, is really possible. However, is the homo sapiens and its brain actually constructed like this, still remains to be understood.

To avoid confusions one should note that strange at the first glance equivalence of classical and quantum models of the system in question is explained by a peculiar representation of both models which dynamics is not a "true" one but only their macroscopic observation (measurement). In the classical model (classical limit of quantum mechanics) the full dynamics of a continuous trajectory can be introduced independent of the measurement normalization, i.e. as invariant with respect to the observer. However, in quantum mechanics this question still reminds open in my opinion. In any event, the noninvariant measurement is certainly related to a very specific noncoherent state of the quantum system during measurement.

A living system open to unrestricted interaction with external sources could never be transformed into a coherent state of a partly alive "Schrödinger cat" !

3. Invariance of the Laws of Physics ? Would it be possible to develop the invariant Law of Physics in spite of arbitrary actions of the human being as an auxiliary element of the science construction (see Section 1) ? In a due time, quite a long ago, this question was put and resolved by Einstein already. Today, his philosophy (logic) of Science could be presented something like this: "The human Science is its model of the real World".

This Einstein's credo, rather well known in science, is the best resolution, in my opinion, of the closed circle of the "mutual affect" between a negligible "mote" in the Universe, a human being, and its Science which Laws control the whole Universe including the human itself. In other words, such a philosophy naturally separates the natural sciences in noninvariant human model and invariant, with respect to the model, the Law of the World. Thus I myself, as well as many others, do include in the conception of Science the Physics only (in the broad sense of the word) which contains all the

other Natural Sciences like chemistry and biology but not humanitarian ones ("unnatural sciences" in a witty remark by S.P. Kapitsa), such as philosophy, philology, economy, sociology, literature, history, law, informatics, diplomacy, politics, in short, all that directly or indirectly depend on the so-called human freedom of will (see Section 5) and, hence, cannot be invariant with respect to human models. In other words, "Supreme verdict of Experiment" is completely irrelevant to humanitarian "knowledge". Instead, the human can only classify it or as its own "conditional agreement", for example, philology and even informatics (?), or as emotional favor ("culture"), or, at last, as "persistent" attempts to guess the "genuine" interests and wishes of the humankind, which moreover are always changing. Curiously, such a separation of some humanitarian disciplines has entered even certain languages, the English, for example (see any Webster's), yet not the Russian, in any case not the soviet Russian ! Notice a clear sign of the conditional character of humanitarian "laws" or, at least, of a totally special form for some of them. Particularly, a "fresh" defence of quantum idealism [13], as a part of philosophy, has nothing to do with any definite science (quantum physics). Notice, that one should not to confuse it with the general human construction of science as discussed above. This is well known, of course (Section 2), but right now there is a fresh argument also: the equivalence of observed (measured) classical and quantum indeterminism (chaos) as discovered by Orlov [10,11] (Sections 2 and 6).

Coming back to the problem of invariance of Physics, one should also keep in mind the importance to become free from seeming influence of the human on the whole Universe. This still leads to, a hidden though, revival of ancient mystics while it could be simply an artefact of the structure of human science (see [7] and Section 2). Unfortunately, such Einstein's logic still has not yet received any development because of a formal contradiction with "basic" philosophy of the quantum mechanics which "forbids" using nonobservable variables in physics. It is not excluded that now, after the Orlov discovery, the relation of physicists to the Einstein logic would also change. In any case, there seem to be here no serious contradictions so far.

4. Evolution of Life prior to the human but according to its Science ! On this initial stage of the life development the creating chaos remains the external one with respect to biological objects. Generally, it is simply heat fluctuations which produce some random changes, particularly making the molecules of environment more complicated. The critical point of

the birth of life may be accepted as the appearance of the so-called *Darwin's triad* (see for example [5]): heritage (providing a long stability of life), variability (providing a slow evolution of life), and selection (natural, providing a fast removing of noncompatible competing species).

In the frame of my hypothesis for the physics of life, the evolution of life seems to be the most interesting as it looks so surprising comparable to other known physical processes that it still is considered by someone as incredible mystics. Roughly, there exist, at least, two essentially different processes of the life evolution. One of them, more simple and well studied, could be termed a local evolution. It is the evolution, which responds to restricted variations of the life in a regular way. In this case the variability of Darwin's triad simply means a sufficiently quick many-variant adaptation to the new conditions (see for example [14]).

Another evolution, practically unstudied yet at all, which goes on simultaneously, is much more interesting. Generally, this global evolution does not depend on the life conditions but it is just the evolution which determines the contemporary "miracle" of the life with extremely complicated structure up to homo sapiens itself.

A detailed historical review of both evolution regimes, Darwin's selectionism and neocatastrophism with sudden births of species, is presented in [15], including the many-year "opposition" of these two scientific directions, which is still not yet resolved. Nevertheless, the author [15] discerns a perspective of a new synthesis of both directions using most recent and most various achievements of the natural sciences, all well known but one which is still completely missed. This is the creating chaos, based on also widely ignorant symbolic dynamics beside some mathematicians.

Meanwhile, the creating chaos (indeterminism) is just the process which allows a natural explanation of sudden births of unrestricted species produced by an external symbolic chaos (Sections 1 and 2). If it is really in agreement with enormous empirical data collected during the epoch of "opposition", this could be considered as the first conformation of the creating-chaos hypothesis, which is not only possible in physics but also does work, as a matter of fact, in the Life, at least prior to the human. Essentially, that conclusion cardinally depends on the existence of classical model for the quantum measurement discovered by Orlov (Section 2). Very important by itself, this discovery allows for a direct relation of a seemingly pure quantum indeterministic measurement with the classical conception of creation which, in my

opinion, plays the central role in the whole problem of the Life.

Interestingly, the cardinal role of discrete quantum spectrum in biology, producing "leap-shape" mutations [5], is essentially the same as a symbolic discrete trajectory of the classical model, i.e. in both cases the observable part of dynamics only. Actually, what is really important is not the discrete spectrum in quantum model or a discrete classical symbolic trajectory but the possibility of unrestricted creating Nature and, hence, the evolution of Life. A quantitative estimate of the evolution parameters is determined by simple classical equations in Section 1.

5. Human kingdom under chaos control ? Now, let's turn to the top of the Nature creation, the human being, contemporary human, homo sapiens, who is cardinally different from any other biological object, including the most close to the human the highest primates, for example the ape. Nowadays, one doesn't need to be an expert for clear seeing the human "might" incomparable with anything else. What is the origin of such a "might" and where it is going to bring us in a near future ? This is one of the most fundamental problem of biology or, more precisely, of contemporary psychology. This problem is well known to the experts, yet nobody even tries to solve it. In my impression, the main obstacle in this and many other scientific problems of the Life is a common ignorance of a relatively new phenomenon of complete indeterminism (Orlov [10,11] or creating chaos [1] or symbolic dynamics (Sections 1 and 2)) while the "ordinary" chaos doesn't help at all in this case [4,5]. Meanwhile, not only biologists but even physicists (!) pay no attention to this new part of their science.

In any way, the human is cardinally different from all the other Life by its *freedom of will* which we directly feel and know simply from our own experience and our personal unique \mathcal{I} . Actually, after creating the human, the Nature has deprived it of the famous Darwin's triad based on the dynamics of biological species and, hence, of the biological evolution as well. With the freedom of will the human has become its own lord, and seems to be already ready to make the same with the famous Vernadsky noosphere.

Unlike Darwin's triad, the human freedom of will, if it really exists according to my hypothesis, is determined by an internal rather than external creating chaos. Roughly, the mechanism of human creation is related to the structure of its own brain. This structure is rather similar for all the highest primates beside the two main differences.

- (1) The human language for the wide external information exchange

among many people and for the internal thinking of a single person. Somebody considers this as the cardinal one. In essence, I cannot say anything here except that in the frame of my hypothesis the second one seems to me more important.

(2) Only the human brain has asymmetry between the both semi-spheres, a very important one, not geometrical but deeply functional.

This asymmetry is so serious that in contemporary psychology the following strange paradox has immediately appeared and is still continuing for quite a lot of time.

On the one hand - the well studied left brain with a relatively simple structure and a regular operation, which however does not single out the human within the animals (beside the language), but on the other - a "zest" (the priceless pearl) of homo sapiens, the right brain, which is so complicated that the experts have preferred to forget this to remain "experts" !

The result ? A science of animals, including the human as well, and a pure empirics for homo sapiens to control the human by human ??? Certainly, I somewhat overcolour in the sense that the creation by the human itself as a product of its right brain and the basis of its "might" are qualitatively known and accepted, at least by some experts. However, farther the science has stopped ! The reason is the same - a new unusual chaos, the complete indeterminism is required which remains unknown to physicists at all (why a new one if there is well developed old ?). Moreover, it looks that even mathematicians don't understand well their new chaos, at least with respect to the applications in physics.

Here are a few words by Poincaré - philosopher from the collection of his publications and speeches on the philosophy of science [16] (p.515).

"Even though I have to finish my considerations soon, I cannot pass over one important point in silence. The science is deterministic, it is such a priori, it does postulate determinism since it could not exist other way. It is such a posteriori as well; if it has postulated this from the very beginning as a necessary condition of its own existence, then later it rigorously proves this by its own existence, and each of its victory is the victory of determinism.. This is the question which has been studied without any success in many centuries, and I cannot even to present it in a few minutes I have".

Poincaré - philosopher just have missed a new mathematical construction developed 10 years before (in 1898) by another mathematician and philosopher Hadamard which *under particular conditions* excludes determinism com-

pletely but not at average only as the usual statistical laws do, accepted by both Poincaré - philosopher and Poincaré - physicist. Apparently, Hadamard himself also missed this phenomenon, at least in applications in physics. Even contemporary mathematicians, to say nothing about the physicists, don't seem to be much curious to a more deep picture of this strange symbolic dynamics. For example, in a mathematical paper [2] one can read: .."quasi-random" behavior ..within the framework of mathematical determinism, i.e. the uniqueness of the solution of Cauchy's problem. .. An apparent loss of determinism .. caused not by random intervention, but rather by our assumption of impossibility of a precise determination of the position of a phase point".

I would like to stress again that the scientific foundation of the human Might is the *Freedom of human Will*, the real freedom, the freedom of selection as Orlov conjectured for the human (see Section 2), and as he proved for a simple example of quantum system [10,11]. It is another problem if the human brain does correspond to this example ? In any case, my impression is that to the present time there are already no serious reasons to expect any essential differences between the physics of biological objects and the other structures in the same domain of the parameters. The evolution of life, including the big leap to the human, is certainly not the Big Bang of the Universe or its inflation. All that is already behind !

The key point is the freedom - of - will reality for the human, its moving force, which for Schrödinger was a subjective philosophy only (Section 2), the fantasy on the existence of god and immortality of psyche, never confirmed. Unlike this, in physics the confirmation is possible and necessary, via experiment (Section 3). And if this will be confirmed indeed, one more, perhaps the most dramatic one, problem is going to start up in a near future, the so-called *problem of sustainable development of mankind* (see for example [17]). The point is that (complete) freedom of will for the human means the (complete) absence of any systematic recurrences to the acts of this freedom (Section 1), hence a random, completely unpredictable behavior of the human with all its "might" over a sufficiently long time $|t| \rightarrow \infty$.

A new paradox again ! On the one hand, the human is "lord and king", and can do anything whatever it does "wish", but on the other, it does this completely at random, "not wising what creating".

The result ? A random wandering of "King and its warriors", that eventually will bring all the humankind to a big catastrophe. This danger is well

understood by even a rather restricted science of Life, and apparently by the world public trying last time some active, I would say agonized, attempts, including the United Nations, to find the solution. Preliminary, too preliminary, the expected solution has been termed "sustainable development of mankind" (see for example [17]). Here, it means the realization, or rather an attempt of that, of a certain agreed action of the whole mankind for realization of a certain selected end.

However, under condition of the freedom of will such a behavior of people is simply impossible as it is unpredictable by definition.

In principle, the catastrophe could be push away for a finite time, if one would manage (sufficiently fast !) to understand its nature and mechanism for some corrections of the chaotic acts of the will. However, also in this case the serious difficulties arise as well concerning coordination of the will even of very, very but various, various as well.

Does it mean, that all the actions of a human, even the most "genial" one are a simple chaos, including the very unusual, symbolic ?

Yes ! If this is the action of the human itself, its main role in life (Section 2). Then, it is not simply chaos but a creating chaos, the inimitable creation of any *particular human* with its own \mathcal{I} ! What is here about "the sustainable development of the whole mankind" ?

Never ! If those are just symbols of the human only, in the discovered by it and developing Science checked and "affirmed" by experiment (Sections 2 and 3). Then, the laws of Science themselves can be or not to be chaotic ones, depending on various conditions. Yet, these are the fundamental laws of Physics (the natural laws, Section 3), including the specific laws of Life and the human itself. The last laws, unlike the first are not universal at all but, to the contrary, in the framework of the accepted hypothesis, do represent the creating chaos, or the complete indeterminism. Generally, it is true in the limit $|t| \rightarrow \infty$ only, while over a finite time $|t| < \infty$ some control of the creating chaos is possible, and even its regularization via the left brain, for example (see above and Section 1).

The trouble of contemporary psychology is just in that the latter, relatively simple and very wide-spread, actually the only using method, turns out to be the least efficient (see above). Moreover, as a matter of fact, it reduces the human to the "ape" !

To the contrary, the source of the human "might" is in the right brain which should be used for the correction of asymptotically unpredictable hu-

man behavior. However, to do this the human needs to understand how does work this most complicated and still mysterious part of its own brain.

And what is not less important for both the researchers of the science of life and its practitioners, is to get rid of a *wrong* impression that the chaos control on a finite time could be extended somehow to any $|t| \rightarrow \infty$. This certainly disagrees with the symbolic dynamics (Section 1), which conserves in the limit the maximal chaos, or the complete indeterminism, only, i.e. the unique creation of the Nature or that of the human itself.

In my view, this is the main lesson for the human from its own studies of the creating chaos, no matter do physicists like that or not.

Instead of conclusion

My crucial question on the still mysterious Life:
what differs human from the "ape".

My answer:

the freedom of will and its complete indeterminism.

That is the source of unrestricted "might" of the human leading to inevitable catastrophe on our little Earth. In spite of all increasing self-delusion, the *homo sapiens* has hardly enough time to rescue itself from it own. My only hope is my own crucial mistake !? But where it is if any ???

1. B.V. Chirikov, Natural Laws and Human Prediction, Proc.Intern.Conf. "Law and Prediction in the Light of Chaos Research" (Salzburg, July 1994), Eds. Paul Weingartner and Gerhard Schurz, Springer, 1996, p. 10.
2. V.M. Alekseev and M.V. Yakobson, Symbolic Dynamics and Hyperbolic Dynamic Systems, Phys.Repts. **75** , 287 (1981).
3. P.V. Simonov, Creating brain: Neurobiological foundations of creation, Moscow, NAUKA, 1993 (see p.9 ???), in Russian.
4. M. Eigen, Naturwiss. **58**, 465 (1971); Molecular selforganization and early stages of evolution, Usp.Fiz.Nauk **109**, 545 (1973).
5. Erwin Schrödinger, What is life ? The physical aspect of the living cell, 1945.

6. G. Chaitin, Algorithmic Information Theory, in: *Information, Randomness and Incompleteness*, World Scientific, 1987, p.38.
7. B. Carr & M. Rees, The anthropic principle and the structure of the physical world, *Nature* **278**, 605 (1979); C. Hogan, Why the universe is just so, *Rev.Mod.Phys.* **72**, 1149 (2000).
8. M. Gell-Mann and J. Hartle, *Quantum Mechanics in the Light of Quantum Cosmology*, Proc. 3rd Int. Symposium on the Foundations of Quantum Mechanics in the Light of New Technology, Tokyo, 1989.
9. A.B. Migdal, The search for truth (some notes on the Science creation), Moscow, ZNANIE, 1978, in Russian.
10. Yu.F. Orlov, Origin of Quantum Indeterminism and Irreversibility of Measurements, *Phys. Rev. Lett.* **82**, 243 (1999).
11. Yu.F. Orlov, Indeterminism without Chaos: Classical Systems with Quantum Properties, Intern. Conf. "Dynamical Chaos in Classical and Quantum Physics", Novosibirsk, Budker INP, 4-9 August 2003.
12. Yu.F. Orlov, Dangerous ideas: memoirs on the Russian life, Arguments and Facts, Moscow, 1992, in Russian.
13. M.A. Popov, In defence of quantum idealism, *Usp.Fiz.Nauk* **173**, 1382 (2003).
14. V.K. Shumny, Fundamental biology and new technology, SD RAS Scientific Session, 2002, Frontiers of Science, To 50th Anniversary of the DNA double helix discovery, SD RAS, Novosibirsk, 2003.
15. E.I. Kolchinsky, Neocatastrophism and selectionism: the eternal dilemma or a possibility of synthesis ? SPb, Nauka, 2002; Yu.V. Natochin, review, *RAS Bulletin*, 2003, Vol. 73, #6, p.555.
16. A. Poincaré, *On Science*, Moscow, Nauka, 1983, A collection of publications and reports about the philosophy of Science, in Russian.
17. M.N. Rutkevich, In search for optimal strategy. To congress "RIO + 10" in Johannesburg, *RAS Bulletin*, 2002, Vol. 72, #10, p.934.