# Post-singular Evolution and Post-singular Civilizations

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*It is shown that the ability of the world civilization to overcome a singularity border (a system crisis) determines some important civilization's feature in an intensive post-singular phase of development. A number of features of the post-singular civilization can stimulate its 'strong communicativeness', which is a prerequisite for the formation of 'the galactic cultural field'. Post-singular civilizations – carriers of the cultural field – are considered as potential partners in interstellar communication and as our own potential future.*

***Keywords:*** *evolution, civilization, singularity, exo-humanism, contact saturation, SETI.*

## 1. Introduction. Scale-Invariance and the Singularity of Evolution

Initially, this work was motivated by a question related to the SETI program (Search for Extra-Terrestrial Intelligence): If intelligent life is a normal phenomenon in the Galaxy and if the rate of technological evolution is as high as on Earth, then the Galaxy must be full of highly-developed technological civilizations and we should see them in all directions.[1] So why do not actually we see them? This question is well known and is frequently referred to as the 'Fermi paradox'.

I prefer, however, the following form of the question, which is of much more significance: Assuming intelligent life to be a normal phenomenon in the Galaxy, what would such a highly-developed, technological civilizations look like and why would it be 'invisible' to us? This question is of great practical importance. If we want to find extraterrestrial civilizations, we need to understand what we are trying to find. Our methods should depend on the object of our search. If you go hunting for a duck, you should know that a duck likes water!

In order to find such an answer, one needs to first develop an understanding of what civilization might look like in the future. This is a challenge, of course, but it is rather possible. The idea is to look at technological development in the light of the general laws of evolution.

I outlined such a model of evolution on Earth from the origin of life up to the present, as a sequence of phases with phase transitions between them. It was a model of *global biospheric revolutions*. Each biospheric revolution is the result of some *evolution crisis*, and

[1] The Kepler mission (Borucki *et al.* 2011) has already discovered 68 planetary candidates of approximately Earth-size during its first three months of operation; 54 of these are found in the temperature range appropriate for a habitable zone. Undoubtedly, this is only the first small portion of what will be much larger results, because long-period planets (about one year and more) have not yet been considered, *etc.*

the revolution (the phase transition) overcomes the crisis. The list of these phase transitions includes 19 events, including the Cambrian explosion, mammalian revolution and the Neolithic revolution. The last analyzed event was the information revolution (computers, post-industrialisms – 1950) (Panov 2005).

Each of the phases becomes shorter in duration with the passage of time. Moreover, the sequence of the phase transitions is scale-invariant, which means that the corresponding sequence of time-points is a simple geometrical progression and that various parts of this sequence may be derived from other parts by scale transformation. We call this *the scaling law of evolution*. But such a sequence of points may not be prolonged to infinity in the time. Yet, the duration of phases tends to zero and the frequency of the phase transitions tends to infinity near a point of time $t^*$. Indeed, the sequence does not exist after the point $t^*$. This point is called the *singularity of evolution*. By its physical meaning the singularity of evolution is a concentration of evolutionary crises – it is something like 'a crisis of crises'. Of course, the singularity of evolution is only a mathematical artifact, because any real quantity may not become infinite. But the prediction of the Singularity inevitably means that the scaling law of evolution that has held for about 4 billion years must be changed to some other law near the point $t^*$.

The position of the Singularity point $t^*$ may be estimated by extrapolation of the sequence of the biospheric revolutions. The result is: $t^* = 2004 \pm 15$ (*Ibid.*). Therefore we are now in the time of the Singularity!

My analysis of the sequence of biospheric revolutions is not the only method that leads to a derivation of the Singularity. It has been long known that the hyperbolic growth law of human population also possesses the property of scale-invariance and that extrapolation of it predicted the Singularity for 2026 (Foerster *et al.* 1960). Additional details of this scenario were elaborated by Kapitza (1996). There is also the notion of a 'technological singularity' that was proposed by Vernor Vinge (1993); it is based on arguments like scale-invariance and was predicted to occur in the first half of the twenty-first century. Thus, a variety of arguments, each of which points to almost the same date for $t^*$, force us to seriously consider the singularity of evolution. But, we must keep in mind that the Singularity is not a single point in time – it is a period of time, approximately the first half of twenty-first century, a time when the laws of evolution and historical trajectories will change dramatically.

Now, suppose that scale-invariance and the existence of the Singularity is a universal property of evolution on all planets where life can produce intelligent civilization. Based on our experience here on Earth, the technological period of our civilization has only been a few decades long and our efforts at cosmic transmission have been low. So the probability of us detecting a similar *pre-singular* civilization in the SETI process would be almost negligible. Therefore, a potential contact partner could only be a *post-singular* civilization. Thus, the problem that we should address is: What would such a post-singular civilization look like? The other side of the question is: What is our own post-singular future? We will argue that these two sides of the question are very closely connected with each other.

## 2. The 'Exo-humanism' of a Post-singular Civilization

Let us consider the use of the concepts of 'humanism' and 'ethics'. A human being is a creature devoid of natural powerful tools of aggression – claws, fangs, *etc.* When a hominid took a stone tool and became the owner of the first technology, nothing prevented them from crippling or even killing a near relative with it. Perhaps, in many cases this was indeed done, but it might also be a reason why populations of especially aggressive hominids did not leave descendants. Less aggressive populations survived, and the prohibition on murder was fixed – first genetically (by survival), then culturally (by regulation).

As technology developed, the killing power of weapons increased. Correspondingly, cultural restrictions on aggression against both people and nature needed to improve. These restrictions were imprinted in ethics, morals and humanism. They were by no means given to human beings *a priori*, but were developed to limit the destructive action of human technology (Nazaretyan 2004, 2009; Eco 2002). There are also other such mechanisms in human culture, such as criminal legislation and its punitive system of fines, prison, *etc.* Hereafter the term 'humanism' will be considered in this kind of a wide sense: any form of cultural restriction on destructive technology.

It is clear that the survival of a civilization after its Singularity means that a civilization has managed to overcome its deepest technology-related crises. In order to overcome them successfully, a post-singular civilization must have elaborated the corresponding adaptation mechanisms and used them for its homeostasis. *If a civilization does not elaborate such mechanisms, it will not enter the post-singular stage of development* – it degrades and/or perishes. It is not difficult to imagine at least some of the necessary preservation mechanisms.

- First, sufficiently effective mechanisms to deter aggression must be elaborated. Otherwise, a civilization will destroy itself by internal conflicts related to the increasing use of irreplaceable natural resources and the simultaneous increase in the killing power of weapons.
- Second, powerful mechanisms restricting material consumption and effective use of resources must be implemented.
- Third, a civilization must overcome the centrifugal influence of corporate and state self-interest and elaborate planetary concepts, because crises near the Singularity occur on a global scale and can be overcome only by common efforts and continuous compromise.
- Fourth, the preservation of civilization must include an increase of ecological consciousness that matures to the point of becoming a social instinct.

A singularity crisis cannot be overcome without a huge jump in the power and in the depth of the mechanisms developed to constrain the destructive effects of technology. We call this jump, *the post-singularity humanization of civilization*. I emphasize once again that such 'humanization' should not be interpreted simplistically or too literally. It certainly may include ethical principles accepted by the majority of people, for example, humanism in its classical sense. However, 'humanization' can also be implemented as a system of legal and punitive measures. Its focus must be on a holistic system of cultural constraints that curb destructive technology-related effects and which will keep civilization alive as a cosmic-technological entity.

The assumption that elaboration of such constraining mechanisms is possible is not arbitrary. Based on many facts, Akop Nazaretyan has shown (2004, 2009) that cultural constraints of aggression have been increasing throughout the history and pre-history of humankind as technological power was increasing. Moreover, they were increasing at a growing rate, so that in spite of the increase in the killing power of weapons, the level of bloodshed (per capita) decreased. Nazaretyan summarized this conclusion which is *paradoxical* for ordinary consciousness as the 'Law of Techno-Humanitarian Balance' (*Ibid.*).

Recent examples of the Law of Techno-Humanitarian Balance in action are the sweeping-out of the bloodiest political regimes of the twentieth century (Stalin, Hitler, Mao Zedong, and Pol Pot) and their replacement by gentler methods of administration. A sign of the awakening of planetary consciousness and the development of ways of overcoming corporate and state self-interest is the Kyoto Protocol. A lot of other examples of the formation of ecological consciousness can be adduced, from Earth Day to international NGOs. Certainly, the idea that a developed form of humanism should be typical for highly-developed cosmic civilizations is not new. It was expressed by Konstantin E. Tsiolkovsky and Ivan A. Efremov early in the twentieth century, and recently, for example, in the papers by Gindilis (2001, 2003) and the book by Nazaretyan (2004).

It is curious that this humanization of terrestrial civilization finds its most direct expression in attitudes to the Cosmos. For example, it is clear that if there were life on Mars, it would be of a most primitive kind. We would expect that humans would think only about their own safety and ignore such potential life. But actually, all vehicles sent to Mars have been carefully sterilized so as not to harm potential Mars life! Another example is the destruction of the space explorer *Galileo* in the atmosphere of Jupiter in 2003, so as not to allow terrestrial microorganisms to infect the Jupiter satellite Europa, where the existence of life is also possible.

The dispute about the permissibility of the experiment 'Deep Impact', whose aim was to bomb the comet Tempel-1 in order to study the chemical composition of the comet, is also indicative of such concerns. Opinions varied. Many professional astronomers and astrophysicists thought that such 'barbaric' methods should not be allowed. The apotheosis of this dispute was a lawsuit brought by Marina Bai in the Presnensky court of Moscow against NASA for an award of moral damages caused by this experiment. The formulation of the lawsuit was as follows: 'The NASA activity encroaches on the vital cultural wealth and the natural life of the Cosmos, which upsets the balance of natural forces in the Universe'. The case was considered by the court, but the claim was denied. A transfer of ethical norms and ecological thought to the Cosmos lies at the heart of this case.

All this could be considered an amusing incident if not for the sympathetic attitude of many professionals. Any large-scale astro-engineering activity, including transformation of comets and other bodies in the solar system, would cause fierce opposition from the public. Large-scale astro-engineering activity may turn out to be impossible, not due to technical reasons but from a post-singular cosmo-ethics point of view.

These examples show that post-singular humanism could hardly exist in a civilization 'for internal use only'. These properties must also appear in relation to the Cosmos as a whole, whatever these relations might be: cosmic engineering, contact with non-sentient and intelligent forms of life on other planets, *etc.* An intrinsically perfect, highly-humanistic system cannot be primitively aggressive in its external manifestations. *Exo-humanism is a system of cultural constraints that limit destructive potential at the technogenic planetary level.*

It should also be emphasized that it is unknown if the process of humanization of *terrestrial* civilization is fast enough and deep enough to overcome the crisis of the Singularity. Our statement is rather conditional: *If* post-singular, cosmo-technological civilizations exist, *then* the process of their humanization in the period of overcoming the Singularity must be fast and deep, and that is why they must be exo-humanistic.

## 3. Cosmic Expansion and Intensive Development

There is a widespread belief that the negative consequences of the need for extensive technological development and the related exhaustion of irreplaceable resources on Earth can be overcome by expansion into outer space. In this fantasy scenario, billions of people will live in cosmic towns, we will use resources of other planets, all unsafe industries will be located in outer space, far from Earth. But such visions are quite groundless.

In particular, the time needed for preparation of such large-scale opening-up and settlement of space is insufficient (Gindilis 2001). It is impossible to physically accumulate enough resources for organization of an ecologically safe and inexpensive but intensive traffic to even a near-earth orbit during the few decades of the technological period. Another obstacle to large-scale astro-engineering could be cosmo-ethical or cosmo-ecological reasons related to exo-humanism. As we saw, these factors are already appearing, in spite of the modest nature of the present-day challenges.

Predictions from the 1970s about what would happen with space technology and space exploration by the end of the 20$^{th}$ century turned out to be highly unrealistic. For example, K. Erike, a participant in the U.S. space program, predicted a space station for 25–100 persons that would be put into orbit after 1985 (Levantovsky 1976: 37). Similarly, a solar power station with the capacity to produce 5 million kilowatts was also predicted, one that weighed 9570 tons and had 45 km$^2$ of batteries in stationary orbit.

These predictions had been based on a linear extrapolation of the rate of space development that had occurred in the middle of the 20$^{th}$ century, which is why they failed to materialize. The tempo of such advances was too much to maintain and many of the proposed plans are still unimplemented. Indeed, a sharp decline in space activities has already occurred. There are other things that need to take place on Earth before such extraterrestrial activity can get back on track.

After overcoming a singularity, a civilization must establish a stable existence for itself without any hope of engaging in rapid cosmic expansion. This period of stabilization must focus on the intensive development of Earth's own resources. Even if large-scale cosmic expansion is possible in principle, it cannot be allowed to occur at the expense of the technological explosion. A considerable period in the post-singular phase must pass before enough necessary resources are accumulated. Since it is difficult to make forecasts about the possibility of cosmic expansion in a distant post-singular phase, and since transition into the intensive phase of development must come first, then let us concentrate on features of behavior of a cosmic civilization in the intensive phase of development.

Proposed models of SETI research during the intensive phase of development would be determined by the overall existing conditions. Since energy resources of a cosmic civilization would be rather restricted, transmitters of signals would be only of pencil-beam diameter, whatever carrier might be used. The most probable receivers also would be of pencil-beam size and would be oriented to monitor separate stars. Powerful omni-directional stationary radiators would be excluded because of their large energy requirements. And it would also be quite probable that they would be rejected because of ethical or ecological imperatives of exo-humanism, because of their destructive effects on outer space.

## 4. Information Crisis

The issue of 'the end of science' deserves a large paper or even a book of its own, but for our purposes here, this range of study will only be considered in brief.[2] First, let us define what we mean by 'science'. There are several methods of cognition: philosophic, religious, *etc.* Science is one of these forms of cognition. A scientific truth is not a synonym for truth in general, but its results can be reproduced. In science, there are two basic classical methods to verify results: 1) a reproducible experiment in natural sciences, or 2) a deduction or calculation in mathematics (deduction is also a method of reproducible reasoning in natural sciences). We call the methodology based on the combined use of reproducible experiment and deduction: *the classical scientific method.* By definition, science is a method of cognition assisted by classical scientific method.

In the period of technological explosion, science – along with consumption of resources and energy – is in a state of a heavy (exponential) growth. The time of doubling (of different characteristics – the number of scientists, the number of publications, and the number of discoveries) is only 10–15 years (Lem 2002; Idlis 1981). The current rate of the development of science cannot last infinitely or simply for a long time; this follows from elementary arithmetic.

In his famous book, *Summa Technologiae*, Stanisław Lem asserts that we will reach the near 'saturation' of the scientific method (Lem 2002). Apparently, he was among the first to seriously discuss the limitations of science and thought that it would cause a future crisis of civilization, which would demand special measures to overcome it. Lem called it the 'information crisis', and we will use this term here.

In 1963, when this book was written, Lem thought that the exponential growth of science would last 30–70 years and that it would end in the period between 1990 and 2030. Lem wrote: 'Thus, if the current rate of scientific growth will remain, then in some 50 years every inhabitant of Earth will be a scientist'. Apparently, his forecast refers to about 2010 and, as can be easily seen, strongly overestimates the real number of scientists. Indeed, as with the space program discussed above, the growth rate in numbers of scientists has already fallen. It seems that Lem's general forecasts are coming true.

The problem of 'the end of science' still keeps exciting peoples' minds. Currently, there is a lot of literature dedicated to it, such as Krylov (1999) and Horgan (2001). From my point of view, the issue is especially important in the context of the evolution of civilization. Such an approach allows us not only to better understand the essence of the crisis but to also think of possible ways of overcoming it.

The scientific method arose in the evolution of civilization, at a specific stage of development, for the solution of important problems. The first elements of the scientific method appeared in the ancient world; however, they were not a leading factor of development at that stage, *i.e.* they were merely one of the forms of *superfluous diversity* (superfluous diversity is a pool of ideas from which society selects and which then lead to new systems after a phase transition). In the ancient world, the leading methods of cognition were philosophy, religion and art. However, the scientific method played a more important role in overcoming agrarian crisis in the late Middle Ages, and then became one the leading fac-

[2] Much more detailed analysis is presented in our paper (Panov 2009).

tors of the first industrial revolution and the subsequent development of civilization. It was a special case of very general mechanisms of evolution. Superfluous diversity was involved each time in overcoming evolutionary crises (Nazaretyan 2004).

However, sooner or later, effective solutions become exhausted, and the classical scientific method is not an exception. This does not mean that science will disappear. Old forms do not totally disappear when new forms appear; they just remain in a reduced form, yielding leadership to more progressive systems. It should be expected that the classical scientific method will lose its leading role in the development of civilization and will be replaced by other forms of cultural activity. 'The end of science' is not necessarily the end of cognition, and, moreover, it is not the end of evolution. New forms of cognition or other types of cultural activity will arise, ones that might not even be considered cognition in our contemporary meaning. This has happened before: The world of mythology was extracted from a whole primeval worldview, which was then replaced by philosophy on nature, religion, *etc.*

Although we employ inductive logic to consider the future of science, it should be understood that, while induction can be a method of constructing such hypotheses, it cannot be used as proof of anything. As far as questions about the very distant future go, a special caution should be made, since some ideas are extrapolated from the scale-invariant pre-singular stage of evolution to the post-singular stage, where the evolutionary result can turn out to be very different than expected.

It is also important to have a notion of the concrete causes that can lead to 'saturation' of the scientific method. It will allow us to understand the dynamics of the process and to estimate, at least roughly, the time scale involved. At least three basic groups of causes can be identified.

First, sooner or later, science will run into limitations caused by the lack of availability of natural resources. Such tendencies already exist. In the United States, we saw the cancellation of construction on the Superconducting Supercollider in 1993 and the recently pared-down space programs. In prospect, *at best,* science expenses could be stabilized at a constant level, taking into account the intensive character of development of post-singular civilization.[3] This must mean stabilization and a gradual decrease of the flow of *new* scientific results, because the cost of every newly solved scientific problem increases due to the increase of its complexity, in spite of development of new scientific methods (computer simulation, processing of data, *etc.*).

At present, only rare cost-effective studies are carried out by lone scientists, as was done a century ago. For the most part, scientific teams work together today, exploiting giant and very expensive experimental facilities. Many modern scientific problems can be solved only by international collaboration. Decline in the flow of scientific information (more precisely, discoveries) causes a decrease of interest of the society in science, which leads to a decrease of fiscal appropriations for studies and a further decrease in the flow of new results. A positive feedback loop is thereby closed. As a result, scientific investigations are cut back. This is especially dangerous because, due to the high rate of collapse, many participants in these events can have no time to understand what is going on. I have presented a mathematical model of this development (Panov 2009).

Secondly, it is clear that science will also encounter ethical limitations related to post-singular humanization. From examples of recent history, we can remember the strong op-

[3] Please, note that it would not be so under the conditions of the extensive growth of a civilization at the expense of the cosmic expansion.

position to experiments on the cloning of human beings. Other kinds of concern also fall into this category, such as opposition to genetically modified products that impede genetic investigation or concerns about radioactive contamination that hinder the development of nuclear-power research. Even a general distrust of science is quite widespread among uneducated people.

In addition, a third group of limitations exist – a field of research can simply be 'exhausted' for further scientific study (Horgan 1996). L. V. Leskov and V. M. Lipunov wrote about that problem in relation to SETI research (Leskov 1985; Lipunov 1997). Certainly, the potential completeness of studies in fundamental physics would not cancel out a possibility of studying phenomena at higher system levels, but it strongly reduces a probability of scientific discovery which, in fact, coincides with the interests of society.

Please, note that, in my opinion, there are no serious grounds to consider the problem of 'the exhaustion' of science to be real. But the public opinion related to it is quite real. Expectations of the end of fundamental physics (even if based on false premises) can cause public pessimism which, via feedbacks, affects the stability of science on the whole.

We have not yet mentioned the expansion of pseudoscience with its distinctly negative attitude towards real science, as well as other factors that seem to us to be less important. Thus, there is not one, but a number of interacting causes that can impede the development of science. That is why the information crisis is actually, to a great extent a *system crisis of science*. Apparently, sooner or later, post-singular civilization must deal with this phenomenon.

Overall, resource limitations would seem to be the most important issue in the crisis of science, but ethical concerns can grow stronger with time. We do not at all mean that the current state of scientific research soon forebodes the end of science; it just indicates an inevitable falling off of efficiency by the classical scientific method. Apparently, terrestrial civilization is near the first phase of this scientific crisis. Nonetheless, developing processes are so dynamic that it is unlikely that the classical scientific method will be a leader of cognition in the coming centuries. This is an issue that will unroll over the next few decades. This knowledge presents us with an opportunity to seek a solution.

Is the information crisis dangerous for civilization? A positive answer is most obvious, but some qualification is necessary. If the cognitive function of mind can be exhausted, then the end of civilization is inevitable (Lipunov 1997). Though this thesis has not been proven, it seems quite plausible and I accept it as a hypothesis. Although science is now the leading method of cognition, it is not the only one, as mentioned above. The information crisis means the closing of only one channel of cognition.

Can a civilization avoid the crisis by making one of the other existing methods of cognition the leading one? Every method mentioned above is older than science and was once a leader, but evolution does not enter the same river twice. It seems that the information crisis will inevitably lead to a general crisis of civilization. This crisis could first manifest itself in science and technology, but it is easy to imagine that such a crisis of science will lead to a larger crisis in general culture: An all-planet 'longing for something new' and a feeling of being in a blind alley may arise.

The crisis can be overcome, if a new strategy is found that can replace the classical scientific method as the leading function of cognition. Such a new strategy could be related to a considerable modification of ideas about reproducibility or truth. Brand new channels of obtaining information could also appear. The search of possible new directions for future development should be related to analysis of the pool of superfluous diversity, since all known cases of new strategies were taken from these pools. Therefore, a number of different scenarios can be conceived. That is to say, it is quite possible that the information crisis is a point of polyfurcation with different possible exits.

Here, we will not analyze all the possibilities of overcoming the information crisis (there are many of them). But it is important that one of the ways of replacement of the classical scientific method is related to solution of the SETI problem. This variant will be discussed in detail in the next section together with other particularities of post-singular civilizations. It is not difficult to see that we are dealing with the search for possibilities to overcome the information crisis among the factors of superfluous diversity. Keep in mind, though, that while work on the SETI problem is one of the forms of cultural activity of humankind, it does not yet play an essential system-forming role.

Let me make one important concluding remark about this information crisis. Although we see the inevitability of a system crisis in science in the more or less distant future, it does not follow that the support of science should be discarded. On the contrary, science should be supported as much as possible, because scientific knowledge will serve as a basis for overcoming many other crises of the singularity.

## 5. Communicativeness of Post-singularity Civilizations

It was shown above that, in the post-singular phase of development, a civilization will have to meet two problems: A restriction on space exploration and an information crisis. Besides taking out a civilization to the way of intensive development, the first problem can cause serious internal discomfort, because it will make people feel closed-in, restricted to their stellar system or a planet, as in a shell. The second problem can cause a dangerous destabilization of the overall system. Let us try to imagine the behavior of a civilization in this situation, relying on the above analysis.

A civilization like ours, which has approached the information crisis, must understand that it is necessary to access new ways of obtaining knowledge in order to preserve homeostasis. These new pathways to knowledge must be alternative to the saturated and degraded classical scientific method. If the problem cannot be solved in some other manner, then obtaining of information from other non-terrestrial civilizations could provide such a method, if it is sufficiently rich and connected to as many correspondents as possible.

Moreover, in such a crisis situation, the discovery of at least one extraterrestrial civilization could give powerful moral support for it to overcome its crisis, because it would demonstrate that civilization has prospects for progress. Simultaneously, this would also solve the problem of 'the shell complex': Real cosmic expansion would be replaced by a virtual informational one. Such cosmic transmissions probably contain information about the historical path of millions of other civilizations, which could be used to optimize pathways for our own civilization's development. That is why SETI contact could radically increase the stability of our civilization.

Such information could be obtained only if other civilizations made cosmic transmissions, which is most likely. Being exo-humanistic, a post-singular civilization would have to engage in this form of communication, which would be so important for other civilizations in the Cosmos. Highly-developed civilizations would not spare themselves with transmissions into space but would try to maximize these efforts. It should be expected that transmissions into space would actually be a stabilizing component for a post-singularity civilization that had experienced the information crisis. Perhaps, this is a possible answer to the question raised by Viktor Shvartsman (1986) about the purpose of interstellar transmissions: Since obtaining new knowledge cannot be the purpose of transmissions, consequently, this activity does not belong to science. But what could be their purpose then?

Civilizations should seek to not only send transmissions into space, but to make them as informative as possible. The simplest way to do that is the transmission of not only its own information but also that received from other cosmic civilizations. An exo-humanistic civilization also must think how to share information about vanished civilizations, which is similar to our present attitude about ancient monuments. Thus, one of the actions of a post-singular civilization at the stage of a system crisis and afterwards is active transmission of messages into space and the relaying of everything that has been received.

On the basis of such a model, any civilization that may have not yet found a contact partner and *which is at the stage of the information crisis* must apply all of its efforts to solve the SETI problem. Obtaining a new source of knowledge becomes a vital necessity of the civilization, if only to provide hope for its people. Only in this state of awareness will a civilization becomes *communicative in a strong sense.* The readiness of a civilization to spend significant resources to address the SETI problem should not be expected to take place earlier than when the information crisis becomes evident to the majority of its people. Historical experience shows that the important problems of civilization are solved only on the principle that: 'Without thunder, there is no religion'. It is evident that terrestrial civilization is still far from this communicative phase.

Does it mean that it makes no sense to engage in solving the SETI problem now? – By no means. At the time when such contact will be seriously needed, the theoretical base and methods of search for cosmic civilizations and communication with them must be ready. The on-going research and growing database of exo-planets of the terrestrial type is extremely important. And all that should be done now. As was noted, the work on the SETI problem could be a key factor in overcoming the future information crisis.

## 6. Galactic Cultural Field and the Character of Information in Cosmic Transmissions

In an earlier paper, I discussed the positive influence that such cosmic contacts might have on stabilizing civilizations. I also showed how a phase transition might be possible in our Galaxy, from the time when the probability of finding a contact partner during the lifetime of a civilization is much less than 1 (*the epoch of silence*) to when it is close to 1 (*the epoch of contact saturation*). Moreover, during the latter state of the Galaxy, it would be very stable (self-sustained). It has been shown that the dynamics of such a transition would be similar to a second order phase transition (Panov 2007).

It was further argued in the previous section that the possibility to overcome the information crisis by engaging in cosmic transmissions would actually have a significant positive influence on the linked civilizations. The expected properties of post-singular civilizations create the possibility for the transition of the Galaxy from the 'epoch of silence' to the 'epoch of contact saturation'. In such a state, the cosmic civilization population of the Galaxy would have rather remarkable properties.

In the epoch of contact saturation, messages sent by a civilization to space during the communication phase will be received and relayed by at least one other civilization with a probability of about 1. That is why information about civilizations that completed the communication phase can be kept in the Galaxy during an indefinitely long time, being transmitted from one civilization to another. Upon establishing the state of contact saturation, the amount of information available to all in the Galaxy increases steadily and turns into a single cultural field. We emphasize that the existence of the cultural field does not mean two-way communications between civilizations.

As information in the cultural field is accumulated, every civilization, proceeding from the imperative of exo-humanism, will process and relay greater and greater amounts of it. When that information begins to flow, the post-singular communication system will become so saturated with data that it will be impossible to relay all of it. Cosmic civilizations will start selecting the most valuable. In its turn, changes of the information content will have a feedback influence on the constitution and properties of civilizations in the Galaxy. The cultural field will turn into a single umbrella-civilization, evolving according to its own laws. Actually, we deal with a qualitatively higher level of organization of matter following the social one. As such, the galactic cultural field has many interesting properties, which I have discussed in detail in a previous paper (Panov 2003).

Establishment of the cultural field is very similar in its essence to the 'big correction' of V. A. Lefebvre (1997). The case in point is the coordinated activity of many intelligent 'cosmic subjects' for improved development of life and intelligence in the Universe. Lefebvre considered the situation in which cosmic subjects do not have the possibility to agree directly with one another upon fulfillment of this work and have to act on the basis of the moral imperative in the hope that the others act in the same manner. Such a scenario of behavior of post-singular civilizations corresponds closely to his idea.

A model of the cultural field suggests that the typical cosmic transmission of one cosmic civilization must contain information of many, maybe millions of other civilizations. It would be a complicated and branched information system. The term 'transmission' is inadequate; one needs to talk about *an exo-bank of data.* Transmission of such a huge amount of information with the help of a modulated laser beam or a wide-band but narrow-beam radio signal would not be an unsolvable problem for a civilization whose energy resources do not exceed those at the planetary stage of development, as expected for an exo-humanistic, post-singular civilization.

It is easy to imagine the possible character of information in exo-banks of knowledge. Obviously, it is mainly meant for post-singular civilizations that have already faced the information crisis (since only such cosmic civilizations could find a contact partner). That is why, such fundamental sciences as physics, mathematics and astronomy would not be the most interested parties in exo-banks, because post-singular civilizations that are close to exhaustion of the scientific method must have a similar level of knowledge in this field. Certainly, some specific information of the fundamental character can be of interest, for instance, parallaxes of quasars and distant galaxies, which was pointed out by V. S. Lebedev (2007).

However, a more fundamental kind of knowledge will become important to facilitate the decoding such exo-bank data. It should be expected that most information will be 'humanitarian' in character, such as biology, history, sociology, literature, art and religion. It would feed the function of cognition instead of cognition in the form of natural sciences. We call a cosmo-technological civilization that has stabilized its existence by processing external information of a humanitarian character as an *exo-humanitarian civilization*.

The conclusions by which we arrive here are close to the idea expressed by Philip Morrison at the Byurakan SETI conference in 1971:

> In my opinion, the most part of this rather complicated signal will mainly refer to what we would call art and history, but not natural sciences and mathematics. For me this is clear from combinatoric considerations, because our society or any other long-living society will solve many natural-scientific and mathematical problems by easier ways than by studying records of interstellar messages (Morrison 1975).

Victor Shvartsman stated similar ideas in 1986: 'An opinion generally accepted among physicists that the extra-terrestrial intelligence must pass fragments of its scientific knowledge to "younger brothers" seems to be very disputable'. He noted that information related to art and games can turn out to be much more important. This opinion is mainly grounded in two considerations. First, scientific information forms a single logical construction. If a part is lost, the whole is lost too. In other words, the scientific information is difficult for decoding and understanding.[4] Whereas information contained in art is much more resistant to the loss of fragments – the kept parts have a definite integrity and value as before. Rules of logical games are very simple and compact. They can be transmitted easily. At the same time, they contain huge amounts of information about an unimaginable number of potentially possible logic sets. Second, art and games say much more about the intellect that created them than impersonal scientific information or even data of neurophysiology.

It should be noted that, in the present paper, the way to similar conclusions differs from arguments of both Morrison and Shvartsman. They consider that the main motive of 'humanization' of a message is that it is difficult to understand interstellar messages of a scientific character. Our idea is that interstellar messages will be accessible for study (or, perhaps, the necessity to study them) only after most of the problems are solved within the framework of the classical scientific paradigm. However, our second motive about the predominant importance of 'humanitarian' information in comparison with scientific has much in common with Shvartsman's ideas though it does not repeat them literally.

But the considerations of Morrison and Shvartsman that it is difficult to extract information from an interstellar message are also very important. How do we decode the exo-banks of knowledge? Certainly, it is difficult to pose such a problem. Only some general considerations about that can be expressed.

It should be expected that an exo-bank of information will contain one or several root messages with a signal attracting attention and instruction for further search for information. This part of the exo-bank must be decoded easily (for instance, on the basis of reduction to natural-scientific or mathematical concepts). But difficulties are certain to be faced in advancement to the 'humanitarian' parts of the exo-bank.

Here the papers of B. N. Panovkin (1981) about the difficulty of mutual understanding of different cosmic civilizations should be remembered. Panovkin considered the process

[4] I do not agree with this reasoning. *Vice versa,* the knowledge in mathematics, physics, chemistry and astronomy (cosmology) are common to all and should be easy to decrypt.

of setting up correspondence between systems of ideas (thesauri) of these civilizations and showed that, generally speaking, this problem is not solvable algorithmically even for a two-way contact. However, in our opinion, such a conclusion does not mean that understanding is impossible. It only means that the process of understanding must be of a substantially non-algorithmic character. But it is the man that is able to an illogical guess or irradiation inaccessible to a finite automaton.

At the initial stage of studying materials of the exo-bank there can be no correspondence between thesauri of different cosmic civilizations at all (except a very narrow field of simple mathematic or natural-scientific concepts). It can be built gradually as the exo-bank is studied in the cycle of a conceptual model or a test. Models of the understanding of some fragments of the exo-bank are suggested, and then these models are tested on other materials of the exo-bank. If the model stands the test, it is accepted and used for construction of newer and finer models, otherwise it is rejected. A non-algorithmic element of this process is the suggestion of new models. Here it is impossible to do without guesses and irradiations. The understanding achieved in this way will never be final, but it will always be of a model-building character.

It is easily noticed that this cyclic process is very similar to the standard cycle of the classical scientific method of a hypothesis – an experiment. That is why the process of understanding the exo-bank can be called 'exo-science'. Thus, after the information crisis the leadership in methods of cognition can pass from science to exo-science.

Exo-science is not simply another version of science. The key-components of exo-science are truth and reproducibility. In exo-science the notion of truth turns out to be of two-levels: 1) How adequate are models of interpretation of information, and 2) How truthful is the interpreted information itself? If it is still possible to achieve something resembling repeatability of results at the first level, then at the second level, in many cases, it will be unachievable in principle. The element of belief becomes inevitable in the obtained knowledge. Besides, the obtained knowledge itself refers not to nature directly, but either to artificially generated information, or to nature, but indirectly through artificial information.

Let us emphasize that the possibility itself of a long process of obtaining knowledge by the method of exo-science is not less important than the content of obtained knowledge. The process of exo-scientific cognition can drag on many thousand years, but this is just what is necessary to support the homeostasis of civilization at the intensive post-singularity phase of development. It is hard to tell how and when this process of exo-scientific cognition will be exhausted (since this must happen eventually).

## 7. Final Remarks

We proposed the scenario of post-singular evolution in which the leadership system is a post-singular civilization in intensive phase of development. A post-singular civilization is exo-humanistic and exo-humanitarian, one that is part of the galactic cultural field (Section 6). The typical features of an exo-humanitarian civilization must be moral imperatives of exo-humanism (Section 2) and, apparently, a declining state of investigations with the classical scientific method, at least in the field of fundamental sciences (Section 4). Such a civilization is communicative in the strong sense (Section 5). It would not be overstating the case to say that, when establishing contact with such a civilization, we contact the wider cultural field and become an element of it.

We would like to emphasize that the quantitative estimates show (Panov 2007) that even at the epoch of contact saturation of the Galaxy (Section 6) it is a very difficult problem to find the first partner for interstellar communication if pencil-beam channels dominated in the galactic cultural field. Therefore, the Fermi paradox (silence of the Cosmos) may easily coexist with the galactic cultural field: Great efforts from each civilization are needed to establish contact with the cultural field. We cannot see a lot of civilizations in all the directions because the civilizations are in intensive post-singular exo-humanistic stage when the energy resources of the civilizations are not large and they can use only pencil-beam channels for interstellar communication. This is a possible answer to the main question stated at the beginning of this paper.

Though we were trying to avoid arbitrary hypotheses, the approach used in the analysis is the scenario approach. The scenario suggested in this paper can turn out to be more or less plausible or be wrong. The crisis phenomena in science can be softer than it was assumed, but they can occur against the background of other crises, which was not taken into account. The strategy of overcoming crisis phenomena based on the solution of the SETI problem can be combined with the strategy of creation of an artificial intelligence or other global conceptions. Maybe, different strategies are incompatible, so, civilizations can be divided into several types according to their way of overcoming the information crisis: cybernetic, communicative, *etc.* Even if a suggested scenario is correct in general, nevertheless, rare strong deviations from it are possible. So, for instance, at a small distance between two civilizations the contact can be established not at the post-singular phase when the strong communicability is achieved, but much earlier. It easily may take place in a star cluster. Such civilizations can go by the way of creation of super-civilizations with a large-scale astro-engineering activity, as is assumed, for example, in some papers (Kardashev 1981; Kaplan and Karadashev 1981). Maybe, the galactic cultural field created by exo-humanitarian civilizations is only a kind of 'incubator' for super-civilizations and only a phase in development of intelligence. All that means that both the search for beam signals typical for the cultural field and the search for 'cosmic miracles' typical for super-civilizations must be implemented simultaneously.

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