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ILYA PRIGOGINE'S PROGRAM FOR THE REMAKING OF TRADITIONAL PHYSICS AND THE RESULTING CONCLUSIONS FOR UNDERSTANDING SOCIAL PROBLEMS [1]

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Abstract. Recent studies within the framework of Ilya Prigogine's research program refer to the classical methods of exact sciences as being completely unsuitable for interpreting social life. In the conception of large Poincaré systems, consisting of an *innumerable* number of particles, which are in *incessant* mutual impact, Prigogine reached the incorporation of the *real* irreversibility (and through that, of the real chance) into the microscopic physics. The verifying power of the new exact science has by now shown that a human being can deliberately construct and organise a tiny part of the world merely because of the existence of the phenomenon of self-organisation. Therefore, it is necessary to acknowledge the fundamental indeterminacy of history of the integral (including humans) world.

1. Introduction

The article takes a philosophical look at Ilya Prigogine's program, which on the basis of understanding the constructive role of irreversibility, starts from the perspective of remaking the physics hitherto existing. Some conclusions are drawn on the basis of comparing classical (including quantum mechanics and even cybernetics-like sciences) and non-classical (where Prigogine's theories belong) exact sciences for understanding social problems, and at the same time refuting a few widely spread misapprehensions. In this paper only these exact sciences that clearly take into account the *history* of systems and their *self-organisation* are considered non-classical exact sciences. The basic element in the demarcation line

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[1] My sincerest thanks to Nobel prize laureate Professor Dr. Ilya Prigogine for reviewing the previous version of this paper and for valuable comments on his approach in self-organisation studies made during the telephonic conversation with me on January 8, 2002. I am grateful for valuable recommendations also to the second reviewer. These comments and recommendations have helped me to finalise my paper.

between the classical and the non-classical exact sciences is the irreversibility – the distinction between the past, the present and the future. It is clear that the non-classical exact sciences have almost single-handedly been developed and studied by Ilya Prigogine.

2. Classical exact sciences and social sciences

Methods used in classical exact sciences (mechanics, quantum mechanics, relativity theories, cybernetics-like theories, etc.) have been most successful primarily from the point of view of creating technology, though their direct aim is the cognition of nature through mathematics and experiment or observation (which is a quasi-experiment). The construction of technology is subject to a practically complete control of human consciousness. The sociologists have also been interested in the perspective of total human control but with respect to society. Ever since their emergence 300 years ago, the reputation of exact sciences has been high; consequently, there are no sciences today – including social sciences – which do not, at least to some extent, use exact scientific methods. In search for the so-called objective truth, many social sciences (probably the majority) rest in one way or another upon clearly defined mathematical means, empirical observation and measurement. Up to now society's development has often been pictured in the manner that when society leaders influence "the right thing", a state can be reached where the development of society as a whole conducts to some optimal condition. But do the expectations to apply *exact* scientific concepts and methods to human society have any reasonable foundations at all? I shall try to analyse this question more thoroughly.

Even in the philosophical sense it is impugnable whether classical physical-mathematical methods can be applied to society. There are essential differences between social sciences and classical exact sciences[2]: unlike the former, the latter remain totally in the framework of human *constructive* activity. In their research, many exact scientists aim at pure objectivity, eliminating all references to the subject. They consider themselves detached from the research object (whether a physical body, a chemical reaction, a plant or an animal) and try to describe its behaviour without analysing their own activities. They do not ponder about how (and according to which requirements) a scientist or a human being in general sees the world and feels about it. These scientists are not concerned about relations between people (including the scientist himself) and research objects, but about relations between research objects themselves. The exact scientific approach enables to *predict* or *explain* (via mathematical logic) the behaviour of *idealised* objects in conditions that are fixed by scientific theories. Classical physics (which is the ideal for exact sciences, i.e. the pure exact science is the idealised physics-

[2] The so-called "pure" exact science is "reversible" physics hitherto existing. However, chemistry is not reduced to "pure" exact science, not to mention biology and social sciences. Rein Vihalemm (1981, 1988, 1989, 1995a, 1995b, 1999, 2001) has looked into this problem.

like science since Galileo (see, e.g. Vihalemm 1995a, 1995b, 1999, 2001)) strove towards the complete control over the object researched. The whole Universe was believed to be subject to laws of classical physics. Even in the discussions about the so-called anthropic principle, the rigid-deterministic mathematical equations were not placed under doubt, only the physical constants were "allowed" some modifications. However, the object is not integral, but a part of reality (in mathematical definition – subset). Classical exact sciences merely studied the *parts* of the world, because the exact scientist tried to reduce his work to "either empirical or theoretical (prognostic) description of the observation spaces" (Palm 1994:117). Parts of reality were expressed by informational models, which were not permitted to contain any hints to the cognised subject. Only the model's adequacy level was essential. However, adequacy merely means that the aspect described through the model exists in reality. The qualitative peculiarities of the real system concerned, as well as the personal characteristic features of the researcher, remain without attention when the exact scientific method is used. The evaluation criterion of an exact scientific theory was and is its ability to predict. The theory was considered excellent so long as the results it predicted were confirmed by experiments. The basic attribute of an experiment is its reproducibility. Any researcher at any time and place must be able to repeat it. The reproducibility of the experiment requires special conditions (initial conditions) that the experimenter has to provide. The exact scientific approach enables, to some extent, to control and reshape nature with higher clarity than common consciousness. This might lead (and has already led some people) to the conception that the only correct way to cognise society is to observe and measure what the societies are up to at the moment. As the exact scientific approach mostly aims at a totally objective research – the so-called subject-free objectivity –, the way people themselves think of society or *why*[3] they act accordingly, i.e. people's personal motives and values, are not considered important. In this approach, the human being is also treated like an object; therefore, during the research process, there is no fundamental difference between a human being and an object researched by exact sciences. Exact sciences analyse relations between objects, but in society, relations between human beings (as well as human beings and objects), which social sciences have to deal with, are more important. It is highly questionable whether the applying of the exact science (mathematics and experiment or observation as a quasi-experiment) in social sciences gives us anything at all in respect of *understanding* the society. Recent studies within exact sciences themselves (see below) refer to the classical methods of exact sciences as being

[3] The "why?"-question must be understood in an Aristotelian way, i.e. as the inseparable unity of material, formal, efficient and final causes. The "why?"-question consists of four questions: "What is it made of?", "What is it?", "What was the source of change to it?", "What is it for?". This unity of causes may be interpreted as a philosophical concept of self-organisation (grasping both the process (without the organiser!) and its result). The first three causes may be interpreted as a philosophical concept of organisation (involving the organiser, the process and its result). (See, e.g. Näpinen 1983a, 1990, 1993, 1994, 1998, Vihalemm 1981, 2001)

completely unsuitable for interpreting social life – they lead to faulty conclusions, though it is technically possible to "mechanistically" describe the behaviour of human beings. However, a sociologist must not omit the social *wholes* (in the meaning of Aristotle's final cause) from his studies. In these wholes the *inner* purposeful relations take place. These inner purposeful relations cannot be described in the *objective* concepts of physical-mathematical sciences. They have to be described only through people's attitudes and beliefs. While the physical-mathematical sciences analyse physical objects (which are the idealisations), in social sciences people (who are not the idealisations, but the real human beings with very different characteristics) and relations between them have to be understood above all, as well as objects, but only the way people accept them (on what grounds and how they relate to them). Furthermore, a sociologist also has to study people's own conceptions about how and *why* people act the way they do. Researchers have often tried to conceive a theory of the corresponding society merely on the basis of a sociologist's conception. Conceptions of people of the corresponding time and place have been ignored. Social sciences, being historical approaches, however, cannot in principle be exact sciences, i.e. based on the *mathematical* project leading to idealisations. The historical approach, based on analogies, is classifying and qualitatively descriptive, since this approach deals with phenomena that contain unique events and cannot be reduced to regularities. There is no need to try to create a new theory in order to understand unique events; instead it is necessary to try to reconstruct the popular concepts that have dominated and still dominate the corresponding society, and to evaluate them. A sociologist has to unravel the questions *why* people act the way they do with respect to each other, *why* they co-operate, what affects their *choices* and how these choices develop into certain complete events.

It is true that Heinz von Foerster (1970, 1973, 1982) and others do not in the so-called second-order cybernetics strive for subject-free objectivity. However, the cybernetics-like theories remain the classical type of science.[4] It has been shown that cybernetics and cybernetics-like theories are characterised not by the philosophically defined category of self-organisation (which is already included in Aristotle's causality theory) but by the philosophically defined category of organisation (Näpinen 1982, 1983a, 1990, 1993, 1994, 1998, Vihalemm and Näpinen 1987). Von Foerster's version of self-organisation science does not follow the Aristotelian way of thinking. All cybernetic theories remain "hard" sciences, *starting* from investigating the machine-like aspects of reality and emphasising the stability of systems. All cybernetic theories do not deal with the open (exchanging the substance, energy or/and information with environment), but with the closed systems. These theories as a purely functionalist and quantitative view of the world, remain totally in the framework of human *constructive* activity and do not therefore involve Aristotle's four causes in their inseparable unity. In

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[4] In the above-mentioned telephonic conversation (January 8, 2002) Ilya Prigogine himself confirmed that the second-order cybernetics differs from Prigogine's own method.

cybernetics and cybernetics-like sciences, too, the scientific picture of the world replaces the real world. It must be stressed that

> *the scientific world picture does not include … things that have not been constructed, that are not understood as artefacts … Instead of the final cause one starts to speak about purpose, which nature itself does not have. Only humans can set aims and achieve them by their activities if they know the laws of nature and set up various processes based on them and organise them purposively*. (Vihalemm 2001:192)

In the cybernetics-like sciences we are not dealing with theories of self-organisation (see Näpinen 1994:158, 175–177), but with theories of organisation which show how and to what extent the natural systems can be constructed by the way of idealised physics-like science. The essential characteristic of self-organising systems is *autonomous* purposive behaviour. The characteristics of a self-organising system cannot be constructed according to an external purpose.

Thus, classical methods of exact sciences seem to be completely unsuitable for the *integral understanding* of social life, belonging to the historical reality. Even if they enabled us to completely control a part of society, it would not mean that we understand that part. A leader does not understand his subjects just because they follow his orders without question. But what about the applicability of these methods that Ilya Prigogine and his school create and propagate, to society? Before trying to answer this question in Section 5 let us explain Prigogine's conception of non-classical science and describe some prejudices in social sciences.

3. Prigogine's non-classical exact science

In the course of many years, I have published nearly 30 papers (most of them in Russian, only a few in Estonian and English) about the research work of Prigogine's school (see, e.g., Näpinen 1982, 1983a, 1983b, 1983c, 1984a, 1984b, 1989, 1990, 1993, 1994, 1997, 1998, 2001a, 2001b, Näpinen and Müürsepp 2002, Vihalemm and Näpinen 1986, 1987), therefore there is no need to enter into particulars. I will just mention the fundamentals.

First of all a few words about the theoretical work that Ilya Prigogine has done in physical-mathematical sciences. In 1977 Ilya Prigogine received a Nobel prize in chemistry. The prize was awarded for his work on the non-linear, non-equilibrium thermodynamics and in particular on the so-called dissipative structures. Prigogine predicted from a theoretical chemistry standpoint the existence of regularly self-oscillating chemical reactions. The type of reaction predicted by Prigogine is known as the Belousov-Zhabotinsky reaction. To Prigogine, irreversibility is a fundamental property of physics. Prigogine (1980) has incorporated reversible and irreversible parts into a new microscopic equation. According to Prigogine's method, the physicist must first introduce the second law of thermodynamics[5] before being able to define the entities. The main concept Prigogine created is the "dissipative structure" (see, e.g. Glansdorff and Prigogine 1971, Nicolis and Prigogine 1977). The dissipative structure may emerge through fluctuations in far-from-equilibrium conditions. In Prigogine's view, the closed cycle of a historical dialogue between science and nature, involving an observer, unstable dynamical systems, randomness, irreversibility and dissipative structures, makes it possible for the observer to recognise himself as a kind of evolved form of the dissipative structure. As the existence of irreversible processes on the microscopic level violates through kinetic equations the symmetry of the canonical equations, and the dissipative structures may, in turn, break the symmetries of space-time, the researcher can, in an objective way, justify the distinction between the future and the past (Prigogine 1980:212–214, Prigogine and Stengers 1984: Conclusion, § 5). Prigogine (1980:213) considers this distinction as an example of a *primitive concept* (Niels Bohr's expression) that in a certain sense precedes the scientific activity. This cyclic scheme shows that the non-equilibrium conditions and the "historical measurement" of dissipative structures make it possible to understand the initial distinction between the past and the future and the fixing of conditions of reversible movement in the *researcher's* system as the properties of far-from-equilibrium system developed from the dissipative structure (Vihalemm and Näpinen 1986:120). Therefore, according to Prigogine, the humans (including the scientists) are not only observers and spectators, but also the actors of history. This new position of the researcher corresponds to the Aristotelian way of thinking: the world is cognised as a big living organism containing the humans (Näpinen 1998, Vihalemm 1981:139–141; 2001). Prigogine's understanding of the world involves all four Aristotle's causes.

Aristotle's way of thinking has been followed in particular by Robert Rosen (1985, 1991, 1993), especially in his conception of *modelling relation* (containing *causality* in a natural system, *implication* in a formalised system, and the relations of *encoding* and *decoding*). The importance of Rosen's life work in connection with understanding how a science works, has been emphasised by Donald C. Mikulecky (1996a, 1996b, 1997) who has shown that the words like "complexity" and "chaos" do not and cannot denote the exact scientific concepts. Mikulecky has written: "Attempts to give chaos a rigorous, "scientific" definition have been anything but successful and the word seems doomed to become a poorly defined buzz-word in the same sense as the word "complexity"." (Mikulecky 1996b:2) The real, natural world itself is entirely complex and, in some aspects, chaotic. The dynamical systems characterised by sensitivity to initial conditions and synonymous "butterfly effect" do not correspond to natural systems at all. The natural systems belong to their environment and to the world as a whole (including humans).

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[5] The second law of thermodynamics, which is the basic principle of Prigogine's program, is not related to experiments because, according to Ilya Prigogine (as well as Max Planck), it merely claims that there exists a quantity in *natural world* that, in the case of every variation, only varies towards one direction.

I have already drawn the following conclusion: "If traditional mathematical natural science excluded chance from science…, then Prigogine's paradigm of self-organisation, through irreversibility, includes chance as well." (Näpinen 2001a:162) Prigogine's paradigm acknowledges the necessity of understanding the reality as a whole (which would also include humans) (Näpinen 2001a:162).

Juri Lotman has also stressed the same: "The introduction of the chance factor to the mechanism of causality is the *most* important contribution of Prigogine's … This *de*automatizes the picture of the Universe." (Lotman 1997:13; italics added)

In connection with human systems Juri Lotman writes:

> *The most intricate object we can ever imagine is the object endowed with intellectual capacity. In this case, its behavior at the bifurcation point acquires the character of a deliberate choice. The possibility of the mind's existence has been programmed in the very existence of chance in nature. However, a structure advanced to the intellectual level transforms chance into f r e e d o m . Consequently, the most complex relations of causality emerge: an act of intellectual choice occurs between cause and effect, c a n c e l l i n g their causal automatism. It follows that, first, the intellectual action results from the development of asymmetrical irreversible processes and is inevitably connected with structural asymmetry, and second, it includes a complicated moment of chance in itself (in fact, the latter is simply a paraphrase of the well-known connection between unpredictability and information).* (Lotman 1997:13; expanded spacing added)

In recent times the work of Stuart A. Kauffman (1993, 1995) has dominated the subject of "complexity studies".[6] Kauffman's works, and research by his colleagues at the Santa Fe Institute, suggest that the evolution of the whole world adheres to principles of self-organisation. He himself describes his own work in biological studies using Boolean networks. Kauffman has pointed out that evolution appears to be a combination of selection and self-organisation. Kauffman develops his research in the way of "hard" science. However, in his "Investigations" Stuart Kauffman (1996) has also said that some of the hypothetical propositions about the so-called autonomous agents may be more narrative than science.

But there is also some critique of Kauffman's approach connected with the theory of dynamical systems. Kauffman and others use a state space representation for a dynamical system. As Donald C. Mikulecky (1996b) has said, it is good for a dynamical, i.e. for a formal (mathematical) system, but it is not an adequate model for a complex system. According to Mikulecky (1996b:4), the problem is that Kauffman never seems to notice where he "stops using models of natural systems and begins to use metaphors instead."

It seems to me that the common dichotomy of subject and object is unsuitable for characterising Prigogine's method as Prigogine's program does not commission physics to describe the world as though the researcher (and the human being in general) did not belong to *the natural world as a whole*. A future physicist has to

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[6] Ilya Prigogine said in the above-mentioned telephonic conversation that Stuart Kauffman has done a good job in studies of self-organisation in the context of biological systems.

consider even his own emotions and feelings (Prigogine has claimed this himself), because he himself belongs to the world he cognises, to the world as a whole.

In conditions of the experiment, phenomena could be nearly reversible and necessary. In situations outside the experiment, however, processes contain the essential element of chance and irreversible. In these situations, the world can no longer be observed as something passive (as it was in classical mechanics and classical exact sciences in general), but is understood as something characterised by a spontaneous activity.

At the beginning of the 20th century, almost all physicists believed that the fundamental laws of the Universe are necessary and reversible; today, more and more researchers are convinced that the fundamental laws of nature are irreversible and accidental in character. The range of application of necessary and reversible laws is very confined. According to Ilya Prigogine, the human existence can also be understood as the realisation of the basic laws of nature expressed by irreversibility and chance. Prigogine is convinced that the research work triggered by the definition of chaos (i.e. the constructive role of irreversibility) will lead to a new research method, which centres on the problem of *becoming* (the importance of which only the philosophers had emphasised before Prigogine). (This may be the case, but only after the new science gets rid of the idealised physics-like method.) However, it is clear by now that *the realistic description of the world around us cannot be possible without including irreversible processes*. Prigogine thus started his theoretical-physical research with the question of the origin of irreversibility and the relations between the irreversibility and the fundamental laws of physics.

How can we understand something new without reducing it to the repetition of one and the same? How can we solve the so-called time paradox and the quantum and cosmological paradox connected with it? (See Prigogine and Stengers 1994, Prigogine 1997). Representatives of classical exact sciences did not look into these problems in connection with philosophy, for they analysed the *non*-historical reality.

For Prigogine, however, these issues have remained problems (both on the conceptual and technical level) for over 50 years (see, e.g. Prigogine and Stengers 1984, 1994, Prigogine 1980, 1997) – since the year 1946 when he proposed the hypothesis that the non-equilibrium could be the source of order. Before starting to cognise the changing world, an enormous work had to be undertaken: the whole physics hitherto existing needed changing (in order to extend the basic conceptual scheme of dynamics for grasping the thermodynamic situations and satisfying the so-called *thermodynamic limit*: the number of particles and the volume in which the particles are located are approaching infinity, but the ratio of the number to the volume remains finite and constant), because the way of cognition introduced by Galileo and Newton (i.e. reducing the world to mathematics and *reproducible* experiments) was simply unsuitable for understanding the *changeable* world. The conception of nature as well as the definition of the laws of nature had to be reformulated. For scientists following Newton's ideas, the world was in principle (from the point of view of omniscient God) totally determinable. The uncertainty hitherto existing was connected merely with temporary narrowness of mind and limited means of calculation, which the further development of science and technology had to overcome. The physics shaped by Prigogine and his co-workers, based on research in non-equilibrium statistical mechanics, the theory of chaos (which rose from the work of Henri Poincaré) and the branch of functional analysis developed by Izrael M. Gelfand, *starts* with acknowledging the fact that *the world seen as a whole, containing the human being, is characterised by fundamental indetermination*. The integral world is dominated by irreversible processes, on the basis of which events released by chance take place (the nature of which is the fact that they do not necessarily have to take place), and some of them can change the sequence of events in the corresponding system's history. Prigogine and his co-workers have by now proposed physical-mathematical theories that *incorporate* the irreversibility both on the microscopic (the so-called *large Poincaré systems* in the extended mechanics and in the extended quantum mechanics, characterised by the *infinity* of particles and the *perpetuity* of their mutual impact on each other) and macroscopic level (*dissipative structures* in the thermodynamics of strongly non-equilibrium processes that emerge from the amplification of fluctuations), where *the idealisations of classical physics* that *isolated the human being from the cognised world*, are no longer used. The world studied in classical physics was reduced to an automaton that follows, without deviations, the program that has been inserted into it; in principle nothing new could happen in this world. However, in classical exact sciences, the human existence is explained by the so-called anthropic principle, in its different versions. Yet the anthropic principle does not explain the fact of human existence either, because the Universe is seen as subject to the laws of classical physics, which do not include chance and irreversibility needed for creative processes. Human and social life primarily represents the emergence of novelties, while society, unlike nature, renews considerably even during one generation. In creating the physics of strongly non-equilibrium processes, Prigogine *started* with the possibility that novelties might emerge in the natural-historical world (containing humans). Novelties can be derived neither from absolute laws nor absolute chances. Prigogine has, for over half a century, avoided the traditional way according to which the emergence of novelties is sought to be understood by adding supplements to the classical physical-mathematical theories (mechanics of *stable* dynamical systems, quantum mechanics of definite systems), i.e. deriving time as the emergence of something new from the dynamics of reversible processes. In the philosophical sense, the fact that this approach had no perspective whatsoever had to be clear from the start, because one cannot, in principle, derive time from non-time. Still, even the physicists who tried to bring irreversibility into dynamics (e.g. Ludwig Boltzmann) could not get rid of their loyalty to Newton's mechanics. The conceptual scheme broadened by Prigogine, however, contains *the element of history* as an unconditioned component: the emergence of novelties is connected with irreversibility, events (that can only be described through probability) and the change of paths of the integral process of development by some events. This brings into physics the "narrative" element that so far worked only in historical sciences. *The element of history cannot in principle be deduced from Newton's equations*; this results from the conception of *instability* (see, e.g. Prigogine 1989) of dynamical systems. Prigogine even insists that his developable theory of unstable dynamical systems would be accepted as a basis in cosmological models. The realisation of Prigogine's program in cosmology would mean that the "Darwinian theory" would be conceived to describe the fundamental particles, too, i.e. a theory which would not only reflect irreversibility, but also events and alterations of integral development processes that some events cause in unstable conditions. Consequently, for instance, according to Prigogine and his co-author philosopher of science Isabelle Stengers, particles that had higher formation speed than others might have emerged during the "Big Bang" (Prigogine and Stengers 1994:244). Classical physical-mathematical theories (mechanics based on Newton's, Lagrange's or Hamilton's equations; quantum mechanics founded on Schrödinger's equation, relativity theory grounded on Einstein's equations, etc.) are thereby *not* declared invalid; instead, limits of their applicability are shown. They are tenable in conditions where irreversibility can be ignored. Newton's or Hamilton's equations are valid in *stable* dynamical systems. Schrödinger's equation responds to quantum systems that consist of a countable number of elements. Einstein's equations describe nothing but repeated cosmological processes.

In classical physics, only *parts* of the physical world were analysed (single trajectories in mechanics, single wave functions in quantum mechanics), and it was erroneously believed that by resting upon the principle of superposition, the whole physical world could be assembled from these. Yet in fact, as proved primarily by the research work of Prigogine's school, the domain modelled by exact sciences that deal with equilibrium and near-equilibrium processes, is merely a very small part of the real world. In philosophical sense, this domain is linear (no integral changes of development paths occur in it); reality modelled by physics of strongly non-equilibrium processes, however, is mostly non-linear (several development continuations are possible with physical systems). By today, it is becoming clear that even our cosmic world may have had a beginning and it may have its own history. The research work of Prigogine's school indicates that the "Big Bang" would not be interpreted as a singular point, but as a creation of the Universe from unstable "quantum vacuum", which could have been characterised by physical constants (the gravitational constant, the velocity of light in the vacuum, and Planck's constant with their currently known values). Novelties may also be possible in the Universe (as an association of the so-called positive energy particles), i.e. the Universe is an open, developing system. In the part in which the new science remains the idealised physics-like science, it is certainly correct to speak merely about a *model* and not about cosmos *as it really is* (Vihalemm 1995a, Näpinen 2001b). However, it is important that the diversity and the emergence of novelties in the world no longer need any explanation in Prigogine's program. These are characteristics of reality that a physicist has to take into consideration while modelling reality. Therefore, from now on even the physics is a mixture, which contains both the constructive basis (where the hypothetical-deductive theories come from) and the natural historical inquiry.

Beginning with the real chaos and the real irreversibility forced Ilya Prigogine to use more flexible mathematical means than before. For instance, Prigogine gave up using the so-called ordinary Hilbert space, substituting it with the so-called generalised Hilbert space (Gelfand space), the function norms ("lengths") of which are uncertain (Prigogine and Stengers 1994:142). These new functions are also called fractals.[7] It may be said that, in general, the mathematical studies of self-organisation mean the using of *attractors* (see, e.g. Engelbrecht and Uus 1993:63–68, 160–179) for fixing varied dynamic behavioural states of complex adaptive systems.

In Prigogine's program, the priority of mathematics is replaced by the priority of biology for physics, yet not in the meaning of a new fundamental level, but in the meaning of a pattern that requires, in physics, an elaboration of notions similar to notions in biology (Näpinen 1983c). The new physical-mathematical concepts (e.g. *microscopic entropy operator*, and *inner time operator*) that Prigogine (see, e.g. 1980) created are based namely on schemes coming from evolutionary biology (Vihalemm and Näpinen 1987, Näpinen 2001a:160–161).

The fundamental concept Prigogine and his colleagues (Tomio Petrosky et al) reached in recent years is the notion of *quantum chaos*, which is valid on the microscopic level of physical description. The quantum chaos is the property of the quantum *large Poincaré systems* and manifests through the decay of quantum correlations in time. This concept does not allow reducing even physics to the initial conditions paradigm (reproducible observation-experiment and mathematical equations) (see, e.g. Näpinen and Müürsepp 2002). The notion of quantum chaos corresponds to the real irreversible processes on the micro-level of physical description.

It is very important to stress that the real time, in principle, cannot be grasped by the idealised physics-like science, in the language of mathematics. Thus, *discussions about real, historical time in natural (non-mathematical) language are not a temporary stage that will pass in science; the real time and everything connected with it (irreversibility, chance, instability, non-recurrence, uncertainty, complexity that cannot be observed, time-spatial non-uniformity, etc.) cannot in principle be apprehended through mathematics and reproducible experiment* (Näpinen 2001b, see also Vihalemm 1995a). In the part where the new physics remains the idealised physics-like science (which started with Galileo), nature is modelled and not described as it really is. The pure mathematical part of physics grasps the law-abiding aspects of reality only. Aristotle was not mistaken by claiming that the sub-lunar world (including our own world of everyday life and experience) in all its complexity and diversity cannot be understood through mathematics.

Ilya Prigogine considers the irreversibility as the basic element of description of the physical world. He understands that the physical reality on *all* levels of physical

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[7] About fractals see, e.g. (Engelbrecht and Uus 1993: 114–135, 179–188, Mandelbrot 1983).

systems (from fundamental particles to the Universe) cannot be researched apart from this real irreversibility. However, if the world is irreversible (i.e. if it cannot return to the former state), then measuring it gives us nothing, because we do not know what the world was like before we measured it, let alone what the world will be like in the future. Prigogine interprets the irreversible physical world as a system of changing *relations* (*mutual impacts*, *resonances* and *correlations*) between particles. Idealisations of the classical mechanics and quantum mechanics so far ignored this real irreversibility. As we know, the traditional mechanics and quantum mechanics were restricted to measuring *current* situations, and were not interested in the preceding and the following. In the former, the co-ordinates or *momenta* (velocities) of particles, in the latter, the wave functions (probability *amplitudes*, state vectors) were measured. Particles were primarily viewed without regarding their mutual impacts (this was considered only temporary), and their movements were described as separate trajectories (in mechanics) or separate wave functions (in quantum mechanics). In reality modelled by new physics, however, the mutual impact between particles never ceases. Phenomena grasped by the new type of laws of physics that Prigogine formulated, remain out of the reality grasped by the laws of classical physics. In the physical-mathematical view, we deal with the so-called *large Poincaré systems* in the new model of reality. Their description, as shown by Prigogine and others, cannot be reduced to the description of single trajectories or single wave functions, but instead they can only be described as an *ensemble* of trajectories or wave functions. A measurement and an observer in general play no determinant role in Prigogine's program. In the quantum theory of large Poincaré systems, the observer with his measuring activity is not "responsible" for the existence of irreversibility on the level of fundamental particles; instead, *irreversibility is declared to belong to the real micro-world itself*. One gets an intuitive idea of irreversibility by describing it both on the macroscopic and microscopic level in terms of correlations and impact mechanisms (by the agency of which correlations develop). In this case, irreversibility can be viewed as a dynamic process during which some types of correlations are "forgotten" (Prigogine and Stengers 1977: Part II, 646). I stress that, at this point, Prigogine merely described the irreversibility intuitively and reached the incorporation of the *real* irreversibility (and through that, of the real chance) into the microscopic physical theory only in the conception of *large Poincaré systems*.[8] Even the notion of the so-called *deterministic chaos* allows identifying irreversibility and chance with gaps in the scientists' knowledge.

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[8] Jean Bricmont (1998–1999), in his critique of Ilya Prigogine's ideas, does not seem to realise this circumstance. Bricmont's publication in Estonian is translated from the manuscript "Science of Chaos or Chaos in Science*?*" presented for publication to the New York Academy of Sciences and in *Physicalia Magazine.* Published in (*Physicalia Magazine*, 1995, 17, 3–4: 159–208). Bricmont has not actually considered *large Poincaré systems* at all. For him a chaotic system is the same as the *deterministic chaos.* But the main conditions for obtaining Prigogine's statistical formulations are "the existence of Poincaré resonances, which lead to new diffusion-type processes that can be incorporated into the statistical description, and extended *persistent* interactions described by *de*localised distribution functions." (Prigogine 1997:155; italics added) I have considered Bricmont's critique of Prigogine's ideas in (Näpinen and Müürsepp 2002).

According to Niels Bohr, as we know, the measuring apparatus was supposed to mediate between the laws of quantum mechanics, valid on the microscopic level, and the world of classical physics. However, Bohr left several questions unanswered, the questions to which Prigogine's theory enables to give answers, because Prigogine "succeeded in showing that the quantum theory of large Poincaré systems and the irremovable mutual impacts lead to the irreducible probabilistic ideas" (Prigogine and Stengers 1994:214). These ideas require no observers, "measurers" or "measuring apparatuses" in nature.

As Prigogine's paradigm of self-organisation is a mixture, which besides the exact scientific method (the idealised physics-like approach) includes, as a starting point, also the pre- and non-scientific understanding of nature (common sense, philosophy, and historical research), "the model "subject-object" … turns out to be a conventional and one-sided abstraction." (Lotman 1997:15) I think that already in the case of Prigogine's paradigm "we are dealing with a complex pulsating dialogue, not an unidirectional reception". (Lotman 1997:15)

4. The prejudices in social sciences

Based on what has been said, it should be clear how erroneous is the conviction of a number of sociologists (demographers and others) that statistics (based on the so-called law of large numbers) gives us essential information about society's *development process*. Statistics postulates that the studied individuals do not differ from each other and are not systematically connected with each other as a result of which any selection from a large population is supposed to be representative. In reality, however, a network of relations developed in society's history connects with each other the different human individuals. Statistics is a science that ascertains the quantitative changes only. However, society's development primarily contains qualitative leaps, which begin with chances that are in principle unpredictable. The latter are also ignored in statistics, as it does not operate with fluctuations but with average values. Actually, statistics does not consider chance real! Chance is identified with ignorance. Society is studied statistically just because it is impossible to receive data about all the system's elements. It is believed that if we knew all the details that characterise the elements, any kind of uncertainty (unpredictability) would be overcome.

One of the most widely spread prejudices in social sciences and among people, as it has been shown especially by Friedrich August Hayek (1988, see also the referred bibliography), is the conception that most of society's institutions are an embodiment of someone's deliberate intention (goal) (Näpinen 1994). The goal or function of the living organism, however, does not mean that an organ of the organism is deliberately formed, but that the organ has some kind of function in relation to the organism as a whole. Likewise, most of society's institutions are not deliberately formed by somebody. People do not build up the structures of society and usually do not even understand them, especially their importance.

Unfortunately, it is exactly this kind of model of rational behaviour that dominates in most social sciences (sociology, economics, etc.) and in understanding culture in general (Mamardashvili 1994:62): people's lives in society are restricted to finding means to achieve narrow goals, and people are used to realising these goals. It is assumed that such goals are clear to the people themselves and can also be grasped in relation to the system of activities by any external observer (Mamardashvili 1994:63). However, *as there exists the phenomenon of self-organisation of social life, it is not correct to reduce all the actions of people to achieving the prognosticated results*. Certainly, some actions have in principle unpredictable results. The determinants of self-organisation could lie among those which are a lot more decisive and consequential for people's fate or for the formation of a human being than just acts caused by the desire for temporary and local profit (i.e. which have predictable results). Human qualities (honesty, sense of justice, wisdom, benevolence and considerate attitude to the world in general) emerge precisely through non-utilitarian action. If children were not allowed to play, i.e. be engaged with activities non-essential for practical life, they would not become humans (Mamardashvili 1994:67). However, grown-ups, too, should not be in any way hindered by anybody if they act without pursuing direct profit or effect, for this hindering is equivalent to destroying people's *new* chances (which nobody can predict) to self-realise their human qualities. Life in human society is primarily the history of organs that form and reform human life (Mamardashvili 1994:49, 65, etc.). These organs are connected with dependencies that determine people's motives, values, goals, etc. The history of human society is the history of the formation of natural organs of human life. *Human actions* in it *are not reduced to serving narrow goals, pursuing benefit or profit, satisfying needs, manipulating people and objects for gaining efficiency*. A self-organising society (blended with, and being a continuation of, nature) and truly social systems in general are not transparent so that they could be totally embraced by an observation from one point (as required by the classical ideal of rationality), even if the observer were an all-powerful intellect (be it called God or otherwise). It is a matter of principle, not the extent of abilities or potentialities of the observer. The self-organising world is simply fundamentally uncertain. The uncertain is something that *still* does not exist, and therefore *nobody* can observe it.

There are two totally different ways to act, either by organising the action in a factory or by pursuing harmony in a society as a whole that is not reduced to the collection of individual "factories" but represents a complex of processes in which countless numbers of individual wills take part (Mamardashvili 1994:68–69, Näpinen 1994). In the first case, expressed in physical terminology, we deal with equilibrium or near-equilibrium systems (which are almost totally controllable by varying initial and boundary conditions). In the second case, however, the systems are strongly non-equilibrium (which are not completely controllable as the initial conditions are the result of the preceding development of the system and different dissipative structures correspond to the same boundary conditions). Just like the experimenter cannot control fluctuations in strongly non-equilibrium physical systems, society leaders (or sociologists) cannot control chance events in society. Strongly non-equilibrium physical systems already create their own internal structures, not to mention systems that contain conscious mind. The task of society researchers is not merely to theoretically reconstruct the development of these structures, but also to understand their participants, in order to *learn from them for the future*. Social actions and phenomena represent natural-historical events and processes. Their description is not reduced to finding out regularities or simply retelling the events. It is necessary to bear in mind both the social-historical circumstances and the personal characteristic features of people in society. In similar circumstances, different human individuals may cause very different qualitative changes in themselves and in society.

We have to regard the internally active reality differently from how we have treated nature and society so far. The verifying power of exact sciences has by now shown that *a human being can deliberately construct and organise merely a tiny part of the world because of the existence of the phenomenon of self-organisation*. Nature and society *together* form a self-organising system, which is not subject to the total human control (Näpinen 1994). *In respect of the self-organising world (containing also the human being), it is not reasonable for humans to be organisers* because, as mankind has sufficiently experienced, the overly extensive and excessively long-lasting manipulation with its parts is harmful to humans themselves and will finally jeopardise the whole existence of mankind. In order to be able to adjust and readjust to the self-organising world in which the network of relations, especially between people, is nowadays prone to the fastest and most unexpected changes, *humans must not rule neither nature and society nor other humans but themselves, their own behaviour and actions.* And even that the humans can do only in accordance with their own nature. Consequently, it is wrong for the sociologists to try to suggest with their theories that it is possible for us, like engineers, to change society, i.e. to assemble society from people just as one assembles a machine from details. (Only the *piecemeal* social engineering, as Karl Raimund Popper (see, e.g. 1961) has argued, is acceptable here.) Instead, it would be reasonable to show where the limits of our mental control lie. It would certainly not be harmful for sociologists (let alone naturalists) to learn about Prigogine's program, because the strongly non-equilibrium physics, thanks to being extended beyond the idealised physics-like science and co-operating with the historical inquiry *as a starting point*, meets the minimal conditions necessary for understanding the *becoming* (emergence and disappearance). *In any case, we have to abandon the scientific rationality that is reduced to the technology of controlling nature and society*.[9]

Social institutions live their own lives, which are not subject to attempts to reform them *radically*. Internal determinants at work in society have emerged

[9] I will note here that the Russian-speaking scientific circles have, independently of Prigogine's program, started to deal with the re-interpretation of scientific rationality. Piama Gaydenko (1991), Merab Mamardashvili (1994) and others have drawn attention to the necessity of a new kind of rationality.

during a long period of development in order to serve complex functions, which we often find difficult to apprehend. The task of a sociologist is therefore to discover these internal determinants and *sometimes* to show ways of creating conditions, where it would be easier for the system of internal determinants to emerge and work for the benefit of mankind.

5. The challenge of Prigogine's program to sociological thinking

I think that the developing of strongly non-equilibrium physics is valuable also for researchers of society because it helps sociologists to get rid of their prejudices that have become rooted under the influence of classical exact scientific notions and methods. (Even the conviction that the only correct way to cognise the world is through the methods based strictly on mathematics and a reproducible experiment or observation, is a prejudice!)

Grégoire Nicolis and Ilya Prigogine (1989) almost single-handedly made self-organising and progressively complex systems a scientific subject across the fields of physics, chemistry, biology and social systems. The physical-mathematical modelling of the development of human associations (Nicolis and Prigogine 1989: Ch. 6, § 6) demonstrates once again that the development of social systems is mixed with unpredictable elements, and therefore a short-time strict planning based on the direct extrapolation of past experience is not only useless but even dangerous. Using such a method may lead society to stagnation and finally to disaster.

The "sciences of complexity" are quite different. They include general systems theory (von Bertalanffy 1984, et al), non-equilibrium thermodynamics which includes the theory of self-organisation (Prigogine 1980, 1997, Prigogine and Stengers 1984, 1994, Glansdorff and Prigogine 1971, Nicolis and Prigogine 1977), chaos theories (Abraham 1994, Gleick 1987), second-order cybernetics (von Foerster 1970, 1973, 1982, Maturana and Varela 1980, 1992, Luhmann 1990, 1995), etc. It is now possible to speak about the evolutionary systems theory, which is providing an alternative to steady-state and equilibrium approaches for the design of social-cultural systems. A central thesis of that theory (derived from the self-organisation theory of Ilya Prigogine and the chaos theory) is that all kinds of systems – physical, chemical, biological – when they enter the state of chaos (the so-called "turbulent chaos") far from the thermodynamic equilibrium, eventually either self-destruct or self-transcend. This analogy between real systems may work. However, there are also big differences between the real systems. Researchers in the idealised physics-like science (which both the first order and the second order cybernetics almost entirely are, but Prigogine's approach is only partly so) can assume that the effects of a given intervention or treatment on certain particles (like atoms and molecules) will generalise to other particles. This is not the case in human society. The behaviour of human individuals depends on specific characteristics of the individuals which researchers cannot observe and control. Therefore, in social systems, we must speak about the complexity that cannot be observed. The second order cybernetics has concentrated on the influence of the biological organisation of the observer on observing. The exact scientific part of Prigogine's microscopic theory of irreversibility deals with the interactions between the particles of large Poincaré systems. Neither can grasp the unobservable complexity! But the historical research, which is the starting point in Prigogine's co-operative approach, includes also the unobservable complexity.

The models in the exact sciences are used to *predict* structures and systems. The natural, evolving and self-organising world, however, is unpredictable. The *science* (i.e. the idealised physics-like science, starting from Galileo (see, e.g. Vihalemm 1995b, 1999, 2001)) has its premises and *limits*. The idealised physics-like science cannot understand the real, living world (including the humans) in all its complexity and diversity, it can only describe and manipulate some of the regularities.

Ilya Prigogine has aspired to bridge the gap between exact sciences ("hard" sciences) and humanities ("soft" sciences) (see, e.g. Näpinen 1997, 2001a). He has brought into physics biological, social and human conceptions. There are many scientists who have tried to do this. But in my opinion only Prigogine and his co-workers and followers have done it in the right way. However, what is missing in Prigogine's writings is that he, as far as I know, has never spoken about the limits of his own *scientific* theories. In fact, Prigogine's approach is the *co-operation* between the classifying-descriptive-historical approach and the *constructive*-hypothetical-deductive method, and the former type of inquiry is a starting point (Vihalemm and Näpinen 1987, Vihalemm 2001:195, 196).

It is also true that classical methods of science have greatly succeeded in resolving the problems of exact science (which come from the technological tasks), but not the problems concerning the integral (including humans) understanding of the natural, living world. In this connection Rein Vihalemm has written:

> *The drawback of classical science is not that it deals with idealisations only and cannot grasp reality in all its complexity. The drawbacks become evident when we do not take into account how and why these idealisations have been created, and under which conditions they are valid, but we begin to take them as the foundation of reality on which everything that objectively exists rests, and what does not result from this foundation and is not in accordance with it, does not actually exist; it is subjective, irreal and illusory (like Einstein's irreversibility and historical time).* (Vihalemm 1995a:2659)

However, Prigogine's new approach, too, has its limits. Rein Vihalemm continues:

> *When I. Prigogine stresses that new science can move further than the idealisations of classical science, being able to embrace instability, chance, irreversibility, unpredictability, historical time, etc., which have been considered subjective or exceptional, or even illusory until now, it can create a false impression that this new science does not deal with idealisations any more,*

> *that it is not a means of cognition resulting from special requirements and aims, but will really understand the real world "as it is" to the point that the problems of the sc. human world, including those of, for example, ethics would be, in principle, scientifically understandable. Real liberation from the myth of classical science presupposes recognition of the limits of science. The myth about science could come into being namely because the limits were not understood*. (Vihalemm 1995a:2659)

About non-classical science, where Prigogine's theories belong, Rein Vihalemm sums:

> *The limits, however, result already from the preconditions of scientific cognition – from the specific character of scientific approach and its aims. Non-classical science, as long as it remains exact science will not lose this feature. If it manages to rid itself from the myth of classical science, the only change will be that it does not equate the scientific worldview, and scientifically modelled reality with the world itself, with reality itself … Non-classical science … claims that there are objective limits to what can be predicted and checked, and these limits can be fixed by laws. The originality of non-classical science lies in the fact that it determined the limits of both classical and non-classical science and, thanks to this, opened up new perspectives for science*. (Vihalemm 1995a: 2659–2660)

Ilya Prigogine has stressed the new perspectives of science only (Vihalemm 1995a:2539).

For me (as well as for Aleksandr Pechenkin (1986:189–191; 1994:374) and Rein Vihalemm (2001:195)) there is no doubt that it is justified to speak about *paradigm change* in physics, introduced by Ilya Prigogine.

It is very important to stress that from Prigogine's theory of non-linear, non-equilibrium thermodynamics of chemical reactions follows the conclusion:

> *In principle, a self-organising system cannot be constructed, since its organisation and behaviour cannot be prescribed and created by an external source. It emerges autonomously in certain conditions (which cannot be prescribed either). The task of the researcher is to investigate in what kind of systems and under what kind of conditions self-organisation emerges.* (Vihalemm 2001:195)

About the applicability of Prigogine's theories to social systems (see also Näpinen 1989) I can say the following. It is correct to speak only about the co-operation between social sciences (as well as humanities) and Prigogine's theories. The methods of social sciences and humanities must be here the starting point. These methods, unlike the methods of the idealised physics-like science, cannot be identical. Ilya Prigogine, like Immanuel Wallerstein (1998: Part 2), has argued against it, reuniting the social science and the natural science: he considers the physical activity as a process of creativity and innovation. "This is surely a challenge to our culture, as it has been practised." (Wallerstein 1998: Part 2, 6) Ilya Prigogine himself has recently explained his creative physical activity in the following way:

> *On the scientific side, our project is perhaps to build a kind of theoretical structure that serves to u n i f y rather than alienate man from nature. As a*

> *theoretical physicist I want to see what the rules of unification are. But unification also requires a better understanding of diversity. Once we see chaos as playing an essential role in the basic laws, we see that the basic laws are probability laws, and from there a whole spectrum of possibilities emerge.*
>
> *In my work I am trying to draw a more unified picture of our universe, and at the same time I am attempting to define our universe as temporal, pluralistic and complex. That is already a big project!* (Prigogine 1999–2001:7; expanded spacing added)

I think that what the researchers of society can learn (or rather remember) from Prigogine's program could be recorded in the following points.

1. The stressing of self-organisation, and therefore amplification, spontaneity and fluctuation in systems of human society by Prigogine is justified (Näpinen 1989). In society one must not try "to categorize people, to pattern their activities into well-defined channels." (Prigogine 1983: 22)
2. For a given environment (boundary conditions) the self-developing system has many possibilities. (That is why Prigogine has spoken about self-organisation, because it is not the boundary conditions which create the self-organisation, but elements of spontaneous development.)
3. Prigogine's approach to the world teaches us the importance of not trying to plan or manage things artificially, but emphasises the ways of stimulating the process of self-organisation instead (Näpinen 1989, 1994).
4. Prigogine's theory of dissipative structures demonstrates that it is impossible to predict what systems or structures will be produced as a result of evolution.
5. Prigogine's approach again stresses that there is no equivalence between what can and what cannot be constructed. The formers are the *simple*, the latter – the *complex* systems (Näpinen 1994:159, etc.). "The complex system possesses *something* that the machine or the simple mechanism does not." (Mikulecky 1997:1) This something is *irreversibly* lost as the system is reduced to its parts. The historical world is entirely complex.
6. The strongly non-equilibrium chaos (the "turbulent chaos") can be treated as a field of possibilities in the historical reality. Because of this creative chaos the possibility of new realities is in each historical reality.
7. Prigogine's research leads to the need for a deeper understanding of the real time. Although there is only one ineluctable and unpredictable arrow of time, there are multiple times. "Time is far more than chronometry and chronology. Time is also duration, cycles, and disjunction." (Wallerstein 1998: Part 3, 1)
8. The so-called laws of nature in the idealised physics-like science represent the reality that has no longer an independent ontological status; they are rather human specific constructs.
9. Classical laws of nature lead to certitudes. Accepting that the future is not determined, we come to the end of certainties. Prigogine's new formulation of laws of nature leads to the real properties of the historical world: instability, chaos, irreversibility, complexity, diversity, historicity, etc. In principle, these

properties cannot be grasped by the idealised physics-like science, but only by the natural historical inquiry (Vihalemm 1995a, Näpinen 2001b).

10. There are no equilibrium and steady, non-oriented states in the historical reality. All complex systems are always in transition.
11. According to Prigogine (2000), we may expect larger fluctuations and increased instability in humanity, because the humanity seems to be in the stage of bifurcation.[10]
12. We have to look upon the permanent uncertainty not as an obstacle to cognition and knowledge but rather as an opportunity to imagine, to create, and to understand (Wallerstein 1998).
13. It seems to be impossible to succeed in applying the principles and methods of all the *exact* sciences (classical and non-classical) to empirical social research.[11] At least one reason for this is the fact that the humans have very different characteristics (manifesting through the freedom of choice) and because of that cannot be analogical to the elements of physical-mathematical systems and even biological systems.
14. Social sciences should not model themselves on the exact sciences (which are aiming at predicting and explaining phenomena) but rather force themselves to give up the ambition to make accurate medium- and long-term predictions, and often even the short-term predictions.
15. Truly social systems are self-developing and self-organising, and therefore they cannot be forecasted, constructed, manipulated, but at best understood. “The world is as it is because of all that has preceded this moment.” (Wallerstein 1998: Part 3, 1)
16. In order to understand ourselves, our society and nature, we must learn to think in the Aristotelian way: to consider the world as a big living organism where we belong (Vihalemm 1981, 2001, Näpinen 1998). “We dismissed final causes too fast. Aristotle was not that foolish. Yes, we need to look at efficient causes, but we need also to look at final causes. The scientists generalized a tactic useful for disentangling themselves from theological and philosophical control systems into a methodological imperative, and this has been disabling.” (Wallerstein 1998: Part 3, 4)

The list can be continued. One important thing, however, must be added. First of all we have to understand what it actually means to understand. We reach understanding of the natural and social world by the way we use models, simulations, and different concepts of historical sciences. Where the pure scientific (i.e. idealised physics-like) approach ends, there the use of concepts of the historical (natural and social) sciences begins. The large part of our understanding we get by different concepts of historical sciences (of historical parts of chemistry,

[10] Ilya Prigogine paid attention to this supposition also in the above-mentioned telephonic conversation (January 8, 2002).

[11] In the telephonic conversation (January 8, 2002), Ilya Prigogine himself claimed that we must not hope too much from applying his approach to social systems, because the social systems differ from physical and chemical systems.

biology, of many social researches and all humanities, including philosophy), and even by common sense, but not by pseudo-science. The scientific (i.e. idealised physics-like) cognition and the scientific knowledge (coming from a mathematical project and being very specific ones) are not the best ones. We need all kinds of knowledge. The knowledge can never be neutral, subject-free and complete. And the understanding should not be reduced to knowledge.

I do not believe that concepts like chaos, complexity, instability, irreversibility, historical time, etc. can ever be defined mathematically. At best they are and remain the concepts of various historical (natural and social-cultural) approaches for denoting some characteristics of the real world. Intuition and imagination, not deduction and scientific experimentation, are the *starting points* for understanding the historical reality.

There is no room in this article to make further acquaintance with Prigogine's program. However, even a less informed reader could conclude from the explanations given above that Prigogine as a theoretical scientist tries to restore the conception of the unitary material world on the basis of the notion of *becoming*: he tries to understand the world and the human being inside it as interrelated processes of becoming (emergence and disappearance). (It must be stressed here that the real processes of becoming in principle cannot be grasped by the idealised physics-like science, but by natural historical inquiry instead. What is needed is the co-operation between the constructive and the historical approaches but not the attempt to replace one by the other.) Prigogine's attempt to restore the conception of the unitary world is completely different from the hopes of some physicists to combine quantum mechanics based on Schrödinger's equation with cosmology based on Einstein's equations. Prigogine and Isabelle Stengers (1994:258) explain their approach in the following way. The classical "theory" that aims at the unitary description of "everything in the world" sets claims to apprehend God's intentions, i.e. to reach the fundamental level of description, on the basis of which every phenomenon (at least in principle) could be derived in a deterministic (deductive) way. However, Prigogine and Stengers speak about a totally different unifying form. The theory of "everything in the world", which would include chaos on the deepest level of physics (let us remember the concept of quantum chaos), would not lead to a reductionistic description outside time. Higher levels would be allowed by fundamental levels but would nevertheless not be derived from them. The unifying element brought in by chaos corresponds, according to Prigogine and Stengers, to the conception of an *open*, *evolving* world. Therefore, the fundamental ideas of Prigogine's paradigm of self-organisation can be summed up in two brief expressions – "the arrow of time" and "the end of certainties".

6. Conclusion

The general conclusions that can be drawn from the foregoing discussion are as follows. There is no justification to apply notions and methods taken from the *exact* sciences (i.e. from the idealised physics-like science) to interpret social life because they are usable in special conditions and for special purposes in exact sciences. Definitions and methods developed within the framework of Prigogine's program, *to the extent that they remain the exact science*, also cannot add anything new to *social* and *cultural* research. Prigogine's treatment of the physical activity as a creative and innovative dialogue between man and nature, however, is the strong challenge to social-cultural studies. Therefore, understanding society *as it really is* remains mainly the task of sociologists themselves. The fact that people, unlike even the most highly developed animals, have the freedom of choice makes social life especially uncertain and unpredictable. A skilful operation with mathematical formulae and predicting events with their help (which is really possible to some extent in case of a certain number of phenomena in certain conditions) do not mean we understand the integral world containing the human being. *The understanding of the integral (including humans) world in all its complexity and diversity presupposes recognising the ideology of self-organisation*. Acquainting ourselves with self-organisation, however, is based primarily on our everyday life and experience, which teaches us that the self-organisation is also related to the *non*-observable complexity. Prigogine's new *exact* scientific models can only embrace (by the so-called laws of chaos) the regular aspect of self-organisation. By the new formulation of laws of nature Ilya Prigogine, in fact, fixed the objective limits to what can be predicted and controlled. Only beyond these limits can the understanding of self-organisation in all its complexity and diversity be possible. This understanding can be based not on the idealised physics-like science, which is grounded on the mathematical construction, but on the common sense, philosophy and all historical researches.

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