The Becoming of Philosophical and Epistemological Foundations for the Methodological Norms in Non-Linear Science

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1. Problems

At the start I will appeal to difficulties with using of previous methodological claims in non-linear science. I mean the understanding of scientific description, explanation and prediction; distinction of the fundamental and the applied sciences; consideration of the empirical and the theoretical knowledge and the organization of these kind of knowledge.

The dichotomies in definition of the kinds of knowledge (fundamental – applied, empirical –theoretical) put a sort of reference system for its methodological description. The normative procedures of description, explanation and prediction are also usually realized through certain dichotomies: description – explanation, explanation – prediction. Although these oppositions are historically defined and depended on epistemological presumes, they work as reference system also. Not overcharging such reference, we have to take it in account.

What about the boundaries of using the previous reference system in non-linear science, I'll demonstrate them with few rhetorical questions. Are the scenarios of penetration in chaos are fundamental or applied knowledge, if they were obtained by calculating on computer with numerical methods on the base of certain phenomenological values of parameters of the growth of herring population or falling the drops out of a faucet? Whether iteration formula is the explanation or description of non-linear dynamic of complex systems, if this dynamic depends on the choices by chance in bifurcation points? Is it the prediction to have a capacity to follow every step in non-linear dynamic of deterministic chaotic trajectory and to have no capacity to say nothing about the prolonged behavior of this system, besides the area of the phase space in which the possible values of parameters are situated?

Not answering these questions (they are just rhetorical) let us consider the understanding of respective methodological procedures. Perhaps it is not the procedures themselves, that do not work in new context. May be the epistemological foundations, which define their opposition, became the obsolete.

Really, if to consider the claim of explanation power of theoretical sentence as a claim of its maximal generality (Popper, 1963, 240-248) the discovery of Feigenbaum's number is completely correspondent to it. What about the doubtfulness of opposition of the description and explanation in non-linear science, this opposition is at all caused not methodologically, but rather epistemologically. Thus, if to accept Hempel-Popper scheme, accordingly to which explanation of the event is deduction of its description from respective universal laws and initial conditions, the description – explanation opposition is not obvious. Vice versa: the best theoretical description of the event is its explanation.

The distinction and opposition of the description and explanation and attributing the privileges to one of these procedures depends on general epistemological position. Thus, positivists as empiricists regarded phenomenon description as preferable to explanation and criticized the explanation as non-scientific procedure. Instrumentalists as pragmatists insisted on theoretical capacity to predict and ignored explanation function of theory, despite of coincidence of the logical structure of the explanation and prediction. Realists distinguished the phenomenon description and their explanation, regarding the explanation as the discovery of the essence, which appearance could be described only theoretically. The position of the critical rationalism was almost the same, though with avoiding the essentialism as seeking for the last essence. In any case, explanation in contradiction to description was connected with disclosure of essence, and it was refused, proceeding from the same understanding. Generally, the understanding of relations between the description and explanation was very close to philosophical foundations of science during all the history of science.

As to nonlinear science an analytic solution of nonlinear equations does not exist as a rule. Their solution by numerical methods with computers presupposes the given value of parameters. So theoretical explanation of phenomenon became rather problematic, if to understand explanation as the logical reduction of hypotheses to others which are of a higher level of universality (by Popper).

Classical tradition to regard a particular event as an appearance of general laws in special conditions can not be used also for the special kind of events: the events of choice by chance one of the variants of solutions in bifurcation points. The one-valued prediction is not possible here so as standard variant of explanation.
Besides, the regularities in nonlinear science do not always express themselves as the laws. The behavior of nonlinear system could be defined by simple formula of iteration procedure, but the behavior itself can be very complex and even it can be chaotic.
I will quote, how the scientists themselves characterize, what the changes have taken place in science in result of its appeal to studying of non-linear processes. “In spite of great successes of physics of the elementary particles or analysis of homological series in molecular genetics, fundamentalist’s credo is already lost its exclusive attractiveness. It is not enough now to discover the main laws and to understand how the world works in principle. The most exact physical laws act in the real world. Every non-linear process comes to bifurcation, where a system can choose one or another way. We have deal with a choice of solutions, which consequences it is impossible to predict, due to the infinitesimal uncertainties blow up and have the long-range effects. In every moment causality is preserved, however it’s not seen anymore after few bifurcations. Sooner or later the initial information has lost its usefulness. During the evolution of every process information is generated and memorized. The laws of nature allow multitude variants for events, but our world has only one history”. (Peitgen and Richter 1986, 17)
If to connect the explanation with disclosure of essence and the last one with discovery of natural laws, as it usually takes place, the opposition of description and explanation obviously corresponds to conceptions of fundamentalists, which credo is just under the doubt in non-linear science. Really, even if non-linear process can be described with non-linear equations these equations have not analytical solutions as a rule. So, they cannot be represented in general form, where it needs only substitute the values of initial conditions to receive this way deductive explanation of phenomenon on the base of knowledge about its stable essence.
What about solutions of non-linear equations with numerical methods, they witness that we have deal not with different appearance of the same essence, but with principally different phenomenon: with dynamically stable dissipative structures for the certain values of parameters and “strange” (chaotic) attractors for the other values. Reference to non-linearity of medium as on the essential ground of all of these phenomena do not save the situation, because under different conditions the non-linear mediums have different set of attractors with concurrency between them.
Thus, transition to consideration of certain existence of certain systems in their historical definiteness with irreversible choices by chance the one of possible ways of their evolution makes other subject for scientific description. This is not more the phenomenon as only the appearance of essence, which is indifferent for their appearances, as it was in classical physics. The subject of non-linear science is the transitive existence of complex self-organized systems. And the philosophical foundations of respective scientific description, explanation and prediction have to be recomprehended.

2. A Way to Solutions

There are ontological and epistemological components in the historically defended system of philosophical foundations of science. They are closely interconnected in their methodological meaning. Thus, methodological standard of causal explanation presumes certain understanding of causality, including respective understanding of necessity, law and so on. At the same time normative methodological procedures are relatively independent by themselves upon their philosophical interpretations (Laudan, 1984). In the situation of global scientific revolution, when the whole system of scientific foundations are being subjected to complete reconstruction (Stepin, 1989,), we can use this independence to base the consideration of the changes. Using the methodological model of scientific theoretical knowledge, general enough to pretend to save its relevance in nonlinear science, we can try to find out right foundations to understand the description, explanation and prediction as functions of nonlinear theories.

I will appeal to Stepin's methodological conception of the organization and generation of theoretical knowledge. His approach from the point of view of activity of scientists in certain cultural historical context, his consideration of the generation and unfolding of theoretical content as constructive procedures, the usage as a base the logical elaboration of genetic method of scientific theory construction (Smirnov, 1962) produced interesting methodological model of scientific theory in its relationships with empirical practice and respective world picture.

This approach opens the possibilities to regard the becoming of theoretical knowledge on its different phases: from first attempt of hypothetical formulation of initial theoretical scheme as a system of abstract idealized objects with respective mathematical apparatus, through constructive groundwork with cycles of appealing to foundations in process of solution of theoretical tasks. The models of such solutions are elaborated due to construction of special theoretical schemes on the base of the abstract objects of fundamental theoretical scheme. These special theoretical schemes mediate the connection of fundamental theoretical scheme with empirical facts and empirical regularities, i.e. an empirical interpretation of a theory.

There is another way to empirical facts: from observation data, obtained in certain device situation, constructed on the base of empirical schemes, in which idealized abstract objects are changed with non idealized abstract objects, represented the real elements of device situation in real experiments. The well known correspondence rules and the very possibility to verificate or falcificate a theory are obtained in the process of the complex procedures of planning and realization of experiments, which are connected with fundamental theoretical scheme through creation of special theoretical schemes and respective empirical schemes.

Surely, it is impossible to tell about content of at least two chapters (2^{nd} and 5^{th}) of Stepin's book in a few phrases. (see the two schemes from these chapters in my translation to English in figures 1 and 2). Besides, the analysis of the problems under interest is just started. All, what I am going to do here, is to show the perspective of this approach.

Thus there is a natural clarification of differences between description and explanation as theoretical description in frame of above mentioned methodological conception. If empirical fact or empirical regularity was obtained on the "bottom up" way, by generalization of observation data, we have description of phenomenon without theoretical explanation. Such facts are theoretically loaded with theory of devices and other background knowledge. And theoretical explanation can be produced on the "top down" way, when respective theory has been created. Then empirical regularity gets the status of empirical law in the process of construction of special theoretical scheme on the base of idealized abstract objects of fundamental theoretical scheme. Mathematical equations exactly fit to the idealized objects in frame of usability of the idealizations. So necessary and universal theoretical sentences can be formulated for respective abstract objects, and deduction of empirical laws from theoretical ones becomes possible.

As to non-linear area, we can regard some effects, even observable ones, as phenomenon of self-organization only after their theoretical reconstruction in frame of respective theory. For instance, neither Benard cells, nor quasi periodic oscillations in Lotka-Volterra model of victim – predator populations cannot be understood as self-organization processes without theoretical interpretation, though we can see the structures in liquid or wolfs and rabbits with the naked eyes.

So, description of self-organization is always theoretical description, obtained by top-down way. On the other hand, explanation, based on numerical methods of nonlinear equation solutions, is connected with certain values of parameters. So it is the theoretical description of certain phenomenon. This is not level of fundamental theoretical scheme, not even level of special theoretical scheme, but it is already the level of empirical fact.

So far as there are few solutions of nonlinear equation, theoretical description includes the information about choice by chance of one of them or the pointing for realizations of each of them. And on the level of special theoretical scheme theoretical explanation in nonlinear area takes place only for the possible, as theoretical reconstruction of necessity expressed in the set of possibilities.

The connection of theoretical explanation with reconstruction of set of possibilities is not so new, at least in physics. Not only Quantum Statistics, but also Classical Statistics reconstructed the states of physical systems, connected by laws, as the sets of possibilities. The distinction of non-linear situation depends on

relation between necessity and randomness and can be clarified by appealing to philosophical foundations of science. At short, necessity defines the set of chances in statistical laws. Choice by chance in bifurcation point means the choice between new additional necessities. Explanation and prediction in nonlinear science do not coincide by their logic structure any more just because of this theoretical uncertainty. It is not the same to have predictable stable spread of values in appearance of law or to have unpredictable choice between different ways of further evolution with inflation of differences.
So far we have real necessity in nonlinear area, which contains real choice by chance, description of phenomenon includes the information about the choice. And it is the theoretical explanation of this phenomenon. There is theoretical reconstruction of the possibilities for choice of further system evolution in singular point on the level of special theoretical scheme, as a result of application of fundamental theoretical scheme.

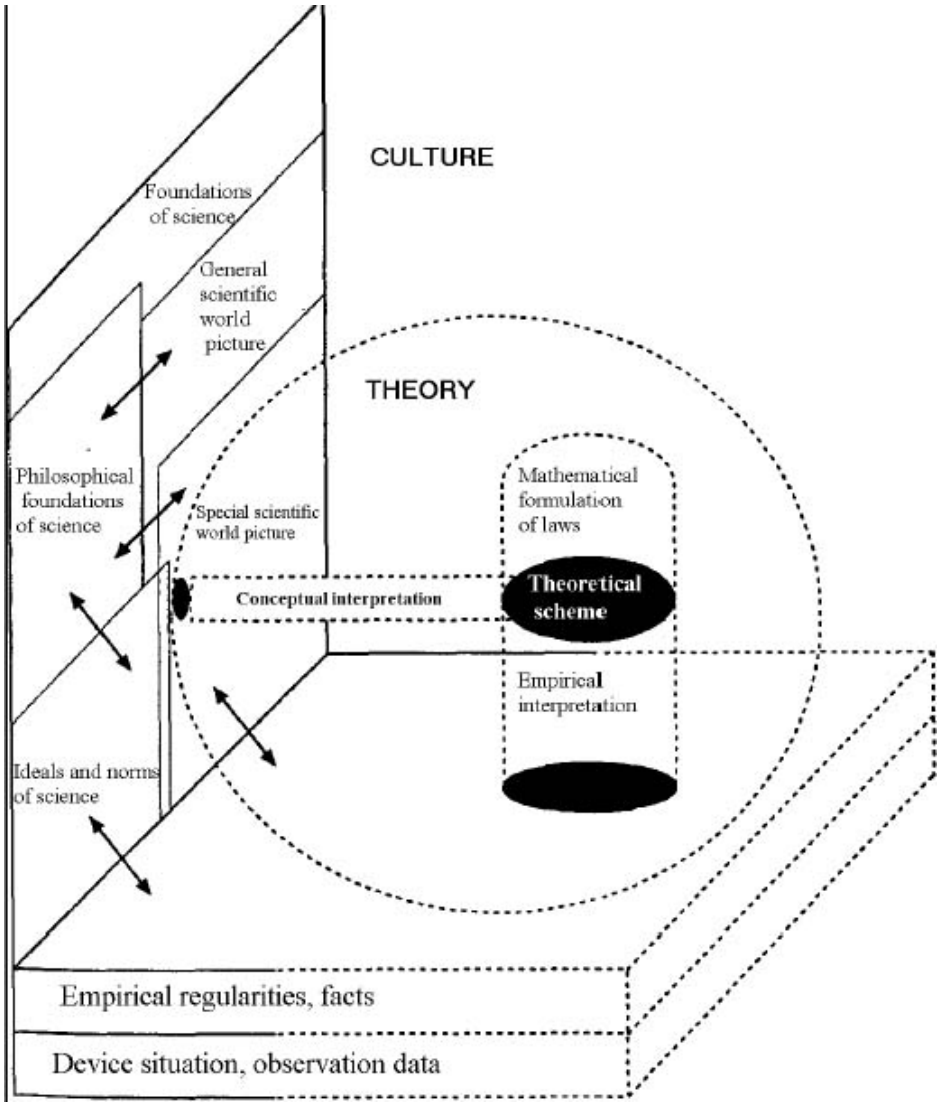

Fig. 1: Picture from the book "Theoretical Knowledge" by V. Stepin

Transdisciplinarity of non-linear science depends on the transdisciplinar importance of fundamental theoretical scheme of Synergetics. For understanding of its generation, unfolding and constructive groundwork and application for solution of various theoretical tasks we can use methodological model of scientific research program by Lakatos (Lakatos, 1970). In despite of sequence of theories, regarded by Lakatos as realization of program in certain scientific discipline, we rather will have rhizome with the same hard core and branches of its application in various scientific disciplines.
I used to appeal to the modification of this model regarding synergetic as general scientific research program (Dobronravova, 1990). However, it was made without connection with Stepin's methodological conception. But Stepin corresponds his own conception with Lakatos'es model by himself (Stepin, 2000,

295-313). So, I think, it's possible to joint these conceptions in methodologically correct way for analysis of non-linear science.
Preliminary, we can admit, that hard core of synergetic research program contains mathematical apparatus of non-linear equations and methods of their solutions and respective methodological principles of their application. As if mathematical reconstruction of nature as mainly non-linear universe is novelty, hard core of the research program is based not on the abstract reconstruction of fundamental theory. New world picture is a ground of generation of new scientific program as it was on the very beginning of generation of Classical Mechanics. (Stepin, 2000, 313-355). The ontological foundations of non-linear world picture originate the methodological principles of synergetic research program, have being re-formulated in a normative way. The above mentioned example of methodological analysis of description and explanation demonstrated how ontological foundations work in methodological way.
I am not ready today to reconstruct the fundamental theoretical scheme of synergetic as system of idealized abstract objects. This scheme is on the way of its constructive groundwork. As hard core of scientific research program it is developing with feedback loops with hypotheses from it's protect belt in progressive shifts of problems on various ways of program application.
Not only hard core of synergetic is changing. I think, that the methodological model we use can be changing also in process of analysis of non-linear science. By the way, the model presumes it by itself. The immersion of abstract objects in new net of relations initiates the new features of objects and reconstruction of the whole scheme sometimes. (Stepin, 2000, pp. 578-610)

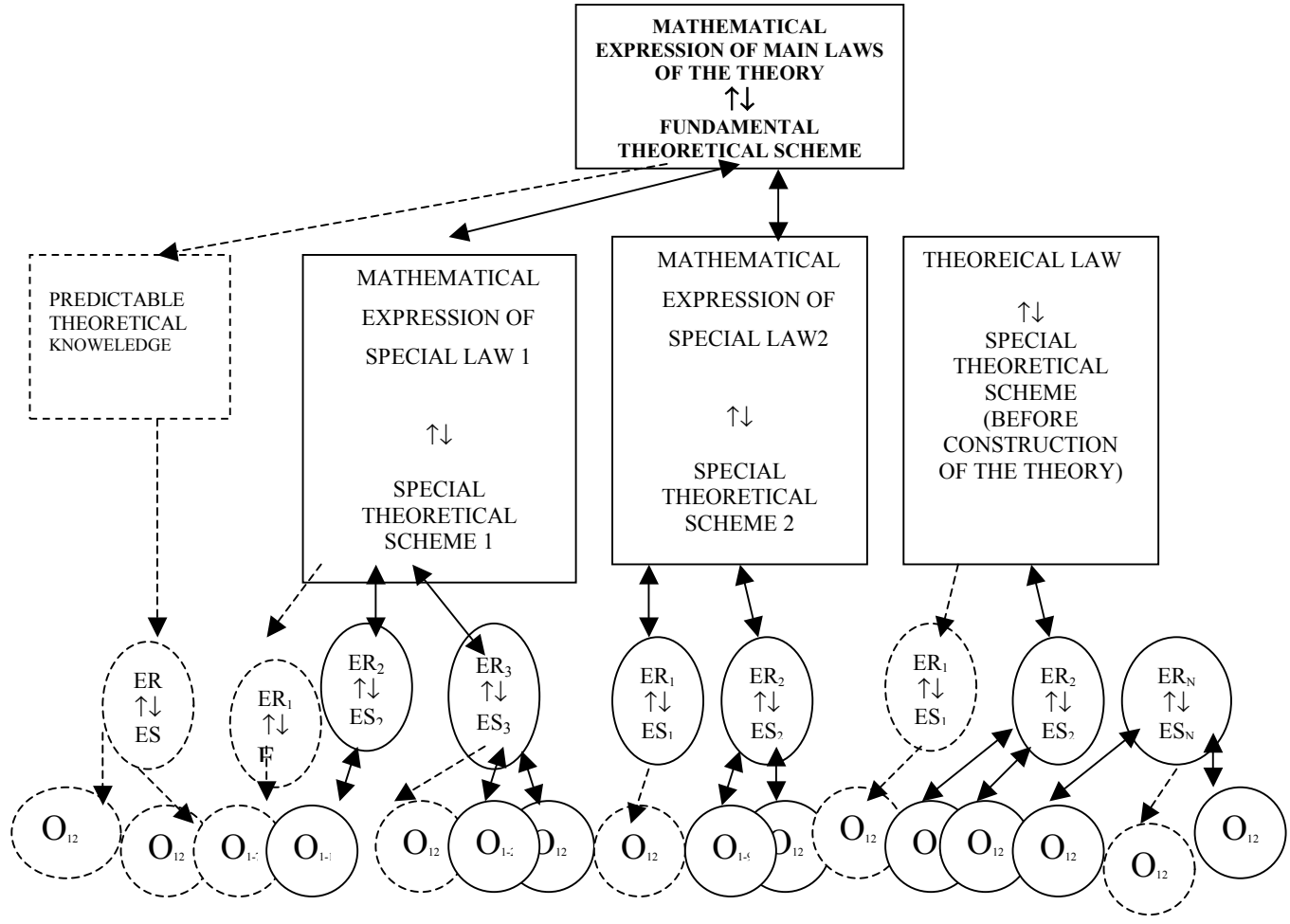

Fig. 2.: Picture from the book "Theoretical Knowledge" by V.Stepin (P.171) – illustration to chapter II.
ER – EMPIRICAL REGULARITY (1,2 – ASSIMILATED BY THE THEORY,
N – NOT ASSIMILATED BY THE THEORY);
ES – EMPIRICAL SCHEME;
O_{1-N} – OBSERVATIONS (1–N – CONVENTIONAL NUMBER
OF OBSERVATIONS)
DS – DEVICE SITUATION

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