Chapter 3

Some Considerations on the Lessons Learnt from the Cavalcade of Changes in Physics' Models

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Abstract

This paper presents an attempt to explain and to make predictions on the change process in the physics' models. One important goal of the search for such an attempt is to develop an approach that is able to have a certain degree of predictability of at least the direction in which the models will change, assuming that in general it is possible to have an answer to the question, whether this change process has a certain rhythmicity and follows some patterns, or it is a totally chaotic one. The paradigmatic approach of Kuhn on changes in science was one of the starting points for this search, and the use of topological aspects to describe models in physics was a starting point of the search for the approach. By using notions of categories and of syzygies from mathematics, a new approach is proposed to evaluate the direction of changes in science and technology, with an example from the nuclear physics and technology.

Keywords: Belief, knowledge process phase, creative solutions in science, old cultural frameworks

1. Introduction

The goal of this paper is to present a new approach on the evaluation of the change process of models in science. The goal of the approach is to be able to increase the existing degree of predictability of the evolution of the models, as given by existing methods [1-6].

It was found out in some examples of its application [7] that the proposed approach indicates better the direction in which the models will change and if this change process has a certain rhythmicity and follows some patterns, or it is a totally chaotic one.

The authors started from the paradigmatic approach of Kuhn on changes in science [1], the use of topological specs to describe models in physics [5,6], and previous similar developments [7,10,12-15].

In this paper the principles of the approach and some results are presented. The novelty of the applied principles is that they are based on a generic description of the science phases (as detailed in previous papers [8,9]) and on the use of the notions of categories and syzygies, as defined in mathematics. The example illustrated in the paper is from the nuclear physics and technology.

As it was shown before in some sample cases (Aristotelian, Newtonian, quantum physics, and relativity theory) [8,9], the change of syzygies is performed by switching from one approach/ science to another by the time the paradox solving process leads to minimum set of syzygies for the given approach. It is also shown on a case considering various energy sources that the syzygy approach in a context of topological description is applicable equally to the object to be studied and its model, which are considered to be in an isomorphism [7].

2. Method

2.1. General aspects

The knowledge topics and the manner they are reflected in the physics models are an old topic of the natural sciences and philosophy. Nevertheless, and may be because of that, actually there is an impressive series of approaches trying to explain and evaluate those aspects. Those approaches are practically part of the main content of the history of science and philosophy. In this context the proposed approach has the following elements of novelty:

i. **Interdisciplinary character**

- **a.** A set of basic principles is defined, starting from notions from mathematics, as for instance, the concepts of **category** and **syzygy**, in a hierarchically developed model. The results are compared with other explanations offered by using other approaches from physics and philosophy (details in [7]). The results may be a basis for answering questions like: *"If and to what degree the changes in models are predictable?"* and *"Is it possible to define rules describing the model change process?"*
- **b.** The analysis performed using the proposed approach is also correlated with the apparent need to screen existing applicable methods used in mathematics, physics, and/or philosophy to obtain answers to the questions formulated at the point (a) above.
- **c.** The whole model change process may explain their generation and scenarios of possible evolution. The examples considered previously [7] illustrate those ideas. For instance, an example is considered of the interpretation of the models for various levels in physics (from subquantum to cosmic).

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ii. The use of some specific cases [8,9] to illustrate the manner to implement the concepts of paradigm and crisis in science [1] by identifying the mechanism/driving forces of the model change process that leads to the situation that some models are adopted from all the other competitive solutions.

iii. The models were considered as topological spaces [2–4]. The basis of the approach to consider the models in physics as topological spaces that study physical systems/objects being topological spaces themselves was presented in [5] in 2008, and they are in agreement with some more recent results obtained from mathematics tools in 2013.

iv. On the other hand, the proposed approach has a strong competitor in a series of totally opposite approaches that consider that the systems existence, their generation, and their destruction, as well as the models describing this process, is a totally chaotic movement.

2.2. Description of main features of the proposed approach

The approach concentrates on finding rules based on which predictions (and not only postdictions) may be made on model change dynamics in physics.

2.2.1. The following components of the approach have to be defined

- The object (for the study) is defined, i.e., the limits and assumptions for the systems are identified
- The main principles/conjectures of the approach are formulated
- The mechanism to be used to verify and validate results is defined

2.2.2. For all the components mentioned above the following guiding rules to describe them will be used

- The use of the notion of category is focused on the search to identify the basic features of the model for which the application of notions of syzygies is possible, as defined by diverse perspectives—mathematics, physics, and philosophy.
- The solutions that are searched from a perspective of paradoxes reached by the use of "mathematics syzygies" may lead to another cycle of using "physics syzygies" and then to one of "philosophy syzygies." Reaching the state of paradoxes for a certain set of syzygies is limited according to the principles of dynamic asymptotic equilibrium in the system description process.
- However, the final state possible to be reached is unknown and therefore from this perspective (of being able to have "final" knowledge) is chaotic.

It is considered that the models generate a topological knowledge structure $K^{(i)}$, that is based on a certain (dominating) theory (Th $K^{(i)}$). The topological structure that results as a knowledge model and the rules of emergence of the physical system itself are described by an isomorphic relationship.

2.2.3. The three principles of the approach mentioned above are as follows [8–10]

Principle 1: The topological structure $K^{(i)}$ is described by the notion of category that is considered to:

a. Reflect a hierarchical structure of "matrioshka" type, that may be described as a more generalized type of cybernetic system, in which the the objects under study and their models are "black boxes" for every level of emergence and, respectively, modeling of the objects/models.

b. The descriptions of Figure 1 are applicable:

- Objects Obj1, Obj2, Obj3
- Morphisms f1, f2, f1* f2, si
- Three identity morphisms (not illustrated in the figure) 1X, 1Y, and 1Z

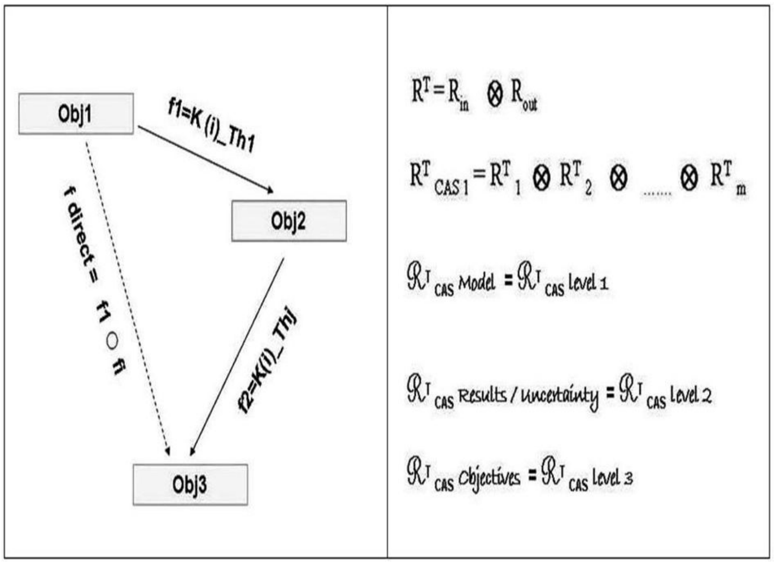

Figure 1. F Description of the category concept

c. C (in the chosen cases) consists of:

- class Ob(C) with elements called objects
- class Hom (C) with elements called morphisms/maps.

d. to be able to define set of minimal conditions describing each phase, that are called syzygies of that set of knowledge relationships that define an algebraic structure.

e. consider that the process of model change consists of having phases of the knowledge process that lead to a certain $K^{(i)}$, i.e., a set described by the rules generated by syzygies, that may be also called paradigms. These paradigms carry with them a set of deviations from the real system/object that are intrinsic to the modeling process and their limits are defined by the set of syzygies.

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Principle 2: The knowledge process (KP) takes place (we will underline that the words "progress" or "evolve" are actually hard to prove and not obvious at all) in iterations made for the categories defined for

- Each object and the whole set as defined by initial assumptions and boundary limits
- At each level of modeling

Up to the point of reaching a critical state due to the number and type of paradoxes embedded in the model [8,9]:

a. In this manner a syzygy set is continuously optimized from diverse approaches—mathematics, physics, philosophy, etc., and based on those optimized sets it is possible to reach (as per the theorem of Hilbert for syzygies in mathematics) a final minimal set of syzygies for a given model. Then by applying the same process from another science perspective this will be repeated.

b. The process of reaching a final optimized state for an approach (with a given set of rules from a certain science) is predictable and it does have a final point. However, the final state of the model as described by the obtained set of syzygies from a given science does not reflect at all the real status of the studied object and therefore new iterations using methods from other sciences to find syzygies are initiated.

c. The KP "imported" approach from another science (mathematics or philosophy for the case of physical objects—as illustrated by the cavalcade of quantum mechanics models of the last decades) lead to a process as described at point (b) above.

d. An example of such a case is the case of NES [7]. It is composed of the following energy levels, defined as energy sources dominating each emergence level:

- Subquantic **SQ**
- Quantic **Q**
- Electromagnetic **EM**
- Molecular **MO**
- Molecular and life **MOL**
- Conscient planetary life **CPL**
- Stellar and universe without life **SUNA**
- Stellar and universe with life **SUA**
- Stellar and universe with conscience **CSU**

Principle 3: The KP is asymptotically stable and complete. Nevertheless, the final structure that results for the KP on a given object cannot be known in its phenomenological detailed characteristics, nor predicted. But the most probable status is that the existence of such a final state can be predicted [8,9].

2.2.4. Description of some specific syzygies

To include more details on the approach presented before and the characteristics of the KP ($K^{(i)}$) a set of syzygies is illustrated for the case of NES, as follows [7]:

- Exergy (Ex) for an NES (defined as the maximum work possible for a process that brings the system to equilibrium with a heat reservoir) as a measure of the process of energy conversion. This generator has the following characteristics:
  - It conserves only when all the processes of the system/environment are reversible
  - It is destroyed when the process is irreversible
- Entropy (Thermodynamic) (EnTh) as a measure of disorder.
- Information Entropy (EnI) as a measure of the limits of knowledge itself.
- Synergy (Sy) as a measure of a set of NES that appear from the existence and interaction all its systems and components, leading to a new set of more characteristics for NES as a whole than for NES components altogether.
- Emergence (Em) from one level to another (for example, from SQ to CSU) as a process in which the entities, patterns, and regularities/irregularities are generated by interactions between smaller (or from lower level) entities, which do not have themselves those properties.
- Nonlinearity (even for simple systems) and/or complexity (NlnCx) for a NES as a source of chaotic behavior of structures of complex systems (SAC).
- The features of a SAC considering fractals (Fr) are defined starting from the characteristics of such systems. In the NES example and its KP structures of $K^{(i)}$ type, as topological structures of the knowledge gained for a given system at a given level, the fractal behaviors is characteristic for describing all levels and each component in a given level.

An illustration of these characteristics is shown in Figure 2.

In Figure 2, the transition matrix may be considered an isomorphic relationship for the aspects considered above. This matrix is actually a function of the considered categories [4]—defined in the KP structure of type$\boldsymbol{K^{(i)}}$ for each source of energy and phase in which the sources may be at a certain stage of changes, as a development of the approaches from [1–6, 11].

Every phase of a NES and every emergent phase are composed of (Figure 3):

- The basic part and the feedback for the structure $COFB_{k}$,
- The layer of connection from one level to another $CLNL_i$
- The layer of connection to the base level $CLMP_j$
- The main layer of the structure ML_j

where $k = 0, 1, 2, 3$; $i = 1, 2, 3$, *si* $j = 1, \ldots 9$.

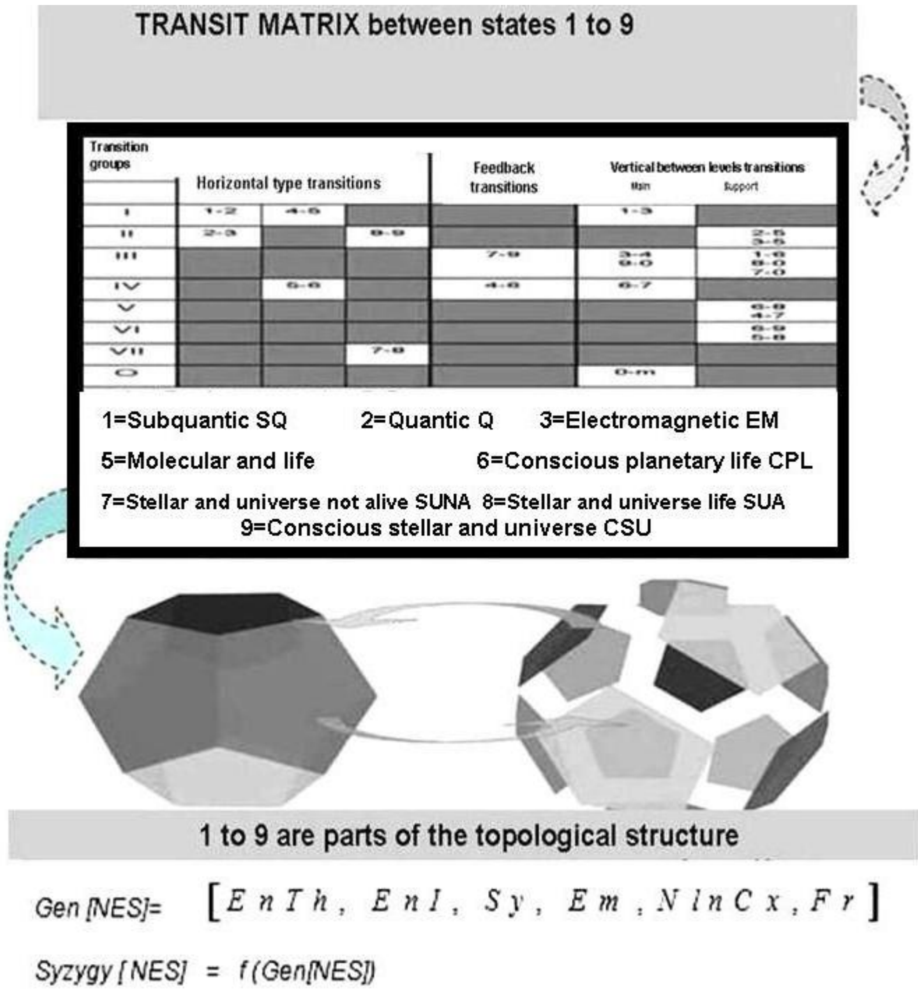

Figure 2. Transition matrix for energy sources and levels of NES example [11]

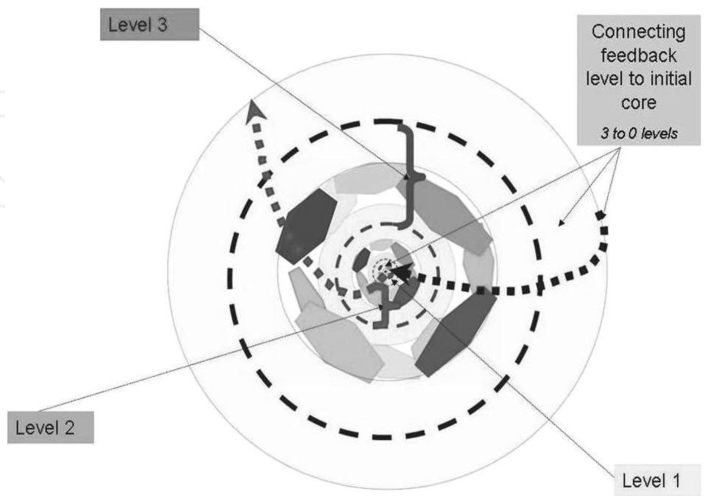

Figure 3. Layers and structure of the KP of K(i) type for the NES example [11]

It can be noted that a given structure of KP for a NES type system has a fractal characteristic.

3.3. Results and conclusions

The approach allows to give some answers to questions on directions of evolution of the models for objects described in physics. The example illustrated is indicating the fractal nature of emergence and changing from one level to another in the process of building a KP structure of $K^{(i)}$ type.

For a NES, this process is repeated in iterations producing versions (R_0,…R_n) generating manifolds of results of MR_i and $MStrR_{i.}$ types (Figure 3).

This process of model generation has the following main characteristics:

- It is quantifiable and predictable for a phase and a given component.
- The type of the final state and the details on the final state (assuming that a real structure of NES type, for instance, exists and it is isomorphic with the final set of models) for a given structure $K^{(i)}$ leads to a state for which its phenomenological characteristics cannot be predicted, and from this perspective this KP state describes a system of knowledge of chaotic type—ChR (Figure 4).

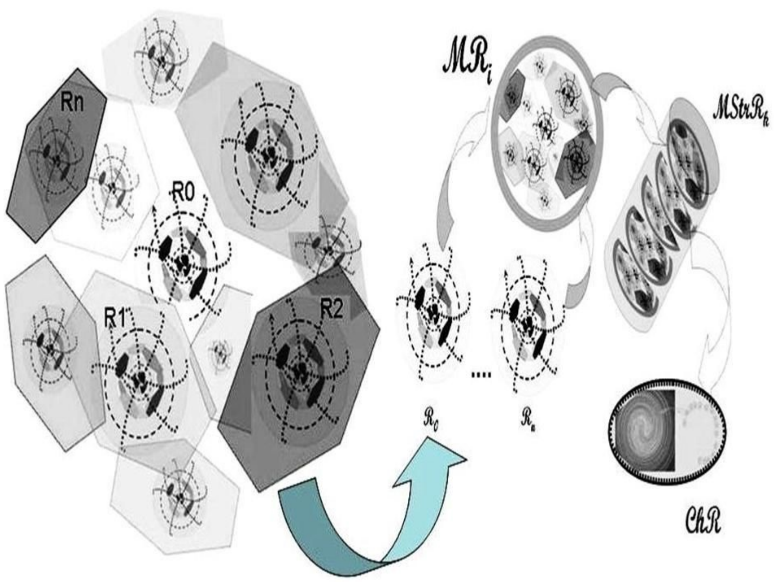

Figure 4. Illustration of emergence for various phases and energy sources [11]

A reformulation of the last statement can be made in the sense that the lessons learnt on NES systems models in this moment (by using the proposed approach) is that

- The process of emergence from one level—one source of energy to another—has a finite character from the number of phases described by syzygy type of characteristics.

- This finite change of states can be predicted and is finite, with a trend to reach an asymptotic level of KP structures.
- However, the detailed phenomenology of the final state is not predictable as the change by the KP topological spaces has a chaotic character from this perspective.

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