laws of symmetry breaking

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Introduction

We came together at fourth time now. We are representing different fields of study, different kinds of the arts, different cultures. One could raise the question, what brings so many different scientists and artists together again and again? The answer seems very simple: it is the common interest in symmetry.

Nevertheless, the case is not so simple. Symmetry does not mean a branch of science or arts. This word denotes an interdisciplinary concept and phenomenon. Its essence is in its interdisciplinary character. Symmetry and asymmetry, order and disorder appear in all of our fields of activity. So, the information we can convey, bears practical value for each other. Therefore, although there is no such discipline like ``symmetrology", but there are common features, and we acknowledge mutually accepted values.

Thus, when we answered the first question, (what brings us together?), we found the glue (that was symmetry), but did not answer the question, what is kept together by this glue? Semantically, there can be two subjects of this last question. In epistemological sense, one of them are we, ourselves. The other is, in ontological sense, the common object of our studies.

Now the next question is, whether there exist common objects of studies, what do not form a discipline? In other words, one can raise the question: are there common principles or common laws what are guiding the symmetry studies conducted in all disciplines? Does this glue keep together (at least symbolically) an ordered structure, in which all of us have our quiet space, where we can maintain the privacy of our creative activity, and without which space the whole structure should collapse?

My answer is definite: yes.
Yes, there are general enough common objects of our studies (at least in philosophical terms).
Yes, there are laws (and not only principles) of symmetry/asymmetry.
Yes, these laws are common, irrespective of the discipline, where we are active.
Yes, there are general laws, what are glued by the phenomena of symmetry (to be more precise, of symmetry breaking).
Earlier or later any field of learning formulates its laws, (this belongs to its identity). So do we now.

These will be demonstrated in my paper.

Maybe the question seems too theoretical for some of you, it cannot be quite neutral for any of us after nearly a decade of work together: whether there are general laws guiding our activities; whether there can be formulated what is common in each other's work; how can we determine what is kept together by this glue called symmetry, asymmetry; what is exactly, which brings our achievements close together? I am convinced that the introduction of some general features in the field of symmetry studies makes our cooperation more conscious. The recent decades demonstrated that methods borrowed by the means of symmetry considerations from different disciplines and arts, led to new discoveries (cf., e.g., the quasicrystals, the fullerenes). What has worked on the level of intuition, may become part of the coordinated activity of scientists and artists in the future.

Philosophical background

Nature proved to be not always symmetric. Although basic laws could be formulated by the application of symmetry principles, most new phenomena appeared by certain distortion of symmetry. Therefore, it was symmetry breaking what led scientists to new discoveries. This is why P. Curie stated ``dissymmetry makes the phenomenon".
The ontological basis of the importance of (dis)symmetry is that material reality indeed has both symmetry properties and symmetry breakings. It has been less realised that symmetry breaking plays important role in the construction of the material world. There is an order (of symmetry breakings), what can be traced along the evolution. These material properties and order can be reflected in the laws of the nature. These are the laws of symmetry and symmetry breaking.
Science and mathematical description looked for order and for the linear phenomena for many centuries, because those were so perfect and beautiful. Less attention was paid to chaos, disordered structures and nonlinear phenomena. The recent two decades turned the attention of scientists to the systematic description (and discovery of laws) of the latter. Similar is the situation with the phenomena of symmetry breaking. We knew and phenomenologically described them. We knew, that they were present in any phenomenon of nature, and most new promising areas for a scientist could be identified by the study of dissymmetric phenomena. However, most works dealing with symmetry itself discussed symmetry and treated laws of symmetry (e.g., Rosen, 1995; van Fraassen, 1989; de Gortari, 1970). Many new transdisciplinary discoveries were made on the basis of the application of symmetry (cf., the discovery of quasicrystals, fullerenes, in the recent two decades). Dissymmetry, and so symmetry breaking was left for the so called ``puzzle solving" research (using this term after T. Kuhn, 1963). Making an order in symmetry breaking was a subject only within separated disciplines, like in particle physics and cosmology, as well as in some biological subdisciplines.

Now, we make an attempt to discuss the role of symmetry breaking at a philosophical level. Laws of symmetry breaking in a wide context will be formulated first.
The laws of ontological levels and symmetry breaking

(1) The law on the determining role of the lower levels.

(1a) Among two consecutive (a lower and an upper) levels, the lower level potentially (but only potentially) possesses the characteristic type of interaction of the consecutive upper level; i.e., that the preceding lower level's types of interaction play the determining role in the development and existence of any level's characteristic interaction. However,

(1b) In the interrelation of two different (an upper and a lower) levels, generally the upper level's structure affects actively the other, since

(1c) Any lower level material structure can reflect its environment only on its own (lower) quality and own level. Within that, the material structure of a lower level can reflect the material structures corresponding to the upper level's forms of material motion also only on its own (lower) level.
(The two statements in (1c) are not-certainly equivalent, because the given levels are determined per definitionem by their characteristic interaction and not by the corresponding form of material motion.) For example, any inanimate being can reflect an animal only as a physical object, and cannot reflect its biological properties; no animal can discern the social differences between human beings.
Since the relation of the two, lower and upper, levels are not symmetric, this law does not open the door to any reductionism. A reductionist approach would allow only the following kind of statement, viz., ``among two consecutive levels, the lower level possesses the characteristic type of interaction of the consecutive upper level." But, according to our laws, (1a) limits the existence of the upper level's characteristic interaction at the lower levels to potentiality, while (1b) and (1c) together contradict any statement which denies the appearance of new qualities at the upper levels.
(2) The law of correspondence between the ontological levels and their potential symmetry properties.

(2a) Each qualitatively higher organisational form in the evolution of matter is marked by the loss of a certain symmetry property, and

(2b) Each loss of a potential symmetry property of matter traces a new material quality. Consequently, the precondition of the development (in its relative totality) of a qualitatively new (material) level is the breaking of a certain symmetry (property), and at the same time, the condition of the continuance (existence) of the new level is to possess (new?) conserved properties. Therefore

(2c) Parallel with the appearance of new material qualities and new (higher) ontological levels, there appear also new symmetries.

(2d) These new symmetries qualitatively differ from those what existed at the previous (lower) levels and what have been broken at the given level. These new symmetries involve new conserved properties.

As a conclusion, the lower and higher ontological levels can be traced by a sequence of symmetry breakings, thus it can be formulated, that

(3) Each symmetry breaking leads to a higher organisational level of matter.

(4) Each higher organisational level of matter is - in a certain sense - less stable than the former one.

The latter statement needs some further explanation. This will be given in the detailed treatise by encountering examples for all the above four laws. Let's now mention only the decreasing self-reproducibility of the living organisms along phylogeny, or the decreasing forces keeping together the inanimate structures from the subatomic particles to the large molecules.

Some open problems

There are some further problems what arise in the interpretation of the above laws. Two of them are crucial. The first one concerns the so called level theories, what are formulated in the framework of philosophy, and what distinguish fundamental and particular levels. Without going into philosophical details, we mention, that generally there are distinguished three fundamental levels of the material world: inanimate nature, the organic world, and human society and thought, while there are further, particular levels within the respective fundamental levels. This is the point, where the next important group of concerns appear: what are the differentia specifica of a given level? What is the main concept, according to which one distinguishes the different levels? There are many candidate concepts for this role, e.g., interactions, forms of motion, order of magnitude relations (principle of `nest of tables'), sequence of genetic evolution, degree of complexity, types of matter, space-time forms, structures. I choose from among them the characteristic interactions, because this works, and plays an equivalent role, both at the fundamental and non-fundamental levels.

The detailed treatise of the mentioned two crucial problems are given in my philosophical works. I do not want to bore too long our interdisciplinary audience with special philosophical problems.

Closing remarks

This treatment could not give a detailed philosophical analysis of the full problem. That was not the aim of this paper. Our goal was only to introduce the laws of symmetry breaking. We did not want to replace any evolution theory; these laws touch them only tangentially. It is important to note that none of the treated laws take stand on the debate of reductionism. We stressed, that they may be used as arguments by both parties - probably they can bring the parties closer to a decision - but in their presented form they do not fulfil a decisive function. This was also not the aim of this paper. The new features of this treatment were to link the level theories with the laws of symmetry breaking.

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