SYMMETRY AND DYNAMISM IN SYSTEMS THEORY

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Abstract. Study of geometrical symmetry, already appeared in ancient times, was continued later by algebra, with group theory and matrix calculus. Since the 19th century, various scientists, mathematicians, chemists, physicists, aestheticians, contributed with studies about symmetry and asymmetry, demonstrating the importance of the alternation symmetry/asymmetry for evolutionary processes.

Keywords: symmetry, asymmetry, orthosenses, dynamic symmetry, symmetric evolution

1. About the concept of symmetry in arts and science

Since millenaries the symmetry of figures was imposed in the aesthetic and pragmatic peoples concerns. The principle of symmetry has been introduced as a scientific concept in the VIth century B.C. by the Greek philosopher Anaximandre, related to the form of Earth and its position in Universe, this one being considered as having a radial symmetry. But the first systematic studies began in the 19th century, when the researches on crystals were been extended on the symmetrical polyhedrons. The study of geometric properties of symmetries is continued by algebra in the same 19th century with the group theory. C. Jordan's papers, published in the years 1868, 1869, and those of H. Hilton in 1903 were mentioned in this domain. In the 20th the algebra adds the instrument of matrix calculus; the papers of F. Seitz, published in 1934 and 1935, those of F. Fumi in 1947, are also quoted. In 1948 J. Burkhard applies the theory of the congruencies in the abstract study of symmetry [16].

Men created symmetry in their constructions because of the knowledge of geometric properties of the symmetry. But besides geometry and algebra, other branches of mathematics use the concept of symmetry; so, symmetry of function is an instrument of mathematical analysis, symmetrical operators *and, or, if and only if* belong to logics too, mathematical theory of fractals introduces the symmetry at scale, symmetry of fractals; mathematical linguistics takes into consideration the importance of symmetry in language.

In Romania the mathematical study of symmetry advanced under the leading of academician Gr. C. Moisil (1906-1973), especially studying the groups of symmetry in crystallography and the equations with partial derivatives of the phenomena.

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Not only mathematicians contribute to the study of the symmetry concept. Scientific chemists, physicists, aestheticians contributed with studies about symmetry. Recognized chemist and biologist L. Pasteur (1822-1895) publishes in 1861 the discovery of the molecular dissymmetry. R.C. Evans at 1848 and later, in the 20th century, Hollema, in 1951, L. Pauling in 1952, F. Hei in 1954, published papers about symmetry in chemistry. In this time biologists like F. Haekel, at 1864, Ludwig at 1932, were implicated in study of symmetry; the physicists P. Curie with papers published in 1884, 1894, and H. Bouasse are remarkable in this domain [16]. Aestheticians like O. Jones, at 1868 wrote theoretical study about symmetry. A special attention must to paid to Matila Ghyka, who published at Paris in 1926 the study *Esthètique des proportions dans la nature et dans les arts* [1986). In the third section of this paper we shall refer to Matila Ghyka's contributions to the theory of symmetry.

Non formalized mathematical definitions are found in almost all encyclopedic dictionaries. Thus, *Universal Dictionary of the Romanian Language* (2011) writes that symmetry is: 1) a regular arrangement of parts, of similar objects, on a side and the other of an axis, a plane or around a point; the correlation of form, position, etc of the opposite parties of a whole; 2) regularity, proportionality, harmony between parts of a whole, beauty resulting from like an arrangement 3) property of two points or two parts belonging to the same figure to be placed at the same distance from a plane, from a line or from a point; 4) property of two (geometric) figures to match exactly.

Universal Encyclopedia Britannica (Ed. Litera, Bucharest, 2011) specifies how different sciences refer to symmetry. Thus, if in geometry this is the property of the sides of a figure to reflect one another face to a line or a plane (axis of symmetry), other disciplines adapted the definition; in biology symmetry means orderly of parts of an animal or a plant; in chemistry it is the fundamental property of the organization of the atoms in molecules or crystals; in physics symmetry is the concept of equilibrium, illustrated by fundamental laws; in nature symmetry is a fundamental concept of the beauty, it corresponds to the equilibrium, order, and so, somebody consider, it reveals the divine principle.

Divine Principle was assigned to the *gold number*, the result of the *gold proportion*, those number x that realizes the condition: $1/x = x/(1- x)$. "The subtle game of proportions and symmetries of the human body, expressed with fidelity by the gold number, was a model of architectural forms for antique Greeks a" (S. Marcus, 1986).

About symmetry in physics, even in this very short expose, must be spoken that the concept was generalized, it signifying *invariance* face the change of the referential system. And so the conclusion is that all the laws of nature have the origin in symmetries. P. W. Anderson, laureate of the Nobel Prize for physics (1977) affirmed, in the year 1972 in his study *More is Different* that "physics is

the study of symmetry", that the symmetry of the laws of physics determines the properties of molecules which exist in nature and that, at the level of quantum mechanics the mathematical expresses of symmetries are not only approximations, they are transposed in precise definitions of the objects described. "From this moment the correlation of these objects with their mathematical description get so closed that it is difficult to separate them".

A new concept tries to impose now in molecular physics: it is that of *super-symmetry*, based on the idea that other kind of symmetry exists between *bosons* and *fermions*.

Symmetry in nature suggested not only the beauty, but also it provided information about the surrounded world. Snowflakes and ice are the most beautiful and delicate images of symmetry. Therefore it is not surprising that religious symbols – the Christian cross, Jewish star, symbol of Taoism, that of Hinduism, Taiji of Chinese neo-Confucianism, the symbol of Buddhism and that of Shintoism – all have symmetries.

In social relations and into the humanities, symmetry expresses reciprocity, empathy, dialog, respect, justice. On the other side, when relations of collaboration begin antagonistic relations, these ones express the asymmetry. Mahatma Gandhi (Mohandas Karamchand, 1869-1948) religious and national apostle of India, the creator of the doctrine of non violent action, figuratively expressed the symmetry of human relationship as being a mirror of the feelings and spiritual life: "Life has taught me that the world is nice if I am nice, that people are sad if I am sad, that all love me if I love them, they are all bad if I hate them; that there are smiling faces if I smile, that there are worried faces if I am worried; that world is happy if I am happy; that people get upset if I am angry, that that are grateful people if I am grateful. Life is like a mirror: if I smile at the mirror, it smiles me back. The attitude I have towards life is the same that live will take in front of me. Who wants to be loved, love! The only reason to be happy is because you decide to be happy".

In aesthetics, symmetry is considered a source of comfort and security manifested in the environment, but excessive symmetry is considered boring and uninteresting. Modernist architecture tries to eliminates symmetries, but sometimes, the asymmetric architectures are dictated by the insufficient space to built (this is also the case of many asymmetric building from Bucharest).

In music, this concept is applied as symmetries of the musical intervals or musical rhythm. In the theory of the symmetries in music the works of Matila Ghyka could be cited.

History of science still finds moments of using terms of symmetry and asymmetry. Example, the study *Asymmetry in electrodynamics from Rowland to Einstein* [8] found that Einstein's famous 1905 paper on relativity invokes the term "symmetry" six times; the authors show that Einstein's arguments are not

based on epistemology, but they are an original physical reasoning. Other terms for symmetry which were used by Einstein's predecessors, especially in connection with Maxwell's equations: reciprocal, parallel.

Symmetry is inseparably linked with its opposite, asymmetry (or dissymmetry, a term less used). The role of the asymmetry was revealed by subatomic physics researches, whose results were published beginning with the seven decade of the 20th century and rewarded with the Nobel Prize for Physics in 2008. Thus, in 1960 Yoichiro Nambu published a mathematical model describing the appearance of symmetry at the subatomic level, the nuclear physicist Andrei Sacharov (1921-1989, Nobel Peace Prize in 1975) published in 1967 and 1979 works about baryonic asymmetry; since 1970 Makoto Kobayashi and Toshihide Maskawa formulated a model to explain the symmetry breaking and the existence of a third family of quarks. Such the role of asymmetry is emphasized, but still remains a mystery the primary asymmetry (http://www.scientia.ro/nobel-2008).

In the researches published since the last decades of the 20th century and at the beginning of the third millenary, in scientific studies the importance of the two complementary concepts, symmetry and asymmetry is emphasized. These entities are used in many branches of science and practical applications.

I quote some relevant domains:

- In biomedical informatics, the analysis of the symmetry and asymmetry is implicated in computer aided diagnosis [19].

- Medical studies introduce the quantification of asymmetry and the calculation of the symmetry index as a common objective in both research and clinical setting [6]. We find also that in neuro-imaging application a way to perform the knowledge integration is to uncover symmetry/asymmetry information from the corresponding regions of the head and to explore its implication to positive clinical findings [19]. The study of skeletal asymmetry leads to important conclusions in medical practice [2].

- In genetics, a very interesting study published in Computing Anticipatory Systems, AIP Conference Proceedings, 2007 refers to "Nature's Code and the Universal Rewrite System in Nature" [7]. The idea is that "Biological concepts, such as translation, transcription, replication, the genetic code and the grouping of amino acids" would benefit by the theory of "Platonic solids, pentagonal symmetry and Fibonacci numbers" which have significant roles in organizing Nature's code".

- In neurology and psychology, facial expressions and hemispheric asymmetry is linked of the brain development [13].

- The social life is examined from the symmetry/asymmetry point of view, when two systems are face to face, for example, in a military theory, the situations which lead to war [1]. This article was quoted by the Journal Dynamics of Asymmetry Conflict. The dynamics of the economic and financial life are also

view as an alternation symmetry/asymmetry. The economic and financial life is analyzed with the alternation symmetry-asymmetry [2], or "Exploring the concept of asymmetry: A typology for analyzing customer–supplier relationships" [9].

- In crystallography, new studies and interpretations are published, some of them using as mathematical model elements of Dirac Algebra.

- Mathematical linguistics, this relative new branch of mathematics takes into consideration the importance of symmetry in languages [11, 12].

2. Mihai Drăgănescu's concept of orthosenses and their symmetry

Reflections of the academician Mihai Drăgănescu (1929-2010) on the concept of symmetry are philosophical, no-formalized by mathematical formulae, but explaining the depths of material world, then considering the nature of human relationship in terms of symmetry and asymmetry. Natural processes involving symmetry are seen as orthosenses, these ones being out of any mathematical model.

Drăgănescu writes about symmetry that it is "the most simple, beautiful and true order" [5]. But being too static, the symmetry shows only the frame of a phenomenon and not the development, the motion. "Symmetry is not the source of the movement, development and progress". Symmetry coexists with its complementary, asymmetry. Broken symmetry and the alternation symmetry / asymmetry, provide processes with dynamism, realize the dynamic of the systems.

In his essay "Symmetry and Asymmetry of Senses", M. Drăgănescu writes that: "It happens something curious, dynamic principles can have a certain symmetry" and he seen the dynamism in the broken of symmetry, which "is never perfect in nature". The symmetry is a priority, but not for a long time, coexisting with its complementary, the asymmetry. [4, 5]. Drăgănescu expresses that "Nature, being poetic because of its symmetry, generates twice symmetries, both in its static principles and dynamic principles". And, according to his philosophical principles about the depth of material world, M. Drăgănescu says both principles are generated by orthosenses, which are phenomenological information: nature introduces a specific symmetry by each of orthosenses, as a kind of simplicity of economy of means. But the multitude of symmetries, by their combinations in universe, lead to breaking of symmetries, and without these breakings this universe there could not exist. Imperfection is a necessity for the existence of any universe.

Another consideration of Mihai Drăgănescu refers to the harmony. His statement is that symmetry is not harmony: "symmetry is beautiful, pure, but only because it is single, it is not in harmony with anything… Harmony requires harmonization between multiple factors".

3. Contributions of Matila Ghyka to the theory of symmetry

The life of the prince Matila Ghyka (1881-1965) could constitute pages of the national history, military history, the history of the Romanian diplomacy, history of art and science.

"Matila Ghyka is marked early in an interdisciplinary training, being in the same time engineer and graduate in letters and law. The long diplomatic activity gave him pause to accumulate a vast culture and to built a pioneering work in aesthetics, by systematic tracking of how the works of art submitted, like the nature, to some regularities which are susceptible to a mathematical description, suggesting some deeper correspondence between scientific and artistic thinking, as one would design the other […] Mircea Eliade considered Ghyka to be a *uomo universal of Renaissance*, lost in our age, a man of a prodigious scientific as well literary and historical culture [11].

In his writings, Ghyka uses the term symmetry in the original meaning of that one, namely as a definition of a pleasant aesthetically proportion. For the living world "it seems to be a marked preference for pentagonal symmetry, a symmetry that is clearly linked by the gold section and unknown in the world of inert matter". From his work we have already quoted the study *Esthètique des proportions dans la nature et dans les arts*, published in 1926 at Paris by Gallimard; it the first book published by a Romanian author at this prestigious house. The book *Gold Number* appeared in 1931 also at Gallimard and it has been translated into Russian in 1936 and in Spanish in 1953. In 1939 Matila Ghyka has become co-founder of the magazine *Simetria*, in Bucharest, with G.M. Cantacuzino, Octav Doicescu and Paul Emil Miclescu.

Salvador Dali, who met Matila Ghyka in 1947 in Los Angeles, was interested in Ghyka's theory on aesthetics and, without understanding the mathematical theory, collaborated with Ghyka to the final touches of his paintings, including the famous Atomic Leda, whose proportions are established by the Romanian aesthetician. Dali's treatise "50 secrets of Magic Craftsmanship" contains in the last part a summary of Matila Ghyka's works.

Aesthetic works of Matila Ghyka, particulary the harmonic proportions illustrated in the book *Gold Number*, have influenced famous creators, including French architect Le Corbusier. UN Secretariat building in New York, designed by Le Corbusier, respects the ration, height (39 floors)/width, equal to a number very closed to the gold number, about 1,618, as it was proposed by Ghyka. Theories from the Ghyka's book *The Geometry of Art and Life* have been used by the Dutch designer Axel Vervoord that made a mahogany, named Ghyka's Coffee table. Russian musicologist L. Sabaneev in 1925 identified a gold number in a Chopin's Study, and Roy Howat found the proportions defined by Fibonacci sequence in duration, rhythm and harmony in Debussy's music. Matila Ghyka maintained a real fact: In music, composers do not propose to follow certain

proportions, but these proportions appear from the peoples aesthetic feelings. But in concrete objects the proportions are imposed by their creator. In addition to painting, sculpture, architecture, musical instruments which follow the proportion were created by Johann Goldfuss in 1969.

Matila Ghyka also referred to the dynamism, to the motion. He said the plants and animals world is linked to pentagonal symmetry, defined by the gold number, symmetry that generates a dynamic periodicity and structures increasing pulsations in a logarithmic spiral.

In Romania many people with resonant names in cultural life of the country have written about the encyclopedic personality of Prince Matila Ghyka and the list is long enough.

In order to not be out of topic, I did not presente biographical data of this great personality of Romanian culture and science in the world. I mention only the last years of his life Matila Ghyka passed in Great Britain, in poverty and sorrow. His tomb is in Gunnersbury Cemetery in London and has been carefully restored by art critic Radu Varia.

4. A mathematical model of symmetric dynamism

Studying and proposing different mathematical models to describe the evolution of dynamical systems, I also considered some pairs of correlated systems by anticipation and retardation, which means mutual coordination by two dual aspects – *anticipation*, as information from future, and retardation, as information from past. In this frame I have demonstrated the existence of some pairs of systems which present a symmetrical evolution. The meaning of symmetry, that I called *symmetry by anticipation and retardation*, is given by the constant ratio between the state functions of the two systems [15]. So, it is a harmony, a symmetry in the evolution of the pair of systems, but this symmetry breaks down under the action of any factor incoming from abroad or from within of one of the two systems, therefore under any new impulse. If the function on time $x(t)$ describes evolution of the states of the first system and $y(t)$ represents the state function of the other system, these being a pair of systems evolving with symmetry by anticipation and retardation, than the mathematical relation is:

$$\frac{x(t)}{y(t)} = \frac{e^{r\tau}}{a+r}$$

The right side does not depend on the time variable t; the conclusion is that one of the two systems of this pair follows in a straight line the other system and reciprocally. The two systems develop proportional states at every moment, so we can say that they have a symmetric behavior [14].

The pages above wanted to suggest the omnipresence of symmetry principles and of the alternation symmetry/asymmetry, this one having a particular importance in the social life of mankind.

A problem could be raise: if the alternation symmetry/asymmetry is the base for dynamism, under what conditions this alternation could also provide stability?

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