International Journal of Academic Research and Development
ISSN: 2455-4197, Impact Factor: RJIF 5.22
www.academicsjournal.com
Volume 2; Issue 1; January 2017; Page No. 30-32

Some considerations about the work of Prigogine in the centenary of his birth

Celso Luis Levada, Huemerson Maceti

Miriam De Magalhães O. Levada, Ivan José Lautenschleguer, Fho-Uniararas, Brazil

Abstract

Ilya Prigogine was born in Moscow, Russia, on January 25, 1917; His family left Russia soon after the Revolution, wandered around Europe, and in 1929 settled in Belgium. He received the Nobel Prize in Chemistry in 1977 for his contributions to the thermodynamics of imbalance, to the theory of dissipative structures. Prigogine received the decisive intellectual influence of two of his professors: Theophile de Donder, doctor of physical sciences and holder of the course of theoretical thermodynamics, and a doctorate in Chemistry and Physics by the Free University of Brussels in 1941. Jean Timmermans an experimenter interested in the applications of classical thermodynamics to liquid solutions and, more generally, to complex systems. He received the Nobel Prize in Chemistry in 1976 and authored several books on scientific dissemination.

Keywords: prigogine, dissipative structures, nobel prize

Introduction

Prigogine was born in Moscow on January 25, 1917, in the initial period of the process of the Russian Revolution. Due to the uncertainties of the Revolution, in a circumstance of transformations, his family left Russia in 1921. His father was director of a small factory before the Revolution of 1917 and was not able to continue with the business in that historical moment. The family emigrated successively to Lithuania and Germany before finally settling in 1929 in Brussels, Belgium, where the future scientist would complete his middle and higher studies. From that moment, Belgium had become her mother country of adoption and, in 1949, he was granted Belgian nationality. At a time when he was deciding the area of his professional studies, during his youth, the world was experiencing the imminence of yet another great war which, of course, posed a series of questions before Prigogine [2]. In difficult times, what profession could one choose? From the beginning, its main interest was centered in the study of the irreversible phenomena of thermodynamic situations out of balance. Most of the physicists, whom Prigogine had informed his project of dealing with non-equilibrium thermodynamics, had a counter-position to it, asserting that it was a ridiculous choice. Despite the opposition, Prigogine persisted in his interrogations and pursued his deep investigations of what he believed contained a new view of reality. From then on, during his life and work, Prigogine introduced a new notion of chaos in science, and this unfolded in a reformulation and expansion of the laws of nature. Chaos is associated with probabilistic laws and the abandonment of determinism and reversibility. Chance and necessity are not opposed. They are complementary. Hence, he refers to the laws of chaos and deterministic chaos. Unpredictable changes in chaotic systems can lead to the emergence of new patterns of order and stability. Prigogine seems to have become a sort of guide in various media, in which it is admitted that science has evolved into a new paradigm in which determinism would have been overcome. In the book The End of Certainties [7] he writes in the Introduction that "the purpose of this book is to present this transformation of the laws of physics, and hence of all our description of nature." Elsewhere in the book, he states that "at whatever level, physics and other sciences confirm our experience of temporality: we live in an evolving universe. We are now able to decipher the message of evolution as it is rooted in the fundamental laws of physics."

In the book From Chaos to Artificial Intelligence [1], he is hailed as the founder of "a new worldview" and, per the author, "his theory admits extrapolations in the most diverse domains: from the formation of cyclones to the organization of ants, through urban growth". Apparently, what he announces is something revolutionary, but is this a universal truth? The truth is that Prigogine's philosophical ideas are far from finding unanimous or even general acceptance among scholars, for example, Prof. Robert Dorfman threatened to resign if Prigogine was hired by the University of Maryland as it came to be considered.

The motivation of ilya prigogine

Prigogine's central concern [6] is how to reconcile the existence of irreversible natural phenomena with the reversibility of the classical mechanics' equations of motion. In a way, this problem was solved by statistical mechanics more than a century ago by Boltzmann. That is, the second law of thermodynamics, linked to the existence of irreversible processes, is valid only at the thermodynamic limit, in which the probability of occurrence of phenomena contrary to it tends to zero. In other words, the microscopic movement is always reversible and deterministic, while macroscopically one can observe an irreversible tendency to balance. This is since there is a tremendous scale difference, and the variables at play are completely different. Positions and velocities of an immense number of particles, in the first case, and volume, pressure, temperature, density, average energy, etc. in the second. These phenomenological macroscopic variables only make real sense in the thermodynamic limit and are defined in terms of the average behaviors of the microscopic variables, and this theory is approached in many books. The fact is that Prigogine is not content with this probabilistic explanation. He wants a theory in which evolution for equilibrium is, mechanically and microscopically, irreversible. For Prigogine, probabilistic interpretation makes macroscopic irreversibility an illusion. In the End of Certainties [7], he mentions that the arrow of time was thus relegated to the realm of phenomenology. It induces us to conclude that the world is perfectly symmetrical in time for a well-informed observer, like the demon imagined by Maxwell, able to observe the microstates. We humans, limited observers, would be responsible for the difference between past and future. This does not mean that the future is "equivalent" to the past or that macroscopic, phenomenological, thermodynamic descriptions are wrong. They apply to a regime of observation and describe very well numerous physical processes, including irreversible ones. If Prigogine wishes to invalidate this view, he must revolutionize classical mechanics. This is what he says he does, therefore, his goal is to introduce a description that includes from the beginning the notion of probability, and for this he considers systems of few degrees of freedom with chaotic dynamics. However, we will see that what he describes is equivalent to the traditional view.

Dissipative Structures

In a stable equilibrium situation, the behavior of the system is symmetrical, uniform and regular, exemplified by a liquid in a container in normal situation and later in a heating situation where the control parameter is a heat action with a certain degree of intensity. As the intensity of heat is increased, the symmetry of the molecules is broken. Faced with the new arrangement of the molecules in the container, a self-organization occurs in which the molecules move, where one descends and another rise, which can be clockwise and counterclockwise. Hence, when the heat reaches the highest degree, the direction of motion of the molecules is unpredictable, new patterns of behavior arise, emerging from equilibrium, resulting in determined chaos, that is, a new structure results. Dissipative structures are phenomena of order creation far from thermodynamic equilibrium. Prigogine [4] has observed that far from the thermodynamic equilibrium, in the presence of energy and material flows maintained from outside the system, there is no single thermodynamic principle that can determine the evolution of the system. This evolution must be studied by introducing the dynamics, using the methods and concepts of the chaotic movement, breaking the symmetry, uniformity and regularity, creation of the new. In dissipative structures, bifurcation points occur that, when moving away from the point of equilibrium, give rise to more than one solution to the nonlinear equations that describe the problem. There is, in general, a succession of bifurcations that alternate deterministic zones and points of probabilistic behavior (the points of bifurcation). Non-linearity implies the existence of multiple solutions. At bifurcation points, the system traverses a path between the various possibilities. It can be seen, therefore, that irreversibility has an important constructive role. Within this framework of discoveries, we need an extension of the laws of nature that allows the inclusion of irreversibility. In Prigogine's theory [3], new concepts were created, such as, fluctuations, dissipative structures, bifurcations, chaos, instabilities, irreversibilities, among others. In equilibrium situations, everything is simple, stable and there is no variation of entropy. It happens that irreversible processes, which constitute the clear majority in the universe, the entropy of the universe grows towards a maximum. Far from equilibrium, the unstable and the complex may appear, but there is also the possibility of forming complex and delicate structures. Under certain conditions these dissipative (entropy) structures can be formed and they can frame self-organizing foci. That is, the dissipative structure can absorb energy and display a certain order. These new concepts are not the result of mere speculation, but of observations, experiments, and research, and of a coherent mathematical reasoning. This theoretical situation does not, however, have an undeniable truth, it is a new way of seeing the various aspects of reality [5].

Final Considerations

Prigogine's theory [8] is applicable to both physical, biological, and social scientific fields and explains, both mathematically and experimentally, how unpredictable changes in chaotic systems can lead to the emergence of new patterns of order and stability in areas as disparate as medicine, psychology, theory Sociology, urbanism, economics, politics, business organizations, astronomy, literature, arts, philosophy, etc. In these dissipative systems, as we have seen, when new patterns of order emerge from chaos, triggered by instabilities and fluctuations, they can generate a change in the self-organizing patterns of the system. When in the biological, social or behavioral self-organizing systems, the equilibrium of the functioning levels is disturbed by some change, by some "noise" (disorder) introduced into the system, the system can rebalance and remain stable, returning to its state Balance. This type of system, capable of rebalancing and constant maintenance of the functioning is denominated homeostatic system. They are self-organizing systems operating in a state of continuous dynamic equilibrium, known as steady state, which is the minimal entropy-generating state used by living beings to maintain the equilibrium of the inner environment. Ilya Prigogine [4] has made important contributions to the thermodynamics of non-equilibrium, but more than this, his texts of scientific dissemination always seek to emphasize "revolutionary" aspects of theories attracting the attention of interested laity in the areas of social sciences, philosophy, biology, etc.

It is undeniable that the full understanding of these claims by Prigogine [9] requires a much broader theoretical deepening. However, it is not the purpose of discussing its theoretical proposal for the universe; What you want is to present your overview. In addition, Prigogine is a good writer, who discusses interesting topics and emphasizes a series of topics that are worthy of attention, such as complex systems, chaotic, out of balance, irreversible phenomena, self-organized, etc.

References

1. Pessis-Pasternak G. From Chaos to Artificial Intelligence, Ed. Unesp, São Paulo, 1992.
2. Prigogine I. Autobiography. http://www.nobel.se/chemistry/laureates/1977/prigogineautobio.html, acessed in 20/11/2016
3. Prigogine, Non-equilibrium Statistical Mechanics, Interscience, New York, 1962.
4. Prigogine. Introduction to thermodynamics of irreversible processes interscience, New York, 1967.
5. Nicolis G, Prigogine I, Self-Organization in nonequilibrium systems john wiley & sons, New York, 1977.
6. France Carvalho R. The historicization of physics and a new dimension of history, Dialogues. 2015; 19(2):813-848, Available at: http://www.redalyc.org/articulo.oa?id=305541164016, accessed 10/20/2016
7. Prigogine I. The end of certainties: time, chaos and the laws of nature. Translated by Roberto Leal Ferreira. São Paulo: Edunesp, 1996.
8. Alberto GS, Cardoso OO. Thought of Ilya Prigogine for administration, text available at http://www.coloquioepistemologia.com.br/anais2013/ANE105.pdf, accessed 10/06/2016
9. Justiniano MF. Time and History - School History Magazine. Year 3, 2004; 1(3):1-16.