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# From Cosmos to Chaos: Philosophical Aspects of Paradigm Shift

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The article aims to highlight that the conceptual apparatus of the contemporary science (not only the problem-solving techniques but also the type of the raised issues) testify the shift of the paradigm, namely, the passage from the Cosmos paradigm to the Chaos paradigm. The significance of the old paradigm, especially considering its astonishing longevity, is related not only with its explanatory potential but also with the innate strife of humans to dwell in the aesthetically and ethically attractive and unconditionally intelligible world. Reductionist methodology became established in the framework of the mechanistic worldview. In this case, simplicity is seen as the main measure of intelligibility; however, the important detail of the elasticity (or, in other words, vagueness) of the simplicity concept is insufficiently considered. The shift towards the new paradigm of chaos is presented as a well-grounded effort of liberation from the universe of anthropocentrism and apriority.

**Keywords:** chaos, order, paradigm shift, determinism

## INTRODUCTION

From the dawn of times humans traditionally think in oppositions: *left* versus *right*, *top* vs *bottom*, *past* vs *future*, *good* vs *evil*, *being* vs *becoming*, etc. These oppositions are merely concept simplifications allowing us to orientate ourselves in the complex world. However, by acquiring new factual knowledge and willing to obtain more profound understanding of the world, we must inevitably get rid of the old concepts or to define them in a new way. In many cases, introduction of entirely novel concepts is required. Radical shifts of the conceptual system at the theoretical level may only be related with the phenomenon to which nowadays we usually refer as the shift of the scientific paradigm or the revolution of science (Kuhn 1996: 149). However, any renewal of the instrumentation of thinking, the entire perspective of reasoning is not simple. For instance, since the dawn of science, the archaic opposition of *Cosmos* versus *Chaos* has been a significant part of the world outlook of the West. Yet, the latest achievements of science urge us to get rid of this opposition. The present article strives to highlight that the issues being raised in fundamental and applied sciences as well as the way of bringing forward these issues cumulatively testify an entirely novel stage of the development of science which may be characterized as a transition to a new paradigm, specifically, to the *Chaos* paradigm.

## APPROACHING CHAOS

*Cosmos* and *Chaos* are lexemes of the Greek origin. In the poetic language of Hesiod, *Chaos*, which etymologically stands for 'gasping emptiness', is the initial state of the world denoted by amorphism and terrifying indefiniteness. From this state, the first gods come into existence, and each of them takes care of a specific field (trade, military, etc.). Under their rule, there exists a definite ontological structure (in other words, *Cosmos*) in the world inhabited by humans. The Greek word *Cosmos* primarily means some *ornamentation*, *decoration*, *military formation*, or, in the most generalized sense, *neat orderliness* (Preus 2015: 105). Seemingly, ancient Greeks treated *Cosmos* and *Chaos* as phenomenological categories endowed with aesthetical, ethical as well as epistemological connotations (cf. Kardelis 2007: 164). From their point of view, whatever is visibly structured and orderly is also beautiful, good and rational. The word *Chaos* denotes whatever is ugly, disproportional, disharmonious and simultaneously amoral, and even essentially unintelligible. The antique worldview is pointedly defined by Oswald Spengler: "The Classical statue in its splendid bodilness all structure and expressive surfaces and no incorporeal *arriere-pensee* whatsoever contains without remainder all that Actuality is for the Classical eye" (Spengler 1991: 95). Of course, concepts migrate not only from one science to another but also from the one cultural context to another; in this "migration", they "are overgrown with different semantic varnishes" (Kačerauskas 2014: 6). However, it seems that until nowadays "semantic varnishes" cannot hide strong esthetical and ethical implications of *Cosmos* and *Chaos*, "essentially Greek" categories.

The classical worldview is prominently reflected in the philosophical texts of Plato and Aristotle serving as the sources shaping the Christian post-Antiquity Western mentality. For example, in *Timaeus* Plato presents the description of the ontological order of universe ('the theory of everything'). It is grounded on the observation that 'the universe is fair'; hence, it originates from the effort of the supernatural artisan-like figure of *Demiurge*. Consequently, the rational explanation of nature is the revelation of a preconceived plan of the Artisan (Plato 2008: 17; 29b). In other words, the ontological structure of the world already seen by the physical vision and fully revealed to the rational reflection presupposes a purposeful action (creation) while the latter implicates a reasonable subject (an agent) (Kardelis 2007: 53 ff.).

The worldview of Plato gradually evolved into the canon of speculative thought. For instance, Aristotle, probably the harshest opponent of Platonism, equates the laws of reasoning (logic) to the objective laws of nature by attributing the modus of absolute necessity to the former as well as to the latter. He criticizes Plato because of his inclination to ignore the dynamism of the material world and the aptitude to treat any alteration as an illusion at the empirical level; on the other hand, he rejects the idea of the universe creation elaborated in *Timaeus*; he claims that the Universe – differently from its constituent parts (specific objects) – has no beginning in time and that the Universe is structurally consummate (Plešnys 1999: 68). The Universe has thus achieved the optimum state of all the potential ones; that is why its qualitative alteration or evolution would lack any rationality. Consequently, it is impossible by default (DeWitt 2010: 83–86).

While the Antiquity worldview is concerned about the image of a sculpture, the worldview of the Early Modern Times focuses on another image, specifically, on the watchmaker analogy. The Antiquity and Medieval teleology (reasoning based on the principle of purposefulness) is substituted by strict determinism – the belief that the established state of things (the state of the world) under the causal laws of nature has been determined by the previous state of things (the state of the world) (Audi 2001: 228–229). It is not hard to realize that this is not a new paradigm but rather a modification of the old (Antiquity) paradigm. There is no doubt that Isaac Newton's *Philosophiæ Naturalis Principia Mathematica* is presumably the strongest contribution to its origin. Newton believed that on the grounds of his discoveries, specifically, the laws of mechanics and the observation of the Sun and planets, it is possible to calculate their interaction and relative weights; hence, the "structure of the world system" is revealed even though a dynamic analysis does not enable us to find out whether the solar system moves by itself or is in tranquility (Disalle 2004: 50).

It should not be forgotten that the determinism of the Early Modern Times is perfectly compatible with the theistic worldview; as the Universe is a perfectly functioning mechanism, the issue of the origin of this mechanism is always pertinent (see Prigogine, Stengers 1984: 29; Audi 2001: 229). The famous Gottfried Leibniz may serve as an eloquent example. He acknowledges Newton's laws of mechanics yet simultaneously emphasizes that "they are not proven absolutely, the way geometry propositions are"; hence they are grounded not on the "principle of necessity" but on such metaphysical axioms as the "principle of perfection and orderliness" (Garber 1998: 315). For instance, while discussing the necessity of acknowledging the law "the consequence is equal to the acting cause" with an opponent, Leibniz remarks that a world where this principle is not valid is logically possible (i. e. imaginable); yet, "such a world would be just chaos" (Ibid.: 319). It is not hard to imagine that the argumentation of Leibniz is persuasive only if the participants of the discussion treat the hereby omitted premise "The world we are living in is not chaotic" as a natural or already proven truth. Seemingly Leibniz saw no obstacles in seeking proof; from his point of view, the world is not *Chaos* as orderliness is superior to disorder, and God, the universally perfect entity, created the optimal world of the logically possible ones (Ibid.: 320). On the other hand, "These magnificent laws [of nature] are fascinating proof of the existence of an intelligent and free entity [i. e. God]" (Ibid.). This mistake of the vicious circle is not a testimony of incompetence of the logic of argumentation but rather a case of almost instinctive resistance against the idea of a chaotic world.

The beliefs of Leibniz and his contemporaries implied, so to say, epistemic optimism (more or less comparable with the optimism of Greek philosophers): it was believed that the world is homogeneous and that experimentation and mathematic calculation may reveal the absolute and ultimate truths (see Prigogine, Stengers 1984: 44). This is echoed a couple of millennia later in the phrase of physicist Richard Feynman that seemingly the nature is comparable to the game of chess where the complexity is only presumable since each move is subordinated to simple rules (Ibid.). In this context, it means that the concept of chaos does not possess any cognitive value. Of course, one may agree with the idea that we are inclined to recognize linear, simple and predictable processes in the nature as they are more readily accessible to our perception; yet this does not imply in any way that our intellectual efforts must be restricted with such objects (Barrow 2007: 147).

Pierre-Simon Laplace largely contributed to the establishment of the mechanistic worldview. He saw the forecast of the future position of objects as an essential quality of scholarly cognition (Laplace 2007: 4). Laplace presented a vision of idealized intelligence (a) capable of quantitatively describing the present state of things with absolute precision, (b) possessing mathematical formulae of all the laws of the nature, and (c) denoted by the infinite capacity of mathematical calculation, which is currently commonly referred to as 'Laplace's demon' (Ibid.). In this case, one adheres to the belief that the universe as a universal system possesses only one way of development (evolution).

It should be stressed that the above listed provisions (at least some of them) are "inherently understandable" not only to the science of the Early Modern Times. For example, Albert Einstein observes that a physicist "must restrict himself within the description of the simplest events belonging to the sphere of our experience"; presumably, a physicist must follow the provision that "the general laws on which the structure of theoretical physics is based" factually apply to "any natural phenomenon whatsoever" (Einstein 1988: 226). Einstein also observes that "With them [general laws], it ought to be possible to arrive at the description, that is to say, the theory, of every natural process, including life, by means of pure deduction, if that process of deduction was not far beyond the capacity of the human intellect" (Ibid.). Transition to the *Chaos* paradigm means questioning all the three stereotypes applied in the epistemology and methodology of the orthodox science (Smith 2007: 3).

## CONCEPTUAL FRAMEWORK OF THE NEW PARADIGM

The paradigm shift is first of all related with the discovery of the limitedness of the forecasting capabilities of Newtonian mechanics: for example, the explanation of peculiarities of Mercury by hypothesizing an existence of new planes (Vulcan) appeared to be wrong; the issue was ultimately resolved only after the application of the Relativity Theory of Einstein. In other areas, gaps of the fundamental theories also became apparent (for more details consult: Skurvydas 2008a, 2008b).

A shift of paradigms is usually related with such more or less revolutionary ideas as: (a) deterministic systems may exhibit a seemingly random behaviour even despite the absence of an external 'source of randomness'; (b) the behaviour of even simple deterministic systems may be hard to forecast in the long run due to their sensitivity to the initial conditions; (c) even though the behaviour of a chaotic system is unpredictable, there exists some 'Order in Chaos' revealing the shared features of a number of chaotic systems (i. e. unpredictable chaos at the micro level yet predictable order at the macro level) (Mitchell 2009: 38). Attempts to eliminate 'Laplace's demon' from the scholarly epistemology usually focus on *noise* or *observational uncertainty*: it is due to the noise that the values obtained during repeated measurements get closer yet they are never identical to the 'objective values' of objects (Smith 2007: 166). However, it would be a mistake to relate the concept of Chaos solely with *the failure of predictability*; in other words, the inability to predict does not define the discussed system; it does not provide information whether *genuine randomness* pertains to the system or not (Batterman 1993: 44–45; Bishop 2009).

In the *Chaos* paradigm we are concerned with the entire system of categories possessing significance in the interdisciplinary perspective (Mainzer 1997: 11–12). The development of the novel paradigm is related with the works of such prominent scholars as Henri Poincaré, an explorer of the Newtonian *three-body problem*, Ilya Prigogine, a Nobel Prize Laureate for the thermodynamic research of *dissipative structures*, Benoit Mandelbrot, the founder of *fractal geometry*, Edward Lorenz, a researcher of opportunities provided by computer simulations for the climate and weather change forecasts (Hooker 2011: 14 ff.). It is usually believed that it is due to Lorenz that the systematic and coordinated research of chaotic systems was initiated.

Of course, this list is not exhaustive. James Clerk Maxwell already observed an aspect of key importance for the paradigm of *Chaos*. He outlined the focal difference between the stable and unstable states of systems by claiming that whenever an infinitely small variation of the present state may cause a definite alteration of the state of the system at a definite time, a claim may be produced that the state of the system is unstable and that the existence of unstable states renders the prediction of future events impossible on the condition that we possess only approximate – yet not exact – knowledge about the present state (cf. Maxwell 1995: 819–820). This means that the observable repetition of phenomena (the cyclical nature of the world) which was treated as an evident proof of the stability of the universe by the thinkers of Ancient Greece does not eliminate the possibility of unpredictable alteration (Ibid.).

Consequently, problems fundamentally differ depending on the dynamic system being stable or unstable (cf. Prigogine 1997: 48). These days, this quality of dynamic systems is usually referred to as the *sensitivity to initial conditions* or *sensitive dependence* (which should not be identified with indefiniteness) (Barrow 2007: 145; Hooker 2011: 25). This essential theoretical aspect is popularly explained as the *Butterfly effect*: 'Does the flap of a butterfly's wings in Brazil set off a tornado in Texas?'; i. e. there exists some essential difference between the state of the world when the wing movement has been performed and the alternative state in which there is no movement at all (cf. Lorenz 1995: 13–15). To put it otherwise, the Chaos theory describes how relatively minor initial alterations in the present state of the system lead to major consequences in the future. Mathematician John von Neumann also observed that dynamic systems contain 'critical points' sensitive to effects; yet he, unfortunately, "did not consider the possibility of *Chaos* where each item is unstable" (Gleick 1987: 20).

It should be remarked that the concept of susceptibility to the initial conditions does not mean that the idea of the description of unstable dynamic processes and the prediction of the course of events is entirely dismissed. To the contrary, it reveals the fact that complex dynamic systems are still considered to be deterministic; hence they are *essentially* predictable (Hoefer 2015). In other words, there is no ambiguity in the fact that systems are denoted by unique evolution and chaotic behaviour at the same time (cf. Bishop 2009). This is the point of transition from the opposition of *Chaos* versus *Cosmos* or (*Disorder* versus *Orderliness*) to the dialectic *Orderliness* in *Disorder* (and at the same time, *Disorder* in *Orderliness*). In the thermodynamics of Prigogine it stands for the immediate interaction of randomness and necessity: whenever fluctuations push the system towards the state of imbalance and threaten its structure, the system reaches its critical (i. e. bifurcation) point. At this point, it is impossible to predict the state of the system at another moment in time since the route of the further development of the system depends on randomness. However, as soon as the route has been chosen, strict determinism predominates until the next point of bifurcation is reached by adhering to the form of the laws of nature which are familiar to us (Prigogine, Stengers 1984: xxii–xxiii; Prigogine 1997: 68 ff).

Another concept of crucial importance for the conceptualization of the phenomenon is that of *nonlinearity* (Bishop 2009; Bishop 2011: 21). A simple example of nonlinearity is the following: "If you are in a state of painful thirst, then a bottle of water increases your well-being significantly. More water means more pleasure. But what if I gave you a cistern of water? Clearly your well-being becomes rapidly insensitive to further quantities" (Taleb 2007: 88–89). A dynamic system is treated as linear or non-linear depending on the nature of the equations of movement describing the system. For example, Lorenz liquid convection equations are a typical example of a nonlinear system (Bishop 2009). Besides, chaotic systems are also observed to feature *exponential growth* which may be illustrated as a cumulative deposit in a bank: the initial deposit yields interest; afterwards the deposit plus interest yields interest and so on. Another example is the so-called *Fibonacci sequence* (1, 1, 2, 3, 5, 8, 13, 21 ..., i. e. $P_n = P_{n-1} + P_{n-2}$). In this context, an aspect of importance is that an explication of the key features of chaos usually refers to the characteristics of mathematical models. Hence, a question always lingers to what extent these models reflect actual physical processes (Smith 2007: 53–54; Hoefer 2015). Mathematical research into the chaos of dynamic systems yields advanced understanding of the threats which we are likely to encounter when trying to discover whether our world is actually ("ontologically") deterministic or not.

Considering the variety of characteristics and the relentless discussion about the necessary and sufficient preconditions, there is no point in expecting to get the universal definition of the concept of *Chaos*. For instance, Stephen Kellert defines *Chaos* as an unstable non-periodical behaviour common in deterministic non-linear dynamic systems; yet not everyone is satisfied with this definition (see Bishop 2009). Occasionally an opinion is expressed (yet somehow vaguely) that *Chaos* is essentially denoted by the *Butterfly effect*, i. e. by the sensitivity to the initial conditions and by the effect of the deck of cards featuring the interlining of trajectories (see Barrow, 2007). Whatever the definition, one of the undoubtedly positive features of the general paradigm of Chaos is that in its framework biological systems are not attempted to be reduced to more primitive yet theoretically more 'convenient' structures. The pointlessness of such reduction is testified by the excellent example provided by Richard Dawkins: if a stone is thrown upwards, it will be moving in a bow-shaped trajectory determined by the laws of the Newtonian mechanics; however, if a bird is thrust upwards – even though its movements are determined by the same laws – it will fly away in a trajectory which is impossible to be determined in advance (see Waldrop 1992: 232).

In the second scenario, a system denoted by *signalling and information processing* is involved. Hence, in this context, *complex adaptive systems* are being discussed. These are the systems featuring extensive networks of elements without central controls and primitive rules of behaviour. This determines a complex collective behaviour, elaborate processing of information and adaptation via learning and evolution (Mitchell 2009: 12–13). Such systems (for example, neurons, brokers, website designers) are occasionally referred to as *self-organizing* systems. Having recognized the phenomenon of self-organization in the social sphere, it was acknowledged that the activity of humans should not be reduced to the strife for predicted results; in other words, there are many more determining factors within *self-organization* than merely the pursuit of benefit (other important benefits also are, for example, honesty, justice, understanding of the world as a universe, etc.) (Ibid.).

It is crucial to remark that nowadays the paradigm of Chaos is not only a particular scientific world outlook but also a certain program of research and a particular methodology. For instance, seemingly, the core feature of each complicated (complex) system is that the origin of such a system remains impossible to cognize if it is treated as the sum of the features of its components (Kaneko, Tsuda 2001: 28–29). In the words of Aristotle, "The entirety is not a simple sum of parts". The efficiency of the new methodology will be determined in the course of time. Meanwhile, we are to draw the conclusions.

## CONCLUSIONS

First of all, whatever can be referred to as the old paradigm of *Cosmos* embodies the innate human strife to dwell in a clearly structured and easily predictable world. It may be claimed that the world is structured and converted into *Cosmos* with the help of logic: the laws and categories of the formal binary logic (the category of sameness, the category of sequence, etc.) are imposed onto the field of physical phenomena; hence, the world is seen through the 'glasses of *apriority*'. One of the key consequences of this trend is the dogma of absolute cognition which is common not only in the ancient philosophy but also in the science of the Early Modern

Times claiming that ultimate and invariable truths about the real and unchangeable order of the Universe are attainable to us. Secondly, the research of 'chaotic systems' undoubtedly enriches the scope of the science by shaping a multidimensional holistic worldview as an alternative to the single-dimensional mechanistic perspective. In the words of Ilya Prigogine, in this case we are facing not only a novel theory (i. e. the so-called *Chaos* theory') but also a new way of reasoning (Prigogine 1997: 20). Essentially, the *Chaos* as inherited from Ancient Greece is a sign or symbol of what we do not know, what simultaneously is existentially important and what should be the focus of our intellectual capacities.

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# Nuo kosmoso link chaoso: filosofiniai paradigmos pokyčio aspektai

*Santrauka*

Šiuolaikinio mokslo konceptualinis aparatas, problemų sprendimo instrumentai ir pats keliamų klausimų pobūdis liudija apie paradigmos pasikeitimą – perėjimą nuo kosmoso prie chaoso. Senosios paradigmos reikšmė, atsižvelgiant į jos stebėtiną ilgaamžiškumą, siejama ne tiek su jos aiškinamuoju potencialu, kiek su įgimtu žmogaus siekiu gyventi estetiškai ir etiškai patraukliame, be išlygų inteligibiliame pasaulyje. Mechanistinės pasaulėžiūros rėmuose įsitvirtino redukcionistinė metodologija, kurioje paprastumas laikomas pagrindiniu inteligibilumo matu, tačiau deramai neatsižvelgiama į tą svarbią aplinkybę, kad pati paprastumo sąvoka esti elastinga ar, kitaip tariant, miglota. Posūkis prie naujosios chaoso paradigmos pristatomas kaip svari pastanga ištrūkti iš antropocentrizmo ir apriorizmo orbitos.

**Raktažodžiai:** chaosas, tvarka, paradigmų pasikeitimas, determinizmas