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Time in Modern Physics versus Time in Orthodox Christian Theology

Abstract

Time is still a mystery among our basic concepts. Although modern fundamental science (more precisely general theory of relativity and thermodynamics of irreversible processes) discovered some new aspects of time dynamics, it is still very far from a complete description. On the other hand, in theology, time reveals itself as having a richer phenomenology. In this sense, times, eons, ages, heavens, etc., come with their role in the architecture of the whole world (both sensible and intelligible). In this paper, we underline the main aspects of time phenomenology in physical science and orthodox theology, showing not only a spiritual dimension of its physical characteristics

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but also a possible way of defining time, connecting sensible and intelligible aspects.

Keywords

Time, Space, Physics, Orthodox Theology, Phenomenology

1 Introduction

What is time? For the time being, nobody knows it in a strict sense. It seems to be a rather mysterious fact among all the other physical concepts. However, its importance is crucial. Essentially, all the natural science today is based on fundamental physics and, in turn, it is based on the primary notions of *space and time*. And indeed, without space and time, there is no possibility of making any experimental measurement and, accordingly, no rational explanation can be made.

However, for space itself, we do have a kind of abstract description. Geometry (which is not a physical science, although space is in the physical world) deals with spatial concepts and characterizes the spaces themselves. Also, its modern mathematical extensions (differential geometry, algebraic geometry, topology, etc.) point out various properties of spaces.

But for time there is no clear and rigorous formulation. For a considerable period in the history of science, time was a kind of background which "flows" continuously and having no mutual effect on any physical phenomenon. This idea allowed the very fruitful approach of modeling "time evolution" of a macroscopic body in a mathematical sense (initiated by the famous physicist Isaac Newton in his brilliant mathematical invention called nowadays "differential calculus"), which was (and still is) extremely useful in physical applications. Moreover, this approach made no distinction between "back and forth" flow (meaning that any

evolution can be "in principle" reversible) because there was no deep reason to consider a variation of time to be only in one direction. Later on, in the XIX century, the problem of reversibility has been settled definitively in the sense that time is irreversible. In its flowing, there is an "arrow" showing only forward evolution (and this was possible because of the development of statistical physics).

This "state of the art" remained unchanged until the beginning of the XX century when the special and general theory of relativity (elaborated by the famous physicist Albert Einstein in 1905 and 1915) proved that time is not "rigid." Instead, it can change in the sense that it can suffer dilation, contraction and even can be "curved" in some specific instances (related to the speed of referentials or matter distribution). Apparently, these properties and phenomena gave a new hope in understanding better what time is. We say apparently because the fundamental theory of physics, which is quantum mechanics, remained stuck in the explication of what is time at the fundamental (microscopic) level. Not even a matching with the theory of relativity has been done, and thus the problem of time and its flowing in one direction is still a mystery at the fundamental physical level.

On the other hand, in Orthodox theology, time seems to have much more aspects and nuances not present in the physical description. The "beginning" of the Genesis, the "beginning" through *Logos* of the St. John's Gospel, the age of the Creation and its seven parts, divisions, etc., put a lot of problems of interpretation which were largely discussed in the works of Holy Fathers. What is really interesting in the theological context is the "multidimensionality" of time. We have "existential" time, personal time, liturgical time, created and un-created eternity, ages, etc. Also, space itself is enlarged in the theological context, namely we have heaven, a heaven of heavens, the third heaven (where St. Apostle Paul was brought) etc. In this paper, we want to pre-

sent more thoroughly how this "multidimensionality" of theological time and physical time can be seen together with their symbolic spiritual dimension.
The first chapter is dedicated to the description of time in physical science. The second chapter discusses the time and eternity in theology and, in the last one, connections between them.

2 Time in physical science

Let us discuss time as it is seen in modern physics. Through *modern physics,* I understand all physics starting with the *Principia* of Isaac Newton until now. Thus, in the *Principia,* Newton describes space and time as totally separate entities from the material world. Time is something that flows evenly, and space is a fixed frame in which all phenomena occur. This fact made possible the notion of *physical law,* which can be modeled by the so-called *equation of evolution* in which knowing the initial condition of a physical system (information about this system at a certain time) one can predict the system at any later time. In this way, science becomes predictive. This prediction is possible because the evolution equation is written as a *differential equation* (a mathematical expression that connects small, *local* variations of quantities with quantities themselves). By solving it, one obtains a *global time dependence* of those quantities. Newtonian ideas have had a tremendous impact on the development of science and engineering, and they are applied today with big success. But there was a voice, even during the time when Newton conceived his ideas, saying the time and space are not properly defined. It is about the famous German scholar and philosopher G. W. Leibnitz, who said something absolutely remarkable for that period; time and space are actually *relational concepts* that show the connection between things. Outside them, these notions have no meaning. In other words, Leibniz says that in a completely empty universe, time and space do not exist at all. They are nothing but *organizers*

of relations between objects. This concept was not taken too seriously, being way too advanced for that period. However, it turned out to be correct much later, with the emergence of the theory of restricted relativity formulated by the famous physicist A. Einstein in 1905 and generalized by him in 1915. This theory produced a first shake in the Newtonian conception of time. According to this theory, time becomes dependent on the observer, in fact, a *relation* between the reference systems. It can "flow" faster or slower and, at speeds equal to the speed of light, *time ceases to flow*. Thus time becomes intimately linked to light. Also, space has the same properties; depending on the speed of observers, it can shrink, and, at the speed of light, space ceases to exist. In addition, in the general theory, a relativity change is not described as the evolution of a physical variable depending on a certain independent variable – time, but rather like a *functional relationship between two events*. In Judaic Caballa, there is a definition of time that corresponds perfectly to this relativistic description - "time is the distance from cause to effect." Although it is a tautological definition (the cause and the effect implicating the existence of *temporal* order), it is in a sense related to what Einstein's theory of relativity is saying. Namely, any interaction (which "mediate" the cause and effect) can propagate with a speed that is maximally the speed of light.

The relativistic conception of time is considered quite good in science since it was verified from an experimental point of view (time dilation observed in some experiments with elementary particles). However, there is something much more subtle, namely the arrow of time, or why time "flows" only in one direction. This is in total contradiction with all the equations in Newtonian mechanics *and* the theory of relativity. Nothing stops the "time" variable from being taken in the opposite direction. However, the daily experience shows us that time is *not at all* reversible but flows in one direction. Physically, the explanation is still unclear, but this fact is considered a consequence of the com-

plexity. That is, physical systems are made up of many subsystems (components) in an (apparently) random dynamic. This fact led to the introduction of the entropy concept, characterizing the degree of disorder of a system, being the *only* physical concept that *cannot but grow* in isolated systems. In this sense, it appears that time as a relation between referentials in Einsteinian relativity or as a relation of a system with itself is an expression of an implacable evolution toward the states of maximum entropy.

On the other hand, for open (non-isolated) systems, complexity can be the source of self-organization and, therefore, of minimal entropy (as shown by the famous chemist Ilya Prigogine). But even in this case, time remains irreversible.[1] It appears here as describing a relation of a complex/open system with itself and with other systems (in this sense, it is open). The field of nonlinear and complex systems is extremely new and dynamic, and there are still many results (theory of emergence, the role of singularities, hidden symmetries, etc.) from which, in the future probably, we will unveil other characteristics of time irreversibility.

Finally, we must refer to the image of time in the fundamental theory of physics, namely quantum mechanics.[2] What is quantum mechanics? Theory of motion and dynamic at the microscopic scale (atomic, nuclear, and subnuclear). It comes with something completely new, namely the *probabilistic image of the state of a physical object* (as opposed to Newtonian mechanics and Einstein's relativity where, within a reference system, any object can be specified exactly with respect to its position and

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1 Illya Prigogine, From Being to Becoming: Time and Complexity in the Physical Sciences, W. H. Freeman, New York 1980.

2 J. G. Muga, R. Sala Mayato, I. L. Egusquiza (eds.), Time in Quantum Mechanics, vol. I, Lecture Notes in Physics 734, Lect. Notes Phys. 734, Springer, Berlin Heidelberg ²2008.

speed). On the other hand, it comes with the limitation of the possibility of knowledge through the indeterminacy relations (meaning that one cannot specify the position and the speed of a particle with a precision greater than a certain threshold related to the Planck's constant). This is not related to a present limitation of the measuring devices to "see deeper," but it is a *principle of limitation* (not related to the capacity of experimental devices).

Now, what is time at the fundamental (quantum) level? Although, as most concepts of classical (Newtonian) physics can be defined, time can no longer be defined as a quantum observable but just as a simple parameter. This is very bad because it means that at the fundamental level the concepts of space and time are *no longer quantum*. However, one can "force" mathematically a quantum definition of time, but in this case, the values of it become complex numbers. Complex numbers are bi-component numbers having a real and an imaginary part. They can be represented as pairs of real numbers as well. Accordingly, in this forced definition, the quantum time has *two dimensions* (is a *dual* time). For the time being there is no experimental evidence of this two-dimensional time, but we shall see that it may have theological meaning. In addition, due to the probabilistic aspect, the location of a quantum particle has no meaning (and accordingly, the notion of the trajectory of a quantum particle has no meaning), and the values of the physical quantities are essentially related to the measurement process (which is fundamental but depends on the observer). The fact that quantum objects are no longer located gave birth to the concept of "*Quantum teleportation,*" seen not as an instantaneous transmission of information but as the existence of correlations between quantum objects at arbitrary distances. Physicists today are rather reticent about defining "quantum time," which becomes a meaningless notion in the same manner as the concept of "fluid surface" becomes meaningless at the atomic scale as well. This fact is behind another very complicated problem, measurement or computing

time in some quantum processes (like quantum transitions or quantum jumps in the interactions of the elementary particles).
At the level of the cosmic scale, time is entirely described by Einstein's general relativity theory.[3] Time is intimately connected to space in the so-called *space-time manifold* (cause anything is characterized by length, width, height, and time), and its structure depends totally on the quantity of matter existing in that manifold. The famous Einstein's equations describe how the presence of matter influences the *geometry* of the space-time manifold (which can be flat, curved, twisted, etc.). We have to stress here that in the formalism of general relativity, there exist "types" of time. In particular, because any event is characterized by spatial and temporal coordinates, the temporal coordinate of any referential system is *not* the physical time of an event occurring in that referential. And that is because the space-time itself is a curved manifold, and only *locally* (in infinitely small regions where the manifold is almost flat) can one put a referential with space-time coordinate axis. Accordingly, the physical time has to be defined *in a different way,* and indeed, in the theory of general relativity, time is computed using a formula that takes into account the structure of the so-called "event-line." The *coordinate of time* thus loses its physical meaning and remains just a parameter. In this way, the Newtonian "background" which flows becomes meaningless (this is a well-known consequence of the invariance of Einstein's equations of general relativity under general changes of space-time coordinates). The physical content of solutions of Einstein's equations is purely relational.
To see this, consider what is actually measured in general relativistic experiments. For example, consider a clock T1 at rest on the surface of the Earth and a clock T2 on a satellite orbiting around the Earth. Call T1 and T2 the readings of the two clocks.

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[3] S. W. Hawking, G. F. R. Ellis, The large scale structure of space-time, Cambridge University Press, Cambridge 1973.

Each measures the proper time along its own event-line in the Earth's gravitational field. Given a solution of the Einstein equations (for the gravitational field, Earth, and satellite), this will predict the value of T2 *as a function of the value of T1 and not at all the actual values of T1 and T2*. So, essentially the general theory of relativity can predict only *relation between times. A fundamental consequence of this experiment is that there is no absolute time.*

In conclusion, in physics, we have, on the one side, a purely relational connected space-time manifold defined for any punctual event and, on the other side, a one-directional time-flow associated with the evolution of complex systems. In this view, space is the *organizer of relations between objects,* and *time is the organizer of relations between a system and itself.* At the quantum level, time still remains a classical concept or becomes a concept that imposes the appearance of *dual time,* which actually has no experimental validation and physical meaning.

3 Time in Orthodox Theology

As Father Dumitru Stăniloae[4] pointed out in his beautiful paper "Time and Eternity": "In Christianity there are two conceptions of God, one which comes from the Bible and belongs to the Christian life and experience and the other coming from Greek philosophy. The first presents God as being alive, full of interest and concern for humanity. The second introduces him as motionless. Eastern Orthodoxy has made great efforts to combine and harmonize these two views. It searched to reconcile both ways of thinking about God through the teaching of divine nature and energies, stating that, by His nature, God remains motionless, but

[4] Dumitru Stăniloae, Timp şi veşnicie, SLG Press, Fairacress Oxford.

He "comes" forth (manifests) outwardly through His energies."[5] Accordingly, in Orthodox Christian Theology the main problem is not the time "intrinsically" but rather the Eternity or more precisely, the time *in relation* to eternity. And related to it is the problem of the *beginning and the end* of the Universe. The time itself appeared in the Bible in the first chapter of "Genesis." For Saint Basil the Great,[6] the first moment of time is not time (Augustine also proved the falsity of the view of the temporal moment as being a *dimensionless* "point" in time) but rather a *border and an opening* to eternity. The first verse of Genesis shows exactly that the whole Creation erects in "something," which is *both time and eternity*. This eternity is a kind of non-temporal instantaneity that also contains the physical time through the sequence "day-night" realized by the light. Since the Creation is taking place in such a dual time-eternity background, it is very difficult to specify precisely how long were the *seven days* of creation and how old is the Universe and the Earth. Not only is it difficult, but it also seems impossible with respect to physical time only.

Furthermore the problem is even more complicated. We have in the Gospel of Saint John the Theologian another "beginning"; *At the beginning was the Logos*. As Lossky underlined, this beginning is not a creation of time but a supra-eternal *relation* between Father and Son which is beyond (not only in a temporal aspect but in all aspects) any *kind of eternity*. That is why in Orthodox Theology, time and eternity display multiple dimensions. They are described as very lovely by the Saint John Damascus in his Dogmatics. He started from the Letter to Jews where Saint Apostle Paul states clearly that "Son made the ages" and reveals that the word "ages" has many meanings like the life of any human being, the 1000 years period, the period after the End of the

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5 Ibidem.

6 Vladimir Lossky, Introducere în teologia ortodoxă (Introduction in Orthodox Theology), Editura Enciclopedica, Bucureşti 1993, p. 80.

Universe, etc. Also, "age" can be understood as being *not time, neither a part of it but a kind of flow, together with a temporal interval flowing together with all created things.*[7] Before the creation of the Universe, it was no measurable physical time (or age) but a *time flowing together with eternity*. Also, after the Final Judgement, there will be non-temporal ages which are cycles of everlasting (eternal) communion with God.[8]

Saint Andrew Fool for Christ gives a more subtle explanation of these aspects. He considers that, according to the Letter for Jews, *the first creation was the ages. The "hypostasis" of the ages is the unlimited sequence of times, eternities, and periods. Their essence is a beautiful spirit fixing himself in seven signs, although he is spreading continuously toward infinity. God himself gave eternal "travel" for ages, and from ages, the angels and humans took their minds. God, also from the essence of the ages, created angelic worlds in a similar manner as man was created from dust.*[9]

This very interesting description shows that angels have a deep relation with ages (a dual relation since the ages consists of time and eternity). Saint Maximus the Confessor simplifies the description saying that we have only two types of eternity. One is un-created and exists within the Holy Trinity, and the other one is created, having a relationship with angelic worlds. This created eternity is called "eon," and it contains in itself the possibility of physical time. We could say not only the possibility, but eon itself comprises a duality of time and created eternity. This point of view is in an apparent contradiction with the Leibnizian vision

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7 Saint John Damascus, Dogmatica (Dogmatics), Scripta, Bucureşti 1993, p. 45.

8 Dumitru Stăniloae, Footnote 100, in: Filocalia vol. III, St. Maximus Confessor, Răspunsuri către Talasie (The Responses to Thalassios), Harisma, Bucureşti 1994, p. 474.

9 St. Andrew Fool for Christ, Sfanta Manastire Paraklitu, Evanghelismos, Bucureşti 2005, pp.163-169.

(used in physical theories) that there was no time before creation (when nothing existed). However, we consider that the contradiction is only apparent since angelic worlds *are something* rather than *nothing*.

So, God created the ages – the first creation - comprising anything inside. The created eternity contains the intelligible description of the world, geometry of ideas, the networks of mathematical truths, unchangeable structures of the Universe, etc. By contrast, the non-created eternity cannot be thought or conceptualized (it can be approached only by an apophatic way or a deep spiritual living).

However, all these considerations do not explain what is eternity. Father D. Staniloae developed a very interesting approach to the explanation of eternity by connecting it to the deep nature of the person. He considers that eternity cannot be a non-movable existence but something which is alive and dynamic. This unchangeable and still dynamic aspect is showing that the source of eternity is the person (any person, not just the divine one). Eternity itself includes a kind of introverted dimension and freedom of will. This is why in eternity, every person experiences a *perpetual novelty, and this novelty comes from the plenitude of communion with other persons*. So eternity is nothing but the personal communion of life *carrying inside the possibility of time*. But this time is an existential and personal time also carrying the possibility of eternity through the communion with persons (including Persons of the Holy Trinity). However, it is not clear what is the relation between this existential/personal time with the physical time.

4 Spiritual dimension of physical time: toward a way of defining Time

The Scripture and the Creation have equal values and say the same message Saint Maximus the Confessor said in his Ambigua.[10] According to this view, any mathematical, physical, chemical, biological, social, historical, etc., phenomenon must have a spiritual dimension. One can ask what is the spiritual dimension of the properties of physical time as they are described today by relativistic, quantum, and statistical physics.

Physical time depends on the observer. This fact has a very important spiritual dimension. Namely, the observer – which is the symbol of the Human Being is normative in the dynamics of time. The person itself can drive time to eternity depending on the communion with other persons and with God.

Space and time become singular at the speed of light; namely, time stops flowing, and space ceases to exist. Indeed, it is quite easy to see that this physical phenomenon shows symbolically that in the light of the Holy Ghost, any person experiences eternity. Light itself shows God's grace, and this grace is compatible only with eternity. Moreover, in God's light, the separation between persons ceases to exist. Namely, there is a perfect communion (exactly as in physics where at the speed of light, space itself disappears).

Gravity and black holes produce time dilation. Strong gravity and black holes suggest that a huge accumulation of matter (which is incompatible with light) can produce time dilation as a path to plenary death. The fact that black holes have the biggest possible entropy (which measures lack of information and disorder) has a spiritual correspondent that "flesh and blood cannot inherit the Kingdom of God" (1 Cor. 15, 50).

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[10] St. Maximus the Confessor, Ambigua, Editura Institutului Biblic şi de Misiune al Bisericii Ortodoxe Române, Bucureşti 1983, p. 127.

Quantum time is a complex number. As we said, if we force the quantization of time using the canonical mathematical methods, we obtain the values of time given not by real numbers but complex numbers. Complex numbers are pairs of reals numbers *having a real part and an imaginary part.* The spiritual interpretation of this is straightforward; the time itself is not "alone" but together, or in relation with *eon* or eternity. So the imaginary time can be seen as suggesting the eon or eternity.

In addition, *complexity and entropy,* as we said, make a *vectorization* of time, namely, time can flow only in one way. Accordingly, the world itself is irreversible. Saint Maximus the Confessor proved that there is a necessary end of the world. And this is because "*merging of the generals produces an appearance of particulars and they, in turn, decompose themselves into generals. Accordingly, such rapidly changing beings cannot be eternal because they spread and transform in uncountable ways*".[11]

On the other hand, all the things in the Universe have their own *logos.* And in addition, all these particular *logoi* are unified in the Divine *Logos.* So the complexity in the Universe can be seen as an action of Divine *Logos* which branches and splits in many *logoi* and in this way, time itself appear as *measuring the variety and enrichment of Creation*. This enrichment cannot go but forward, continuously renewing its diversity and filling it with rationality. This fact is also emphasized by Saint Maximus the Confessor when he says, "*God, having finished creating the first reasons (logoi) and the universal essences of things, is still working today, not only sustaining them in existence but also bringing them up to date, unfolding and constituting the given virtual parts in essences."*[12]

Now, one can see that all these progressive unfoldings of *logoi* give rise to a possible definition of time, namely:

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11 St. Maximus the Confessor, Ambigua, Question 52, p. 166f.

12 St. Maximus the Confessor, "The Responses to Thalassios", p. 45.

Time is the embodiment (or plasticization) of rational/logical chains and patterns of intelligible things (including human thoughts) in the created material Universe. Time is intimately related to changing. Any change is a rational-logical chain (at the intelligible level) from cause to effect. Accordingly, time must be an embodiment of this chain in the material world. Moreover, "*from ages, the angels and humans took their minds,"* so the mind itself, the source of logical reasons and thoughts, is related to the *logos* of ages. Of course, the above definition is not in the rigorous sense; it is just an alternative way of seeing the concept of physical time.

The possibility of existence "beyond" time appears only in *freedom* when there is no longer a *predefined strict reasoning chain*. Eternity becomes the personal communion of life and carries in itself the possibility of time - that is, exactly what Father Staniloae said.

Then, we remember that Saint Andrew Fool for Christ said, "*from the logoi of the ages the angels were made just as the body of the man was made from the dust*." Therefore, we can speculate that from the *logoi* of the ages, God made the *body of the angels*[13], that is, the rational-intelligible *corporeal* structure of the angels.

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13 Vladimir Lossky, *Introduction to Orthodox Theology,* p. 111: "Angels cannot be defined as unincarnated spirits. Even if they are called such by the Holy Fathers or in the Liturgy, they are not pure spirits. An angelic corporeality exists and can even be made visible. In the West, the idea of the incorporeal nature of angels was imposed by Thomism, but the Franciscan monks held the opposite position. In the 19th century, in Russia, St. Ignatius Briancianinov defended the idea of the corporality of angels by contradicting St. Theophanes the Reclused".

5 Conclusions

In this paper, we tried to present some differences between visions of time in modern physics and orthodox theology. In modern physics, the concept of time is rather poor, and it is strictly connected (at the macroscopic level) with two aspects; the geometric one (in the theory of relativity), where time is a part of the four-dimensional space-time manifold endowed with a metric and the thermodynamic one where it is related to the irreversible evolution of complex systems. At the quantum level, these relativistic and thermodynamic aspects no longer exist, and time becomes just a simple parameter measuring the absolute changing of quantum states. The unification of geometric vision of space-time in relativity with the fundamental quantum description of nature is the biggest unsolved problem of theoretical physics today.

On the other hand, in Orthodox Theology, time is much more richer. Various levels of times, eons, eternities, ages, etc., open a gate to a new reflection of what is time, even at the basic, physical level. The fact that "ages" were the first creation of God (Heb., 1, 2) shows that time itself has a specific nature, different from space (contrary to the physical vision of connected space-time), and moreover, it has also a purely existential dimension, related to the communion of persons and with God. These personal relations within the freedom given by Holy Ghost make possible the emergence of eternity.

Then we showed the spiritual dimension of these physical aspects, making them as a kind of icon envisaging the presence of God's commandments in Creation.

Finally, based on the complexity of the Universe, logical links, and interconnections of *logoi* at an intelligible level, we propose a possible way of defining time as being the plasticization of rational/logical chains and patterns of intelligible things (including human thoughts) in the created material Universe.