Solved what spacetime is?

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Table of Contents

Summary

In this essay the author overcomes the theoretical contradiction between General Relativity that defines the gravitational field as a geometric aspect of spacetime, either as potential or curvature, and Quantum Gravity that defines it as a fundamental force of interaction, with the change in the conception of spacetime of structural geometric property from the gravitational field, to the conception of spacetime structural geometric property of matter in motion.

Spacetime is not a continent of matter (Substantialism) but rather is contained in matter insofar as it constitutes the geometric structure that gives it its shape and allows its changes, to which as space it confers its ability to contain and as time its capacity to becoming. Nor is spacetime the category of geometric relations of material bodies and their events (Relationism), since it is not a relational property of matter but rather the geometric spacetime structural property of matter, which it endows with their abilities to self-contain and transform.

The author's conception of spacetime is that dynamic energy-matter, geometrically endowed with the four dimensions of spacetime, is spatially self-contained and temporarily self-transforming.

The wave-particle, of matter and of the field, does not exist in spacetime, but this is the intrinsic structural geometric property of the wave-particle, therefore, attached to its own internal nature, as its intrinsic dimensional geometric property which with the force of law is manifested in its quantitative measurements, either when the wave particle itself is taken or in relation to others.

Thus, only theories on gravity from Quantum Gravity are possible, although they must be reformulated, renouncing to integrate them with the geometric vision derived from the equations of the so-called "General Relativity".

PACS

04.20.-q Classical General Relativity

04.60.-m Quantum gravity

1. Introduction.

Physics is the science of space and time, of mass and energy, and of movement about their ontology [1], their structures, properties, and mutual interactions, though not their reactions. Therefore, only of those interactions that, although, can produce a change in the physical properties and even new elements, in the radioactive transformations, but never a change in the chemical properties, since, in the physical phenomena no new substances.

Space and time, since their appearance in ancient thought, have been linked to the shape (geometry) and movement (physics) of material objects. As everybody or particle has shape and every movement has a trajectory (in geometric terms a curve), geometry and physics are the theoretical tools used to understand space and time. Updates to geometry and physics appear historically connected and, of course, with the evolution of the concepts of space and time [Page 1, 1]. The geometry that, during its appearance, was closely linked with the material form, used to measure objects, became a formal science, divorced from the material form and became governed by the laws of pure reason, the logic of thought, which caused that in the science of physics space and time acquired their own abstract existence, for many centuries, disconnected from material existence, even in Newton's work. It was only at the epoch of General Relativity that space and time, combined in spacetime from a Minkowski mathematical model although defined in Riemann geometry as a four dimensional manifold of positive curvature, achieved the status of being closely connected with material existence, by which it would be conditioned and in turn would condition; but, in any case, preserving its own entity ontologically, either as a substance or as a relational category [2], since not being defined by Physics it is Philosophy that does it.

For its part, General Relativity is a geometric theory called geometrodynamic [3] (Wheeler, 1963) of spacetime, which maintains that there is no vacuum and it curves due to its content of dynamic matter and energy autonomously, while the spacetime for being changing in function of the reconfigurations of matter-energy is dynamic-dependent, whose component particles of matter-energy are determined to move freely within causal geodesics, \`time type if they are particles with a mass different from zero and null or light type if they are particles of the electromagnetic field´ [Page 17, 2], which causes gravitation, which is therefore not a force but "an aspect of the geometry of spacetime" [Page 2, 3]. The curvature of spacetime is the gravitational field that is thus, geometric-dynamic entity dependent on matter-energy transformations, and the spacetime its structural property. "Spacetime does not claim an existence of its own, but claims the category of structural quality of the gravitational field" (Einstein, 1954).

The General Relativity resulted from a program of geometrization of the science of Physics from spacetime, privileging with respect to matter and energy, given its importance in the understanding of motion, in front of the anomaly of Mercury's orbit according to Newton's celestial mechanics and the constancy of the speed c of the photons in vacuum, found in the Michelson-Morley experiments and leaving aside the physical transformations that occur between the forms and states of matter and energy, so in the end it turned out that the gravitational field, being a metric field, breaks the chain of transformations between the different fields existing in nature. Minkowski, a former professor at Einstein, introduced geometric method and thought into Special Relativity, who, inspired by Félix Klein's work on new non-Euclidean geometries, in his Erlangen program the traditional algebraic instruments of support of physics were replaced by geometric. "Minkowski indicated that the geometers have focused on the transformation of space. But they have ignored the transformation groups associated with mechanics, those that connect various inertial states of motion. Minkowski proceeded to treat those groups in exactly the same way as the geometric groups. In particular he constructed the geometry associated with the Lorentz transformation. For starters, it was not the geometry of space, but of spacetime, and the notion of spacetime was introduced to Physics almost as a product of the Erlangen program. Furthermore, he found that spacetime has the hyperbolic structure now associated with Minkowski's spacetime. From this geometric perspective the formulation of a theory that satisfies the principle of relativity in inertial systems becomes trivial. It is only required to formulate the theory in terms of the geometric entities of the spacetime effect of the various types of spacetime vectors by Minkowski defined and the theory will automatically be Lorentz covariant” (Norton, 1993). Later, in 1915, with the formulation of General Relativity, Einstein adopted spacetime with Riemann geometry geometrized gravity.

The bridge between special and general relativity was the Entwurf theory. Between 1905 and 1907, Einstein like Poincare and Minkowski failed to obtain a relativistic theory of gravitation, RTG, from Special Relativity due to the impossibility of describing the gravitational potential using a 4-vector. At this point Einstein was unaware of the tensors. RTG was accomplished in the 1980s in Russia by a group of mathematician-physicists under the leadership of Anatoli Logunov, albeit from Poincare's relativity, Entwurf theory supported in absolute differential calculus although the tensors applied to the Minkowski spacetime, variational calculus and gauge theory.

In 1912, the mathematician Marcel Grossmann, who had served as a professor of descriptive geometry, from the Absolute Differential Calculus, introduced in 1901 by Gregorio Ricci-Curbastro and Tullio Levi-Civitta, introduced Einstein the tensors, a new powerful mathematical tool, with the power of being able to integrate the principles of equivalence and relativity at the same time, given its covariance property, which could be applied in the Riemann spacetime or in the Minkowski spacetime, a special case of the first when the curvature tensor $R^{i}_{jkl} = 0$. Absolute differential calculus represents quantities as geometric objects, as such is complementary to the Erlangen program.

Einstein chose the tensors applied to Minkowski's spacetime since he, as a physicist, at that point had reconsidered his original idea of gravity as homogeneous and understood it as extended gravity that must be an electromagnetic-like energy phenomenon and was indispensable "that the conservation laws are satisfied by the material processes and the gravitational field taken together. So, we demand the existence of the expression $t_{\mu\nu}$ for the impulse and energy flows of the gravitational field, together with the corresponding amounts $T_{\mu\nu}$ of the material processes” (Einstein, 1913). Einstein devised the argument of the hole to justify the limited covariance, which occurs when the tensors are applied to the Minkowsky´s spacetime, due to its lack of universality that, if it possesses the Riemann spacetime, avoiding the indeterminism that would result from a general covariance. But, the equations of the Entwurf theory failed to give at the limit of weak gravity those of Newton and, on the other hand, in astronomy the trajectory of Mercury.

General relativity arose not as the further development of Entwurf theory but from a deep personal crisis of Einstein's, in fierce competition with the best German mathematician of the time, David Hilbert, begun in July 1915, and ended in November 1915 , when Hilbert first and 5 days later Einstein delivered the equations giving the results, that the equations of the Entwurf theory could not. Einstein was forced to apply the tensors to Riemann's spacetime, the other alternative that Grossmann had given Einstein, at the cost of renouncing the materiality of the gravitational field, which became a field of geometric nature, devoid of physical reality. This had to deviate from the hole argument, for which, with the help of the philosopher Moritz Schlick, he elaborated "the point coincidence argument" with which the indeterminism of the general covariance was overcome. Einstein presented the general covariance as the realization of the general principle of relativity. And without knowing how the equations work.

"As pointed out 90 years ago by Hilbert (1917), Einstein (1918), Schrodinger (1918) and Bauer (1918) within the focus of geometric gravity (General Relativity) there are no impulse-energy tensor characteristics for the field of gravity" (Baryshev, 2008). Thus, geometry gobbled up Physics, form to content.

General Relativity has attempted to unify with Quantum Physics [4], which intuitively derives an explanation of gravity as the effect of the material gravitational field, composed of virtual gravitons, and recovers it as an interaction force, the most general of the fundamental forces of nature. "In quantum mechanics, the forces or interactions between material particles are assumed to be all transmitted by full-spin particles." "The gravitational force ... is attributed to the exchange of gravitons between the particles that form ... bodies." "From the quantum mechanical point of view of considering the gravitational field, the force between two material particles is represented as transmitted by a spin 2 particle called a graviton" (Hawking, 1988).

The unification strategies are of two types: from General Relativity, the gravitational field explain it as material or from Quantum Physics, all fields explain it as geometric [5]. This has been the mostly preferred strategy, but it fails to exceed the low energy limit. Recently, Cala and Smeenk (2006) challenge it by choosing and theoretically supporting a solution within the first strategy.

With the internal gravitomagnetism or frame dragging, established experimentally in the Gravity Probe B, performed by the Stanford and NASA teams, in 2004, and the supposed detection of gravitational waves, in 2015, the spacetime would be a ¡material field¡ [Guillen, 2016], [Bunge, 2017], [Romero, 2017].

V. G. Turishev (2011) of NASA and Paul Worden (2012) of Stanford University wrote in independently articles: according "frame-dragging effect: Rotating matter drags space-time ("space-time as a viscous fluid").

However, the issue of spacetime remains unresolved. In 2018, for the "International Society for the Advanced Study of Space-time", the nature of spacetime "stay open"; Between May 14 and 17, the "Institute for Foundational Studies Hermann Minkowski" held the "Fifth International Conference on the Nature and Ontology of Spacetime" in Varna, Bulgaria and, in May, in Nature, it was written: "People have always taken space for granted. It is just emptiness, after all, a backdrop for everything else. Time, too, simply moves on and on. But if physicists have learned anything from the long work to unify their theories, it is that space and time form a system of such astonishing complexity that it can challenge our most ardent efforts to understand" (Musser, 2018). Is that spacetime is an enigma (Lorente, 2006), because "we really don't know what spacetime" (Odenwald, 2015).

In 1989, Logunov demonstrated that gravitational waves cannot be derived from the Grossmann-Einstein-Hilbert equations, since a metric gravitational field cannot radiate despite its supposed dynamism and that Einstein definitively resigned in 1938. Pressed by Lorentz, Prize Nobel 1905, Einstein called it relativistic ether, conferring on it of word materiality and answering what was its speed ?, at Born's request, since when did Einstein have such a conception in Entwurf's theory; For that forced reason, Einstein introduced gravitational waves between 1916 and 1918; When Lorentz passed away and his influence died out in the scientific community, Einstein consecutively ended the relativistic ether and gravitational waves. The author has formulated that the waves, initially detected by LIGO, in 2016, although a new type of quadrupole waves, are not gravitational waves

(Guillén, 2016). Such a discovery is not strange since, being the result of the use of a highly sensitive technology for quadrupole disturbances unknown aspects of matter-energy must appear, although insufficient to detect true gravitational waves due to the extraordinary weakness of the Logunov´s graviton estimated on the order of 4.5 10^{-66} g.

This, so far, insurmountable contradiction between the gravitational field as a geometric field in the macrocosm, where the mechanics of General Relativity is valid, and the gravitational field as a material field on the Planck scale, of the microcosm, where quantum mechanics is valid, is examined in this essay with the goal of overcoming this contradiction, from the perspective of spacetime from where it has strategically emerged.

1.1 Notes

[1] Intersection between physics and philosophy insofar as it has as one of its main objects being as being.

[2] It is impressive that, in the transition from prescientific to scientific thought, in Althusser's terms, when generality one or a theoretical body was elaborated, which in the methodological process of scientific research, replaces the real object, was produced, as a truly undesirable effect or early loss of reason, that spacetime will separate from matter and acquire an autonomous existence, which has lasted for so many centuries. And even, General Relativity, in formulating interdependent spacetime and matter, only managed to bring spacetime closer to matter, from whose interior it detached itself.

[3] Evolution of three-dimensional configurations.

[4] The right-hand side of the field equations [of general relativity] describes matter sources, the behavior of which is governed by quantum theory. The left-hand side of the field equations describes gravitation as a classical field. If the right-hand side represents quantized matter then the field equations as they stand are inconsistent (Riggs, 1996).

[5] The conceptual incompatibility between General Relativity and Quantum Mechanics is generally seen as a sufficient motivation for the development of a theory of Quantum Gravity. If - so a typical argumentation - Quantum Mechanics gives a universally valid basis for the description of the dynamic behavior of all-natural system, then the gravitational field should have quantum properties, like all other fundamental interaction fields. And, if General Relativity can be seen as an adequate description of the classical aspects of gravity and spacetime - and their mutual relation -, this leads, together with the rather convincing arguments against semi-classical theories of gravity, to a strategy which takes a quantization of General Relativity as the natural avenue to a theory of Quantum Gravity. And, because in General Relativity the gravitational field is represented by the spacetime metric, a quantization of the gravitational field would in some sense correspond to a quantization of geometry. Spacetime would have quantum properties. (Reiner Hedrich, 2009).

2. Substantialism and Relationism.

The question of space and time arose, in pre-Socratic times, from the questions: The Universe and its becoming in which it is contained? Is space and time your continent? To which were added the questions about the intelligibility of the local movement that led to the question: Are space and time relations?

Plato and Aristotle, “background-dependents”, defended that space and time are the fixed background that contain the Universe and its becoming, while Heraclitus and Democritus that space and time are nothing more than relations that register the movement between the bodies that compose the Universe and are “background independents” [6].

In the 17th century, the discussion reached Newton and Leibniz: is space real or does it result from the relations between material bodies? Either matter and space or matter and relations. This dilemma resulted in, even today, spacetime relations being seen as relations between points at which events occur (Substantialism) or as relations between events themselves (Relationism).

In Newton geometry (not as the set of metric relations between material objects but as the metric characteristics of space), simultaneity, and inertial structure are intrinsic properties of an absolute real meta physical space [Page 200, 5], whereas, for relationalists they cease to be and are structures, in which relations between material objects are encoded, these are the relational structures.

In Newton matter provides dynamics on a fixed background. In intrinsic dynamics (Relationism) this background is suppressed. Intrinsic dynamics describe the evolution of matter in relative configuration space. This is possible because its main element: instantaneous configurations (fields or particles), change their intrinsic configuration (in relation to themselves), because matter is dynamic [Page 208, 5].

Newton's Substantialism was debated by Leibniz, who, in modernity, is credited with Relationism, denying the persistence of points of space in time, arguing that, if the world were elsewhere or inverted or on the move, ontological redundancy would occur, while the spatiotemporal relations between its components would not be altered.

Descartes argued that space is identical to the extent that is directly connected to material objects; without there being space without objects or empty space. Huygens found motion unrelated to material objects absurd and Leibniz found that the physical support of motion should reside in matter and its relations. Leibniz concluded that space, extensible to time, is the ordered set of relations between material objects and all movement is relative, although absolute movement exists, but not with respect to space but when the cause of movement is intrinsic to the object that it moves [7].

In Relationism space and time would lack physical reality and would be simple categories that express the dimensional relations between material objects that have volume and are subject to change [8].

Although, Leibniz did not specify the movement support structures these can be: topological, geometric, and causal; this one based on absolute simultaneity.

The rejection of the identity of the spatial points leaves Relationism the problem of the justification of inertia, therefore, by not formulating it, it remains without an inertial structure. This was what happened to Leibniz who, by denying the ontological character of the points of space, cannot explain the inertial structure and, therefore, the inertial movement [9].

The consequence is that Newton's Substantialism endures due to the inertial structure of motion, which exists and would be independent of matter, although stripped of absolute motion relative to absolute space and formulated in the context of the spacetime manifold (General Relativity) in exchange for space. The spacetime manifold is a geometric object that generalizes the concept of surface for four dimensions; It is deformable, that is, it admits multiplicity of forms due to topological transformations (the global structure of spacetime) and has the property that at each point (event since the points no longer represent particles) it is differentiable in Minkowski tangent spaces, which are pseudo Euclidean spaces, but, constrained to maximum speed c.

Thus, Newton's error in considering absolute motion in relation to absolute space is solved, since spacetime has the structure to define absolute acceleration, without the need for absolute space, because it has an affine structure (inertial) to through all spacetime. This is a quasi-Euclidean abstract geometric structure (Minkowski space according to the theory of Special Relativity) that hangs at each point of the manifold and allows the explanation of the properties of movement from geodesics on it. This structure serves to determine which trajectories are inertial (geodesic) and to encode the general structure of the inertial force, which maintains the absolute acceleration (the change in speed, between different coordinate systems, is absolute), but not the rest and absolute speed. Spacetime itself makes it possible to establish the absolute acceleration with respect to the affine connection and allows the explanation of inertial motion as geodetic motion (rectilinear for Newton and Minkowski's plane spacetime) and, therefore, the existence of absolute motion with respect to this affine structure or family of inertial systems ($\Gamma^{\sigma}_{\mu\nu}$), which would be independent of the presence of matter or field [Page 29, 5]. The existence of the inertial structure is taken as an intrinsic structural property of spacetime, which in this way is real (thesis of Sophisticated Substantialism) [Page 30, 5].

In Sophisticated Substantialism, the Galilei group of transformations must be interpreted as different representations of the same physical reality. These transformations do not generate displaced worlds in space. In this way, although, the identity of the points of the space is suppressed, the redundancy is replaced by possible representations. Then, Leibniz's ontological redundancy becomes the possible representations of the same physical reality [Pag. 30, 5].

But, because in General Relativity spacetime and the gravitational field are identified, as Rovelli (1997) says, the debate between Substantialism and Relationism is still present, since, ultimately, it has not been resolved that it is real or property of the another: whether the spacetime or the gravitational field [Page 143, 5]. But once frame drag and purported gravitational waves are accepted only Substantialism is possible.

Relationism and Substantialism are identified in that spacetime is a geometric object and they differ in that for Relationism it is an ideal geometric object which is formulated in relation to material existence, while for Substantialism it is an real geometric object, whose substantiality is understood as presence, existing by itself, although, it is non-material presence. However, there is a group that gives to Substantialism a material reality. To this group belong the scientists linked to the frame drag and the supposed gravitational waves of LIGO and those who follow them.

2.1. Notes.

[6] ¨Since the Greeks, the argument has raged between those who believed that space and time have an eternally fixed, absolute character and those who thought space and time are no more than relations between events that themselves evolve in time. Plato, Aristotle, and Newton were absolutists. Heraclites, Democritus, Leibniz, Mach, and Einstein (the younger) were relationalists¨ [Page 6, 4].

[7] `Leibniz's relational view states that space is the order of coexisting things and time is the order of successive events. Leibniz makes time and space relative to material events in the Universe. Without material happenings time and space can only be ideal. In a physical sense, time and space become relational properties: for time and space to exist the Universe must be filled with matter and changing material events. Time and space become relations between spatial-temporal locations´ [Page 1, 6].

[8] `Relationism holds that space and time do not exist in isolation from matter. Spatial relations exist between material bodies, and temporal relations exist between physical events´ [Page 1, 7]. `Relationists will deny that spacetime points enjoy this robust sort of existence, and will accept spatiotemporal relations between events as primitive´ [Page 2, 8].

[9] "Leibniz makes the relational view too dependent on the existence of material processes or entities in the Universe. John Earman characterizes Leibnizian Relationism as the view that spatiotemporal relations among bodies and events are direct. That is, there is no underlying substratum of spacetime points, which physical events would merely occupy. Michael Friedman holds that Leibnizian Relationism wishes to limit the domain over which quantifiers of our theories range to the set of physical events, that is, the set of spacetime points that are actually occupied by material objects and processes. In Friedman's formulation, Relationism constructs spatial-temporal relations between bodies as embeddable in a fictional spacetime. This fictional spacetime acts as a representation of the properties of concrete physical objects and the relations between them." [Page 2, 6]. "The lack of inertial trajectories in the material world and the prohibition of unoccupied inertial frames deprive the relationist of the possibility of defining inertial frames of references. The general consensus is that Leibnizian spacetime amounts to no more than a topology of time and therefore fails to support a proper theory of motion" [Page 3, 6].

[10] Similar to the point, line, or plane whose existence is ideal.

3. Time and space according Newton.

Originated by the separation in thought of the form of content, from the geometry of matter-energy, Newton's logic succeeds in capturing that mechanical movement is broken down: into what moves (matter-energy), the medium in which the movement occurs and the relations of space and time that arise in the relative movement between different frames of reference, which may well be explained by Relationism, not the medium for which Newton chooses Substantialism since the medium would be the space and time that, also, in accordance with the ideological division, very influential in his time, of the existent in matter and the immaterial, would be a metaphysical entity, and neither other entity better that the geometric space and time. Space and time would provide the geometric structures of movement, in special the inertial structure that Relationism lacks.

Of course, in Newton, time and space, as a universal medium, are continents of matter and its motion. Matter-energy is within the space and time that contain it. In this conception, known as mechanistic, space, time and matter are objective, absolute, independent and real [Page 1, 9]. Space and time are independent of each other and absolute, in their own nature unrelated to anything external. Therefore, they are also independent of matter-energy and motion for all frames of reference, from which it turns out that although through the inertial structure it determines their trajectories it does not affect their speeds and the simultaneity is absolute for all the events that are recorded by observers.

The geometric and inertial structures of space make the force-free particles move uniformly and rectilinearly and allow the other structures of motion that are accelerated and gravitational to be established.

Matter, if considered from the point of view of its discrete composition, is defined as aggregations of organized particles in elements or substances; more generally, matter is called substance. Also, matter can be treated as a continuum, as long as its properties are described as a function of the coordinates of space (x_1, x_2, x_3) and time (t); in such a case, matter is called a field. Consequently, in the past, to refer to matter, we had the terms of substance and field.

Space and time too container of the ether, introduced in relation to the research of Faraday and Maxwell, at the beginning of the 19th century, which would be the necessary medium to transport electromagnetic waves. In this case, the field, previously restricted only to the description of intrinsic states of material objects, would also exist in empty space; which implied that initially the concept of field changed from being material property and came to be considered as an extended object, since it was considered a form of matter, with mechanical properties. This field was the ether. Consequently, electromagnetic fields were defined as mechanical states of the ether.

Due to the absence of interaction, which was established experimentally by Michelson-Morley, between the ether, considered mechanically, and the material substance, in the neo-Newtonian review, made in the late nineteenth century, the ether was defined as a structural property of space, consequently, materializing it, and this was represented by a mathematical-geometric abstraction (grid screening) that serves as a support (pseudo manifold) to give direction to the events and measure their separations and angles (metric). This conception of the ether implies the change in the concept of field that happened to quality of the space. However, today, both definitions of field remain in dispute, the relationalists prefer "extended object" while the substantialists prefer "the qualities of space".

The Newtonian Universe, after the revision carried out with the introduction of electromagnetism, is infinite and unlimited and is made up of solid particles (matter) and vacuum. Each particle is capable of acting instantly at a distance, in a vacuum, and exert forces (fields), which are transmitted in a vacuum, directly, on other particles [Page 415, 10]. In this way, the concept of substance remains for matter in all its forms and states and the concept of field remains for electromagnetic, weak, strong and gravitational forces.

In Newton on time, as with respect to space, there is a mathematical definition operational, not physical, that philosophy supplies, although, as such, it is not unique. In the case of time, there is a debate between presentism (only the present is) and eternalism (present, past and future are). Both philosophical conceptions of time controversial although, presentism is preferred in Newton.

3.1. Continents time and space.

Space and time would constitute the continent (pre-Socratic original idea) within which matter and field, contained, move [Page 1, 13].

Space is intuited as the container of objects that have volume and time as the container-support of their movement. "Newton's conception is prototypical of the container model" [Page 415, 10] [11].

Newton maintained that space and time contained the Universe independently of it and the movement of those who observe and measure it, in such a way that the Universe could disappear and space and time exist completely empty, additionally without undergoing any change; always identical and immovable space and time [Page 58, 15] [12].

Newton's thesis that space, extensible to time, is a container entity of matter, makes it a substantial entity, but because it is composed of points, of course, of null-dimension, it is a metaphysical entity that, nevertheless, storage the matter-energy. Therefore, also, space and time can be considered in their immateriality as a simple category of thought, although this interpretation is exceptional [13].

3.2. Independence between space and time.

In Newton's mechanics, space and time interact with each other and with matter through movement. During their interactions, both container and content, retain their absolute character, but related according to the three laws of mechanics (inertia, action-reaction, force) that determine in motion the existence of inertial, accelerated and gravitational structures. But, space and time (continent) and matter and field (content) are essentially different. Space and time are the immaterial background while matter and field occupy it.

Newton's space and time is defined, in Euclid's geometry, by the pair (configuration space (R^3, t), metric (η_{ij}, t)) that is represented geometrically and graphically as a non-deformable rectangular grid pattern, which it would constitute the great 4-D mesh, container of the Universe. The configuration space (R^3, t) is made up of points and topology, while the metric (η_{ij}, t) is made up of Euclidean geometry, inertial structure and absolute causality. Euclidean geometry allows infinite speeds.

Each reference system (observers in relative movement) constitutes a coordinate system (geometrically, particular grid pattern), whose points are defined according to the space coordinates (x_1, x_2, x_3) and the time coordinate (t). These values between coordinate systems are converted according to Galilei's orthogonal and linear transformation group ($x_1' = x_1 + v * t$, $x_2' = x_2$, $x_3' = x_3$, $t' = t$) that relates the coordinates of a system of reference, s´, with the coordinates of another reference system, s, that is in uniform rectilinear motion with respect to it. Galilei's group does not apply when the moving reference system, s, contains the electromagnetic field, therefore, it is outside the scope of Newtonian mechanics.

3.3. Absolute simultaneity.

In Newtonian mechanics, in the Universe, a single clock is used to measure time and a single unit length measuring rod is used to measure space. The conjugation of space and time makes it possible to determine the simultaneity in the occurrence between events characteristic of moving matter, in different coordinate systems.

The action at instant distance implies that the simultaneity is absolute, that is, an invariant that forms the basis of the Galilei transformation group.

3.4. Euclidean space.

Space is a static three-dimensional linear continuum of points, whose internal representation is that of three orthogonal axes that intersect at a common point, described and measured by Euclid's geometry of straight lines. Each point in space is specified by the coordinates x_1, x_2, x_3 and the infinitesimal interval between two points, or metric of the space, is given by: $ds^2 = dx_1^2 + dx_2^2 + dx_3^2$.

3.5. Time and presentism.

Time is a linear, mono-dimensional continuum that flows in order and with the same rhythm, from the present, to the past and towards the future, at every point in space. This concept of time corresponds to physical time and not to evolutionary or historical time of philosophy, that is, it is the time intuited in the change of position of objects, in space, due to their translational and / or rotational movements [11].

The presentism in philosophy corresponds to the physical concept of time, which declares that only the present exists, a privilege that implies that being only exists in the present. Neither the past nor the future exist.

¨Presentism it holds, roughly, that only present things exist¨ [Page 13, 12]. "This exist might have either of two meanings, resulting in two disambiguations:

- Only present things exist now. (Pra)

- Only present things existed, exist, or will exist. (Prb)

(Pra) appears to be true, and trivially so. (Prb) It seems obviously false” [P. 14, 12].

The present is everything that exists of the physical phenomenon at the moment, although, what exists for the knowing being is always indirectly detected as information encoded in the present (Memory) that always corresponds to the past, provided that such information, according to Special Relativity, has been transmitted with the speed minor that c. The only possibility for the cognitive being to detect reality in the present is for it to communicate with infinite speed, or better, so much so that an instantaneous connection between the cognitive and reality can be assumed, such speed is understood by Newton as instantaneous action.

Presentism is compatible with the relativity of Galileo and Newton's mechanics since time is independent of space.

3.6. Ether.

With the introduction of the wave theory of light, by Hooke and Huygens, the space was supposed to be filled with "Ether", a continuous substantial medium, with mechanical properties [14].

Approximately three centuries later, faced with the futility of detecting the ether, Lorentz stripped it of its mechanical character and dynamically redefined it only insofar as it affects the bodies since they move within it [Page 2, 18] [15].

Drude and Larmor finished eliminating the ether as a material substance since the ether would be the space itself endowed with physical properties [Page 2, 18]. However, it still remained the necessary medium for the propagation of light waves (electromagnetic field), according to Maxwell's laws, which are not invariant (lacking symmetry) with the Galilei transformation and, therefore, they do not meet Galilei's principle of relativity. Thus, the ether continued to be used as a universal motionless referent of motion. [Page 18, 1].

3.7. The Neo Newtonian Review.

The positions that objects occupy in space with time, allow to represent the material movement geometrically, by means of curves called world lines, in the coordinate axis systems. The world line is the history of the particle in spacetime, although, in Newton's mechanics, the notion of spacetime is not necessary, nor is the notion of event [Page 1, 13]. Spacetime is introduced in the post relativistic neo-Newtonian review [16].

3.8. Eternalism versus presentism.

In accordance with the physical notion of spacetime, the idea of eternalism arises philosophically according to which all times exist equally. The past is memory, the present is and the future is possibility [17]. Time is a dimension of reality along with the three spatial dimensions and therefore all times: past and future are just as real as the present.

Eternalism is only an attribute of spacetime and not of the events it hosts.

Eternalism is imposed on presentism since in the face of the past that exists encoded in the present, but not presentism, presentism says that of the being that has ceased to exist some of its properties can endure, that is, properties without being. ¨It incomprehensible how something that does not even exist could bear properties, etc.¨ [Page 25, 12].

The critical cases against presentism, which emerge from the presence of the past in the present, refer to the fact that the past endures in the form of memory, therefore, ontologically (due to its contents) different from the present, but that in presentism due the times themselves are assumed, disconnected from the reality to which they refer, they are equal categories. These cases are:

"1 Past truth. ¨We think, for example, that Napoleon invaded Russia.¨ ¨But if Napoleon does not even exist, what makes it (now) true that he invaded Russia? ¨ [Page 23, 12].

2 Reference to past objects. How can I refer to what does not exist? ¨ [Page 24, 12].

3 Relations to past objects. ¨most or all causal relations `involve 'at least one non-existent relatum¨. ¨non-existent objects can bear properties¨ [Page 24, 12].

However, eternalism contradicts itself when it stops considering times as simple categories of thought and ontologically assumes the existence of the future different from the existence of the past and the present that they inexplicably assume have an analogous existence, with the fact that the past it always endures as memory while the present refers to what exists. This ill-posed problem of eternalism led to past-presentism, in which it is declared that "only past and present exist; the future remains unreal" [Page 13, 12] [18].

Past-presentism is in turn debated for being based on the idea of determinism of the Universe against which the following objections are raised:

"- Classical Mechanics is not deterministic.

- If the world were deterministic, it could surely have been otherwise. Would presentism then be false of such a world? Or would it still be true, but with far fewer past facts? It seems imprudent to rest the truth of past facts on something as contingent as determinism.

- Suppose for convenience to particulate ontology. Dynamics is (or at least appears to be) second order: the state of the world at one time depends on the positions and velocities of its constituent particles at another. And how do we understand velocities? Usually as quotient limits: distance traveled over time taken (as the latter tends to zero). But that is to say that the velocity of a particle depends upon facts about where it was (and when). These are past facts; they are exactly what the presentism is trying to ground" [Page 26, 12].

Therefore, in Newton philosophically, time is not clearly conceived, since for Newton, presentism and neo-Newtonism, eternalism suffer from total truthfulness and are conceptually incomplete.

3.9. Inertial, accelerated and gravitational structures.

The Euclidean coordinate system of space and time is an inertial system in which, in the absence of forces, rigid objects in motion, that is, without phase change (change of state or material shape) but position in time, will maintain its relative state of rest or uniform rectilinear movement with respect to other coordinate systems (relative movement, which implies the change in distance of an object in relation to others) or with respect to space (absolute movement, which is the translation of an object of one absolute position to another). This inertial character of movement arises directly from Euclidean geometry [19].

Newton by shifting between inertial to non-inertial systems formulated the existence of absolute motion. This is established because the centrifugal force appears (present during the rotational movement, which was tested by Newton in the experiments, both of the bucket of water, and in the tension of the cord that joins two spheres).

In the persistence or identity of the points of space through time, an exclusive attribute of Substantialism, Newton had the universal reference system with respect to which he solidly defined absolute motion and absolute states of rest and speed. The persistence of the points of space in time allowed Newton to extend the simultaneous relations between points (distances) to the relations in different instants (times). The space is conceived at rest or at least not accelerated.

There is no dynamic difference between relative and absolute motion except with respect to the causes or effects (forces) that have their dynamic manifestation in non-inertial systems, which are the subjects of forces. When the force causes the change in momentum (momentum), the system is accelerated and when the force is exerted at a distance between the masses of the bodies, the gravitational system is produced.

In Newton's space and time, the Galilei principle prevails that all the laws of mechanics are the same for all observers in inertial systems.

3.10. Notes.

[11] ´Space, we believe, is where things are and time what provides the stretch for them to be there when we look again ... Space is the medium in which things maintain or, as the case may be, change their location; time is the medium in which they must conserve their identity lest they disappear qua “things” and be reduced to momentary apparitions.´ [P. 1, 14].

[12] Newton in his work Principia (1687) says: "Absolute space in its nature without relation to anything external, remain always similar and immovable". `Time and space were absolute properties of Newton's Universe in the sense that they were not dependent on material events happening in the Universe´ ` Newton postulated the existence of a substratum of spacetime points, which need not be occupied by material bodies´ [Page 2, 6].

[13] “Soon it was recognized that this kind of “stage”, completely independent of matter, was actually only a metaphysical category given the fact that no physical reality can be associated with it. As a consequence, mechanics in absolute space and time was replaced in practice by the use of preferred inertial systems e.g. the one defined in terms of the fixed stars” [Page 5, 16].

[14] “Huygens introduced the wave theory of light. According to his theory, light waves propagate via oscillations of a new medium which consists of very tiny particles, which he named ether particles. I have considered the rest frame of the luminiferous ether as a preferred frame” “The ether concept reappeared in Maxwell’s theory of classical electrodynamics. Faraday unified Coulomb’s theory of electricity with Ampere’s theory of magnetism. Maxwell unified Faraday’s theory with Huygens ’wave theory of light, where in Maxwell’s theory light is considered as an oscillating electromagnetic wave which propagates through the luminiferous ether of Huygens” [Page 1, 17].

[15] “The development of the theory of electromagnetism led later on to the concept of a special ubiquitous medium, the ether, in which the electromagnetic waves could propagate, and with Lorentz this ether was described as the embodiment of a space absolutely at rest " [Page 5, 16].

[16] ¨In a Newtonian spacetime, for every two events there is a fact of the matter as to the magnitudes of both their spatial separation and the temporal interval between them. In a neo-Newtonian or Galilean spacetime, there is a determinate temporal interval between any two events and, if they are simultaneous, a determinate distance also. But there is no standard of absolute rest in such a spacetime, and hence no fact of the matter as to whether events at different times are co-located, 10 meters apart, or 10 light-years apart¨ [Page 44, 12].

[17] ¨all times, exist equally; the present is not ontologically privileged." [Page 13, 12].

[18] "A further variation is McCall's (1976, 1994) branching future model which takes the future to consist of many real but as-yet-unactualized possibilities" [Page 13, 12].

[19] ¨An inertial frame is a reference frame in which force-free particles move in straight lines, and with respect to which the laws of physics assume the same (canonical) form¨ [Page 43, 12].

4. Spacetime according Einstein.

Einstein retains the geometric nature of Newton's spacetime, albeit without its clear metaphysical purpose characteristic of 17th century medievalism.

Einstein's relativity comprises the formulations of Special Relativity for a flat spacetime, and that of General Relativity for curved space.

In Special Relativity, space and time are not independent of each other, as in Newton, but constitute a new absolute: relativistic spacetime [Page 1, 19], which means that the ds metric of spacetime it is invariant for all observers in inertial systems and that time and space are mutually relative.

Spacetime is a continuum orthonormal pseudo Euclidean of four dimensions (three of space plus time, which is the fourth dimension interrelated by speed interchangeable according to different observers in motion with maximum speed c), which exists independently of both the matter and the field to which contains, since it is the 'mere framework for physical events' [Page 58, 20].

The event, determined by the coordinates x_1, x_2, x_3, t, is the true element of the spacetime continuum. Einstein says: 'what has physical reality is neither the point in space nor the instant of time when something happens but only the event itself' [Page 84, 21]. In this way, in my opinion, Einstein reifies the Newtonian point and the physical reality of spacetime is authentically material, since it resides in the material event. But Einstein does not banish the existence of the point that without physical reality, it acquires a metaphysical character.

Minkowski's geometry corresponds to Einstein's spacetime and Euclid's geometry corresponds to Newton's space.

Einstein-Minkowski spacetime, like Newton-Euclid space, is the immutable continent where, contained, matter and field exist, as well as their physical movement, without affecting spacetime [Page 1, 19], that it may exist emptiness of matter, although not of field. Both the electromagnetic and gravitational fields represent energy, and because energy has mass, they are forms of material existence. However, spacetime as an inertial structure constitutes a kind of non-material field. The empty spacetime of matter, of course, also of electromagnetism and gravity, in itself constitutes the substrate of the inertial structure, that is, it constitutes a flat geometric field, which can no longer be constituted by events and therefore returns Einstein to Newton's points. Consequently, gravity defined as spacetime curvature, in General Relativity, therefore, as a curved geometric field, comes to constitute the development or generalization of the idea of the inertial structure of spacetime of Special Relativity that finally after all comes from Newton. The contradiction existing in Relativity, between his conception of spacetime constituted by material events and at the same time constituted by points as a substratum of inertia, has its support in the distinction made of the field between geometric (as $\Gamma^{\sigma}_{\mu\nu}$, $g_{\mu\nu}$) and material (the rest).

4.1. Einstein-Minkowski spacetime.

The Einstein-Minkowski spacetime is flat pseudo Euclidean, internally it corresponds to a geometric system composed of four orthogonal axes that intersect at a common point, similar to Euclid's three-dimensional space or neo-Newtonian spacetime, in which their lines of curvature Minimum or geodetic are straight, but they limit the speed of the particles or objects to maximum c.

The geometry, which describes spacetime, is that of Minkowski, who introduced it in 1908. The interval between two events is given by: $ds^2 = \eta_{uv}\, dx^u dx^v$, where η_{uv} are equations of straight lines, and is a value invariant involving $ds^2 = ds'^2$ [20].

The Minkowski spacetime continuum has the structures: Events, topology, geometry, inertial field, causality. Events and topology are the components of the R^4 configuration space, while Minkowski geometry, inertial field, and relative causality are the components of the η_{uv} metric. Furthermore, Minkowski geometry is defined in such a way that c is invariant for all observers, regardless of their relative state of rest or movement, and the maximum speed limit at which particles or objects, with mass at rest, cannot reach. Only the photon or massless particles at rest can reach c.

Logical consequence, of Minkowski geometry, is the unification between matter and field through $E = mc^2$, since a physical cause is required so that the particles with mass at rest cannot get to c and this is the one that the energy of the kinetic field of an object, that is, the kinetic energy, not the mass, with increasing speed it increases and as represents mass it has inertia that in the vicinity of the threshold c the inertia of the kinetic energy tends to infinity, which makes it impossible its further increase.

Physical problems about movement, posed within the framework of Special Relativity, are treated as geometric problems in the Minkowski continuum (R^4, metric η_{uv}) that, therefore, are solved geometrically [Page 19, 1].

Gravity continues to be defined as force, but, no longer of instantaneous action due to limit c, furthermore, within Special Relativity, its problems lack a solution, since gravity does not have a geometric character. Not so the measurements of the electromagnetic field whose relativism, between its electrical and magnetic components, with respect to observers in relative motion, finds in Minkowski the geometry appropriate to its nature. The relativity principle of motion extends to the electromagnetic field, which is included in the mechanics of Special Relativity.

4.2. Relativity between space and time.

In Special Relativity, for the different observers there is no time or absolute space, but they depend on the movement of the person who measures them [Page 1, 9], that is, they depend on the coordinate system chosen, therefore, space and time are relative.

What is the difference between space and spacetime? In space, length and time measurements are fixed. In spacetime, length and time are relative, depending on speed and place in space. The length contracts and the time extends from an external perspective´ [Page 1, 22] [21].

The relativism of the components of spacetime is the consequence of Einstein's interpretation of the Lorentz transformation group [$x_1' = (x_1 + vt) / \sqrt{\alpha}$), $x_2' = x_2$, $x_3' = x_3$, $t' = (t + v/c^2) / \sqrt{\alpha}$] as relative contractions of spacetime and not of bodies, as originally stated by Lorentz. The length, dx_1, and the time are transformed between different observers, in relative motion, according to this Lorentz transformation group, which implies that the length contracts and the time expands proportionally to the value $\alpha = (1 - v^2/c^2)$, given as a function of the speed of the observer with respect to c, and the length of the space tends to zero and the second of the time to infinity, with which time tends to stop closed at c.

The Lorentz transformation relates the spacetime coordinate system of an event with those of the same event in another coordinate system, in uniform rectilinear motion with respect to it. This is the general form of coordinated time and space. Time, dt, flows with a different rhythm and length, dx_1, changes its pattern in the animated coordinate systems of relative movement with respect to the corresponding dimensions of time and length in the coordinate systems taken at rest. Therefore, the simultaneity between events becomes relative since simultaneous events in a resting coordinate system cease to be relative to moving coordinate systems. However, it is a effect of coordinates.

Due to the relative nature of coordinated time and space, a clock is required to measure time, dt, and a unit length metric rod to measure length, dx_1, in each existing inertial coordinate system in the Universe [22].

But, also, in the particular form of time and proper space there are absolute, invariant for all observers. The proper time, τ, is that of the events that occur at the same spatial point, where the length corresponds to: $dx_1 = 0$, therefore, it is the time measured by the same clock at rest, placed at that point. The proper time is exactly $\tau = ds/c$. The proper space is that of the events that occur simultaneously, that is, when $dt = 0$, in which case dx_1 is invariant.

4.3. Past, present and future.

In spacetime there is no present (as such) since in Minkowski there is no time [Page 5, 23] but there is the spacetime continuum, in which the four dimensions intermingle between observers placed in different inertial frames [Clifford Johnson, 1999]. This is the consequence of the relativity of simultaneity which implies that simultaneous events in one frame of reference are not in another. ¨That means that we must abandon the classic understanding of the present as (at least) a simultaneous set of events. And that in turn means that we lose our adherence to the claim that in some way the present is (existentially) privileged [Page 42, 12].

What is valid for two different events, in all frames of reference, is that because $ds^2 = ds'^2$ is related as space (spacelike), connected by some spatial distance, if their spacetime separation is greater than 0 ($ds^2 > 0$). They are related as time (timelike), connected by some temporal distance, if their spacetime separation is less than 0 ($ds^2 < 0$). Or they are related as light (lightlike), connected by some light signal, if their spacetime separation is zero ($ds^2 = 0$) [Page 44, 12].

Every event exists at the point of the intercept between the light cones of the absolute past and the absolute future, which open outwards and are relative to it. The cone of the future gathers all those events that it can influence while the cone of the past gathers all those that can influence it. These two cones bring together all the events connected to a reference event through lightlike or timelike. The other events connected by spacelike are excluded from the possibility of causality.

4.4. In favor of eternalism.

The spacetime when gathering all the events of the Universe past, present and future acquires the character that all the times are, eternalism, whereas in Newton only the present is, presentism.

`According to the relativity of simultaneity, each point in the Universe can contain a certain network of events that make up its current moment. For the philosopher Palle Yourgrau, it follows that what is identified as the "now" relative to a specific point or frame of reference will differ from the "now" in a different frame, provided that both frames are in relative motion one of the other. Therefore, there is nothing equivalent to a present state of the entire Universe, thus denying the absolute time that Newton preached. This has been used in the Rietdijk-Putnam discussion to demonstrate that Relativity predicts a block Universe (sometimes called eternalism) in which events are fixed in four unalterable dimensions (the future, for example, would already be here), according to which time somehow does not flow, as opposed to the traditional vision of a Universe of three dimensions that are modulated by the passage of time´ [Page 1, 24] [23].

4.5. In favor of perishability.

Eternalism is complemented by endurance or perishability.

Endurance holds that particles have spatial, but not temporal, parts, that is, that they exist integers at all times of their existence (Gibson, 2007). The particles persist through time since they exist completely at different times. Each moment of existence of the particles corresponds to the present separated from the past and future [24].

Endurance is inconsistent in itself because it conceives immutable objects, albeit spatially extended [25].

For endurance the consequence of the immutability of objects is, as Merricks observes: "that an enduring object can have all of its parts in one place, P, and also have all of its parts in a distinct non-overlapping place, P*. This absurdity follows from the possibility of motion combined with [eternalism] and the view that an object is wholly present at each time at which it exists¨ [Page 83, 12]. Which violates the principle of Van Inwagen: ¨What exactly fills one region of space at a given time cannot be what exactly fills a distinct region of space at that time¨ [Page 84, 12]. Consequently, the change in objects occurs outside of time, in instants.

On the other hand, the durability maintains that the particles or objects, in addition to the spatial parts, also have temporal parts (Sider, 2001). A particle exists in time because it has identity and exists as a continuous reality; that as a whole it must be considered in all its temporal parts [26].

Perishability is not eternalism since: ´Both are `four-dimensional', but one (eternalism) concerns spacetime, and the other physical objects (perishability). Nor is there an immediate entailment from one to the other; prima facie there might exist a four-dimensional manifold with all times and places ontologically equal, and yet objects within that manifold might be multi-located. Historically these two doctrines have been conflated¨ [Page 83, 12].

The inconsistency of perishability is to maintain that events really exist forever [27].

Special Relativity, according to the general consensus, favors perishability due to its conception of continuous spacetime [28].

4.6. Inertial structure.

In Special Relativity the ether ceases to be a physical property of spacetime by itself and the ether becomes mediated by the existence of the inertial structure of motion. Einstein says: "consisted in taking away from the ether its last mechanical quality, namely, its immobility" [Page 2, 18]. However, since all movements cannot be reduced to symmetrical Relationism between two arbitrary reference systems, as is the case with inertial frames, it is assumed that these are supported in the inertial ether of background spacetime [29].

For Einstein, spacetime, as a substrate, is full of field although not of matter since it does not depend on the coordinates, that is, although it is a materially empty space, it is full of geometric field. And, in order to be able to describe the matter that occupies space and is dependent on coordinates, it is necessary to accept the existence of empty spacetime as an inertial system, with its corresponding metric properties, that it causes in bodies free of forces, in relative motion, follow rectilinear trajectories, since otherwise the description of what fills the space would be meaningless [Page 1, 26].

The properties of spacetime do not depend on the presence of matter or on the observers who measure these properties [Page 1, 27]. In other words, 'spacetime tells matter how to move' but matter does not influence spacetime.

In the spacetime of Special Relativity the principle prevails that all the laws of physics (except gravity) are the same for all inertial observers.

4.7. In favor of Substantialism.

Special Relativity is at odds with Leibniz's Relationism because it is based on universal time, which implies the absolute simultaneity of Newton's mechanics, while the relativism of space and time in Special Relativity is precisely based in relative simultaneity, because connectivity between events is constrained at speed c [30].

Newton's Special Relativity dynamics have the same structures (geometry and inertia) incorporated into the qualities of space and consider the gravitational field as a background-dependent physical field. Newton's theory of spacetime and Special Relativity are Substantialism in effect, Minkowski spacetime is the fixed substrate where matter-energy is contained.

4.8. Notes

[20] ¨This quantity is an invariant; it has the same numerical value even when the points are re-described (that is, re-coordinatized) with respect to a different inertial frame¨ [Page 44, 12]. ¨Just as the temporal interval and spatial distance between distinct events are frame relative in Spatial Relativity, so too in Minkowski spacetime is there no fact of the matter concerning (the magnitude of) these quantities. But Minkowski spacetime does respect what emerges from Special Relativity as absolute: there is a fact of the matter regarding the separation of any two events¨ [Page 44, 12].

[21] `Relativity tells us that time and distance change depending on the relative motion of the observers'` only the speed of light measured by all observers is the same´ [Brief summary of Spacetime Theories].

[22]. According to Special Relativity, each inertial frame has its own relative time. One can infer via the Lorentz transformations on the time of the other inertial frames. Absolute space and time do not exist. Furthermore, space is homogeneous and isotropic, there does not exist any rotational axis of the Universe" [Page 1, 17].

[23] ¨relativity strongly favored eternalism over presentism¨ [Page 109, 12]. ¨Consider a cartoon strip. Asterix is supposed to be wholly present in each frame (in which he appears). Eternalists assert that no particular frame, and no set of depicted events, is ontologically privileged; all exist equally¨. ¨If any theory of time is compatible with time travel, eternalism surely is¨ [Page 85, 12].

[24] The endurance says that: "objects are wholly present at each and every moment of their existence. During that existence, they move in their entirety through space. They are spatially extended, with spatial parts; but not temporally extended, or with temporal parts¨ [Page 74, 12]. ¨enduring objects are supposedly wholly present throughout their careers¨. [P. 75, 12]. ´enperishability entails presentism, the view that only the present exists (objects, radiations or memories existing now, regardless of their deterministic or probabilistic causation, according to the observer of a certain frame of reference), and special relativity entails its denial (because it denies the notion of the absolute present), enperishability is inconsistent with relativity.´ [Page 2-3, 25].

[25] ¨would entail something obviously false: that objects never gain or lose parts¨ [Page 75, 12]. ¨I do not think it disastrous to formulate endurance in terms of a denial of temporally proper parts. But note that this formulation would be inadequate if an object could be temporally extended without possessing temporal parts; such an object would then count as enduring (which I suspect the enperishability would very much resist). "[Page 76, 12].

[26] `A physical object is wholly present (with all its essential existential properties and not the mere presence of its radiations or its memory supported in any existential way) at all times at which it exists.´` The perdurantist ontology features four-dimensional objects extended in time as well as space.´ [Page 2-3, 25].

[27] ¨Critics of perdurance emphasize its counter-intuitive claims¨ ¨Thomson dismisses it as a crazy metaphysic (1983) ¨ [Page 73, 12].

[28] ¨Perdurantist account of how an object persists through time: it has temporary parts whenever it exists. What is a temporary part though? It is tempting to reply: what is a spatial part? The perdurantist holds these to be largely analogous; if we understand one, we should understand the other. A fuller reply is available though: a temporal part is an improper part of its parent object as at a particular time, and exists only at that time¨ [Page 72, 12]. ¨the enperishability holds that one and the same persisting object exactly occupies multiple, instantaneous spacetime regions. But how can we understand instantaneous in the absence of an absolute simultaneity? ¨ [Page 109, 12]. ¨Balashov's central contention is that only perdurance is compatible with a relativistic interpretation of coexistence¨ [Page 110, 12].

[29] “The ether had only transmuted its character from a mechanical substance to an absolute inertial spacetime” [Page 2, 18]. “Nevertheless, Einstein was aware of the fact that his theory did not at all imply the rejection of concepts like empty space; instead he stressed that the main consequence of Special Relativity regarding the ether was to force the discarding of the last property that Lorentz left to it, the immobility. The ether can exist but it must be deprived of any a priori mechanical property” [Page 5, 16]. "Such directly unobservable frames of reference confer physical properties on empty spacetime, and were held by Einstein as a new embodiment of the ether." “An ether is an entity that does not have sources — therefore cannot be influenced in any way — and cannot be observed directly, although it can be observed indirectly via the behavior of test particles. Two constructs that realize this notion are Newtonian space and special relativistic spacetime (characterized by the constant metric field η). We name these ethers inertial ethers" [Pag 8, 18]. "This ether of special relativity is nothing other than a background inertial spacetime, i.e. an infinite family of inertial frames linked by Lorentzian transformations. It is characterized by the everywhere-constant metric field η and represents an indirectly observable empty spacetime endowed with physical properties: it defines the standards of space, time and motion for a test particle in an otherwise empty world” [Page 9, 18].

[30] `Leibniz rejected the idea of absolute space and time but retained the idea of universal time.´` The observers become aware that there is no longer any notion of absolute simultaneity. Two events, which are simultaneous for one observer, confined to one reference frame, may not be simultaneous for observers in a reference frame moving with constant velocity relative to the first. This is due to the finite and invariant speed of light. As a consequence, there are no instantaneous signals between events on a simultaneity plane and not perfectly rigid bodies´ [Page 8, 6].

5. The spacetime property of the gravitational field.

Einstein, after the formulation of Special Relativity in 1905, went through three stages towards General Relativity. In Special Relativity he managed to unify in relativistic mechanics the two mechanics that had emerged at the end of the Newtonian period: mechanics based on Galileo's principle of relativity, restricted to inertial motion that he explained as a geometric aspect of flat space, the Euclid geometry and the Galilei coordinate transformation group for the movement within the phenomenon of the material substance and the incomplete Lorentz mechanics, just by having the space and time coordinate transformation group, the electromagnetic field considered in those years strange to the substantial phenomenon.

Einstein in the foundation of relativistic mechanics united the principle of relativity with the Lorentz transformation group, integrating the electromagnetic field with the substance through the equivalence between mass (qualitative property of the material substance, currently, fermionic forms of existence of matter) and energy (qualitative property of bosons, today, bosonic form of existence of matter) according to $E = mc^2$, originally without its proper geometry that only had from 1908, by Minkowski, that united space and time in spacetime.

In the first stage, (1907-1911), the phenomenon of gravity, outside of Special Relativity, Einstein believed he explained it, in 1907, when he said he had his "happiest idea of my life", as a consequence of the generalization of the principle of relativity to all kinds of motion: accelerated and gravitational, explaining them as a geometric aspect of the Minkowski spacetime based on the equivalence between the inertial and gravitational masses according to $m_i = m_g$. His apparently admirable solution insofar as he relativized all kinds of motion, explaining them as a simple coordinate effect, as Galilei had done with the states of rest and inertial motion. The obvious result is that movement is illusory, dependent on observers. Later, of course, after his happiest thought of his life, Einstein realized that as gravity he only explained acceleration but not attraction, for which, with his great ingenuity, he called it homogeneous gravity, which due to spacetime of Minkowski, is precisely ¡absence of gravity! Furthermore, the principle of equivalence between all kinds of movements lacks internal consistency since while the dilation of time and the contraction of length are physical in the frames of reference under gravity or accelerated, it is a coordinate effect on inertial motion.

Einstein in the second stage, (1912-1913), in Entwurf theory, sought to explain the authentic gravity, which he called extended gravity, as a phenomenon of matter in the bosonic form, therefore, of origin similar to electromagnetism that due to mathematical and conceptual limitations of its epoch failed, six decades later resolved by Logunov and his group.

In the third stage, (1914-1915), Einstein succumbed in front of his competitor Hilbert, math giant of his time, who imposed the application of the tensors on the Riemann spacetime manifold, which he had not admitted in front of his undergraduate partner, his same ethnic origin and friend Marcel Grossmann, for which Einstein renounced the material character of gravity and geometrized it, after all his destiny returned him to his project of the first stage.

In the conception of General Relativity, (1915), derived from the Einstein-Grossmann-Hilbert equations, the distribution of the energy-mass of the Universe determines the geometry of spacetime, which curves intrinsically due to the tension that mass and energy exert on spacetime. This statement comes from the principle of Mach, who originally to eliminate the effect of spacetime geometry on motion, formulated, in Science of Mechanics (1883), that the inertial motion of a material particle is due to its motion with respect to the center of mass of the entire Universe [page 113, 21], which implies the existence of a real force between two relatively accelerated objects in exchange for a fictitious force, as Newton argued, and that the reference to motion to invisible space is it substitutes for the movement reference to the material Universe; the space is replaced by a group of the fixed stars, that is to say, as a referent of the movement the abstract points of the space are changed, as soon as they are not empirically known, by material points.

Mach argued that for Relationism it was necessary to correctly interpret inertia and for this I relativized the inertial structure by explaining it as the result of the instantaneous interaction between local matter and very distant stellar matter, with which the physical reality of space, as a substrate from the inertial structure, it vanished and the founder of triumphant empirio-criticism reintroduced Leibniz's Relationism.

For Mach space is the geometric abstraction of the relations between all material objects that have volume, motion, even accelerated, is relative between material objects and it is the totality of stellar matter that determines the existence of the inertial structure, whereupon Mach sought to blame the matter for the inertia of the bodies [Page 32, 5]. Later, Einstein with its inertial structure $\Gamma^{\sigma}{}_{\mu\nu}$ and its metric $g_{\mu\nu}$, associated with the energy-momentum tensor $T_{\mu\nu}$, advances in that direction, but different from Mach.

The foundation of the relativization of inertia and of all motion in Mach is Newton's instantaneous remote action, which was prohibited in Special Relativity, which limits remote action to speed c.

Einstein reinterpreted the Mach principle, based on the principle of equivalence between inertial and gravitational masses. Although, Einstein, following his mentor Mach, set out to establish inertial forces as real, the result was the restoration of Newton's fictional forces (Centripetal, Centrifuge, Coriolis, etc.), but, which Einstein extended to the force of gravity, which itself is a real force for Newton and Mach and even for Einstein himself in Special Relativity. But, in General Relativity, the gravitational force is fictitious, since, for most of the most renowned relativistic physicists, also known as Modern General Relativity, it is only the effect of spacetime curvature on the trajectory of the moving particles or objects. In this way, the gravitational force is replaced by the metric of spacetime. However, what Einstein held was that gravitational force is fictitious because gravitation is observer dependent. That is, a uniform gravitational system can be created from a uniform accelerated system or an inertial system can be created from a homogeneous gravitational system by changing the frame of reference of the observer.

Einstein, like Mach, relativized all movements, and made the covariance of physical laws universal. But, Einstein, unlike Mach, relied on the inertial and gravitational mass equivalency to abolish the privilege of relative motion of the inertial system and generalize it to the accelerated and gravitational systems. This generalization is known as the consequence of the principle of equivalence between the gravitational system and the inertial system and the principle of equivalence between the uniformly accelerated system and the gravitational system. However, this general relativization of motion does not imply the denial of the existence of spacetime as the substratum of the inertial structure, since, under conditions on the limit, where matter ceases to influence, spacetime would fully exist Substantialism. Furthermore, from the principle of equivalence between inertial and gravitational mass, as an approximation, gravity can be explained as the generalized inertia to the curved spacetime according to the author's work, in 2017 [31], therefore, gravity must be understood as the effect of matter on manifold; that is, matter coded as curvature at points in spacetime. On the other hand, the fundamental independence of General Relativity is not that of Relationism, which denies the existence of a background, but refers to the independence of spacetime geometry with respect to a single geometry; However, without reason, the relationalists highlight it as if it were the rejection of the existence of a background, although what is certain is that it cannot be fixed but dynamic. Therefore, Einstein in trying, in another way, to save Relationism, pursued by Mach, did not succeed and this failure was repeated whenever he tried. In my opinion, Einstein's strongest effort was with the introduction, in his system of field equations, of the cosmological constant that vacuums solutions without the presence of matter (T=0), in the limit conditions, that is, in Minkowski's flat spacetime. But that Einstein had to abandon, according to his words, as his worst mistake, in front of the solution of the expanding Universe found, to his equations, by De Sitter. The question is so paradoxical that in 1998, when the cosmological constant was reintroduced, with the discovery of accelerated expansion, it precisely became a Substantialism argument that this phenomenon cannot be explained except by reference to spacetime itself (David J. Baker, 2004). Of course, the cosmological constant gives physical reality to the vacuum, but not to the gravitational field that remains geometric.

In classical physics, inertial systems are the only ones where Newton's laws of mechanics are valid and where they are covariant. Einstein's pretension, in General Relativity, to relativize motion was not achieved, but the laws of physics are covariant between all coordinate systems, both inertial and accelerated and gravitational [32], although as a property of tensors, when applied to Riemann geometry. `The equivalence principle forces to consider non-inertial reference systems, and in that sense general changes of coordinates. In this way the laws of the physics of the objective world must be independent of the coordinate system used´ [Page 7, 28]. And since, in the space of General Relativity, the principle of general covariance governs, that all the laws of physics are the same for all observers, that the relationalists, erroneously, assert it for the supposed independence of a fixed background from General Relativity, and that they only succeed in the fixed, but not in what refers to the existence of a background.

5.1. Gravity is geometric.

In General Relativity, Mach is present as it is the distribution of matter, which is represented by the energy-momentum tensor, T_{uv}, although local, that determines the geodetic movement when curving the spacetime, described by the g_{uv} metric. 'Gravity is not about any force imposed on a passive spacetime background; rather, it consists of the distortion of spacetime itself. A gravitational field is a curvature of spacetime' [Page 58, 20] [33]. The force exerted by the gravitational field on the particles is an intrinsically geometric pseudo force that the particles experience when they do not follow geodetic lines. Particles in geodetic motion (in free fall) do not experience any force [34].

Einstein based on the works of Ricci and Levi-Civita, on the Absolute Differential Calculus, and Lorentz, on the differentiable manifold, adapted the geometry for curved spaces of Riemann to the differentiable Lorentz manifold, for the metric tensor η, plane in Special Relativity, of spacetime, make it the representation of the gravitational field g, which the spacetimes tangents, at each point have the flat Minkowski metric η and, at the same time, each component g_{uv} curves and behaves, for a weak gravitational field, as the 10 gravitational potentials of classical mechanics, which are described by Einstein's 10 second order partial differential equations, since, the metric tensor g has u * v = 16 components, of which 10 are independent because this tensor is symmetric ($g_{uv} = g_{vu}$).

Thus, Einstein found the pair (M, g_{uv}) to describe spacetime, which allows solving problems of gravity as geometric problems on the four-dimensional manifold, M, and metric curve g_{uv}, which represents the gravitational field [35], in function of the energy-momentum tensor T_{uv}, that is, of the mass-energy [36] on uv, differentiable in each event in the Minkowski spacetime η. Therefore, all gravitational problems are solved geometrically, using Einstein's 10 equations [37] [Page 20, 1]. The tension exerted by T_{uv} curve M, determining the curvature (g), which fixes a geometry, giving the geodesic of spacetime, which establishes the geodetic movement of matter. The metric describes the curvature (gravitational field) of the manifold (bare spacetime). The metric is not unique (there is not a single geometry). Of course, the gravitational field is identified with the spacetime metric. Therefore, the gravitational field is geometric in nature. "The geometric structure of space-time is governed by the principles of general invariance, a related connection, and a metric" (Schrodinger, 1950).

But in the pair (M, g_{uv}) what is the manifold M? Without a doubt, the M manifold is the bare spacetime, in a fundamental state, without the qualities of measurement or addressing. For its part, g_{uv} is the geometry corresponding to the manifold M, since, as geometry, it must necessarily correspond to a given configuration space, in this case M. And, since g_{uv} encodes the curved geometry of M, it is g_{uv} the gravitational field itself, since gravity is the curvature of spacetime. As it can easily be inferred uv refers to a point of the manifold M; that is, to an event, since the components of the M manifold are the events. Also, it can be easily inferred that there is an indissoluble unit between the metric g and the manifold M, in the same way, that there is an indissoluble unit between the metric η_{ij} and the configuration space R^4 of the Special Relativity, and between the metric (η_{ij}, t) and Newton's configuration space (R^3, t), since, although it is possible to conceive the configuration space naked the opposite if it is not possible, that is, to conceive a metric without a space of setting. So how can it be argued that there is fundamental independence in General Relativity? Of course, in all three cases, is not bare spacetime a background, although with different geometric characteristics? In the case of Minkowski and Newton, the background obeys plane geometry and, on the other hand, is fixed, due to its independence of the matter-energy.

There are a large number of possible geometries that depend on the initial conditions that are established for each exact solution of the ten Einstein equations. Each solution of the equations will depend on the assumptions. For example, homogeneous and isotropic, large-scale, Friedmann-Lemaitre-Robertson-Walker (FLRW) spacetime, homogeneous and anisotropic of Bianchi spacetime, spherically symmetric, completely empty of Schwarzschild spacetime, symmetric fully empty maximum with a positive cosmological constant of the De Sitter spacetime, maximum symmetric completely empty with a negative cosmological constant of the anti-De Sitter spacetime, generalization of the Schwarzschild metric, carried out by Roy Kerr, in 1963, which describes the geometry of the spacetime around a black hole axially unloaded symmetric with a spherical event horizon and is known as the Kerr metric (or Kerr vacuum), setting absolute rotational motion, etc. Minkowski's spacetime would be the simplest case of the laws of nature since the metric functions (g_{uv}) must satisfy the Riemann condition. And according to the Schwarzschild metric, it must tend infinitely to the Minkowski metric (η_{ij}), which restores the inertial structure of spacetime, beyond the limit in which matter stops acting on it. Also, in tangent spacetime at the infinitesimal limit.

5.2. The interrelation between spacetime and mass-energy.

Mass-energy affects not only space but also time and both at the same time. The greater the presence of energy-mass in a region of spacetime, the more it curves and, therefore, the more its properties deviate from Euclid's geometry [Page 1, 9].

It is Einstein's field equations that describe how matter-energy is influenced by the curvature of spacetime and how spacetime is intrinsically curved by matter-energy [Page 1,26].

The distribution of energy-mass determines that the four-dimensional geometry of spacetime, within finite regions [Page 1, 33], curves intrinsically, according to $ds^2 = g_{uv}\, dx^u dx^v$ that corresponds to the metric (distances and angles) in the Riemann geometry for continuous four-dimensional curves, internally composed of four intersecting curvilinear axes, where the sum of the angles of a triangle, inscribed on its surface, exceeds 180 degrees.

Thus, spacetime cannot exist empty [Page 1, 26], but is an active structure referred to the field-matter to which it gives its direction and is not the passive and independent fixed background (represented geometrically, by the four-dimensional mesh) of Newton on which field-matter moves.

Spacetime is a dynamic continent structure whose shape is curved by the presence of the field-matter and twists due to its movement. This phenomenon is called frame drag or gravitomagnetism [Page 1, 22].

As a consequence of its curvature, spacetime loses the absolute character it has in Special Relativity and acquires a relative character, since it is determined by the physical conditions of what it contains.

Curved spacetime implies that the rate of time flow and the length pattern is determined by the gravitational field stress at each event. "Gravity affects time and distance, narrowing time and contracting distance" [page 1,22]. For its part, the gravitational field changes in time and space depending on the distribution of energy-mass [Page 1, 9]. Space and time do not change independently of each other, but in close connection.

In direct proportion to the density at rest, that is, the density of matter, σ, time expands and contracts length. Therefore, time flows with a rat of its own and there is a pattern of length between every two next events of the gravitational field, since ds^2 is known as a function of x_v in finite intervals [Page 152, 21]. Thus, the measurement of time and length changes from event to event of spacetime [38] and requires a clock at rest to measure time, dt, and a measuring rod of unit length at rest to measure length, dx_1, in each event of a finite interval of the gravitational field. When ds^2 is infinitesimal, σ tends to zero, and the tangent spacetime, in each event of the gravitational field, is the Minkowski spacetime where Special Relativity is valid. For this reason, spacetime in General Relativity is called the Lorentz or semi-Riemannian manifold, that is, because it is the curved spacetime in each differentiable event in plane spacetime. In this way, the infinitesimal intervals of spacetime appear flat while the effects of curvature are evident at finite intervals, but keep in mind that the curvature in the events is not removable, since its cause the matter-energy is not removable.

5.3. The gravitational field and its relation to energy-mass.

In General Relativity, the geometry of space and time is dependent on matter, whereas it is not in Newton and Euclid. This dependence, from the epistemological point of view, constitutes the return of spacetime to matter, from which it had become independent, during the transition from prescientific to scientific thought, and is, undoubtedly, a great theoretical achievement of Einstein.

The relation between the gravitational field and the energy-mass is $G_{uv} = 8\,ЛG/c^2\,T_{uv}$ that gives the curvature in a spacetime event, in relation to the energy-mass relation in it. "Newton's constant, G, measures the" stiffness "of spacetime itself, that is, its resistance to being curved by the presence of energy." [Page 3, 34].

Einstein's equation: $G_{uv} = 8ЛG/c^2\,T_{uv}$ shows how the flow of energy and momentum through a spacetime event affects its curvature there, which is defined by Ricci's second-order tensor that partially determines the curvature of spacetime, since only it gives the curvature for three dimensions [39], R_{uv}, and the Ricci scalar that in each point of spacetime measure the intrinsic geometry of spacetime, near that point [40], R, which does not apply for vacuum, that is, where there is no source of gravitation, but also the empty spacetime curves, asymptotically with respect to the gravitational field of a local region, which is described by the Weyl tensor, $C_{\beta}{}^{\alpha}{}_{uv}$, which transports the curvature information regardless of the gravitational source and completes the curvature part of the four-dimensional array of the spacetime of Lorentz, not specified by the Ricci tensor [Page 1, 27] [41].

The effect described by the Weyl tensor [42], defined in Newton's terms as tidal forces, on the empty spacetime [43] is that it curves, so, in my opinion, it should not be understood as an effect of gravitational wave, in the sense, of energy transport, since, in this case, the energy is consumed geometrically. In other words, the correct interpretation of the Weyl tensor is that it completes the description of the static gravitational field (g), which the Ricci tensor does not entirely achieve [44]. Whereas, in General Relativity the gravitational wave would are ripples of the curvature of spacetime, which carry energy but due to absence of the tensor t_{uv} are not possible. Weyl's tensor describes how empty spacetime curves, that is, in Newton's terms the tidal force [45]. Thus, the static gravitational field (g) is described by the Ricci and Weyl tensors [46]. On the other hand, the induced curvature, described by the Weyl tensor, causes the empty spacetime to exist as a static gravitational field, due to distant sources of gravitation of matter. Weyl's tensor, too, leads to the formulation that spacetime is primitively plane and, therefore, spacetime is primitively independent of matter, as Newton put it.

5.4. Spacetime and gravitational field an inseparable unit.

The indivisibility between the g_{uv} metric and the M manifold of spacetime was defined by Einstein as follows: 'In General Relativity, spacetime, as opposed to what fills the space depending on the coordinates, has no separate existence. In other words, a pure gravitational field could have been described in terms of the g_{uv}, that is, as functions of the coordinates, by solving the gravitational equations. Indeed, if we imagine that the gravitational field, that is, the g_{uv} functions, are eliminated, there will no longer be a space, but absolutely nothing, not even a topological space [47]. This is so, because the g_{uv} functions describe not only the field, but also and at the same time the topological and metric structural properties of the spacetime manifold' [Page 1, 26]. `There is no such thing as empty space [48], that is, a space without a field. Spacetime does not claim for itself an existence of its own, but claims the category of structural quality of the gravitational field '[Page 1, 26]. Then `A space, analyzed from the point of view of the theory of General Relativity, is not a space without a field, but a special case of the g_{uv} field, for which, for the coordinate system that has been used, In itself, it has no objective significance, the g_{uv} functions have values that do not depend on the coordinates' [Page 1, 26].

The impossibility, which exists in General Relativity, the manifold M regardless of the metric, has been misinterpreted, by some physicists and philosophers who consider it to be a Relationism statement by Einstein in the sense that "the metric (or gravitational) field as more closely resembling Descartes' relational theory of space". On the other hand, because General Relativity is a matter-dependent theory of spacetime, therefore, the idea of spacetime `does not exist without relation to matter or fields, its own topology arises in this relations.´ [Page 422, 10], is often confused as Einstein's reaffirmation in Relationism, since it is misinterpreted as if it were dealing with "this view" metric field relations ": by holding that all fields, including the metric field, are physical fields", Here with physical fields it is wanted to sustain that it is not possible to consider the naked M manifold (See Rovelli (1997), and Dorato (2000)).

In the author's opinion, the correct interpretation is, on the one hand, that the existence of g_{uv} is not possible without the M manifold of spacetime, nor this without g_{uv} its curvature, gravitational field, provided that the curvature of spacetime is gravity, on the other hand, g_{uv} is dependent on T_{uv}, the matter-field, since it is this that causes the spacetime metric to be curved. Both qualities of the gravitational field as curvature and that of the curvature dependent on matter are exclusive to General Relativity. In themselves, they are neither relational nor Substantialism. However, the author considers that Einstein made an error in considering that the fundamental is the g_{uv} metric and not the M manifold, when he defines spacetime as the structural property of the gravitational field, since, according to the logic existing in General Relativity , the metric is the quality and not the entity that supports it, which would be the manifold, therefore, the correct thing, in terms of General Relativity, that is, that the gravitational field is the structural property of spacetime. This necessary correction, in the author's opinion, is neutral regarding the dispute that Substantialism and Relationism, maintain, since, well the entity, the manifold M, may be substantial or relational, according to the arguments of one and the other.

5.5. Spacetime, gravitational field, and vacuum.

Therefore, the gravitational field extends in a vacuum. Therefore, spacetime in General Relativity does not exist without gravity, as it does in Minkowski's spacetime of Special Relativity and independent of matter as in Newton's space and time.

However, in the possible physical interpretations of the stress-energy tensor, T_{uv}, there is a class that is that of solutions for vacuum, $T_{uv} \equiv 0$, for hypothetical regions where there is no matter or gravitational fields. Those are the non-trivial solutions, that the Doctor Sergei Kopeikin told me: 'General Relativity states that it can exist without any matter - so called vacuum solutions of the Einstein equations. Examples are: Schwarzschild black hole, Kerr black hole, Friedman-Robertson-Walker cosmological solutions, and many others', E-mail: Mon, 18. Jun 2007 19:07:49 -0500 [48].

The laws of the gravitational field of General Relativity allow us to suppose that Minkowski's spacetime is the simplest particular case of the laws of nature, since in, $ds^2 = g_{uv}\, dx^u dx^v$ the g_{uv}, although they are functions of the coordinates, which are determined by the arbitrarily chosen transformation, these g_{uv} are not arbitrary functions of the new coordinates, but functions such that $ds^2 = \eta_{ik}\, dx^i dx^k$ can be recovered by a continuous transformation of four coordinates, for which the g_{uv} functions must satisfy the Riemann condition . Also, it suggests that Einstein's spacetime is not essentially different from Minkowski's spacetime, that is, that there is a primitive identity between the two, which conspires strongly against the Relationism interpretation that is made of General Relativity, since the Minkowski's best understanding of spacetime is the Substantialism.

Schwarzschild (1916) found the first solution to Einstein's equations and incidentally founded relativistic cosmology, although, for a class of planet, star or theoretical black hole as the only existing object in the Universe, within an empty, uncharged spacetime electric and rotation (angular momentum 0), that Roy Kerr (1963), when solving them with the incorporation of rotation about its central axis, made it a very common star existing in nature. Schwarzschild, based on this solution, which is a good approximation of the external gravitational field of the Earth or the Sun, describes the gravitational field in a vacuum (outside the reference star) and introduced the assumption that the g_{uv} metric must tend in infinity to Minkowski's η_{ik} metric, thereby restoring the absolute inertial structure as a property of spacetime, beyond the limit at which matter ceases to act upon it [50]. The same occurs in all the solutions for an empty spacetime ($T_{uv} \equiv 0$). Thus, spacetime regained its Substantialism ontological status, while maintaining the indissolubility between the M manifold and the g_{uv} metric, advocated by Einstein. In this way, the ether can be reintroduced, although, in General Relativity it is clearly geometric [51].

Another solution, later found, is Willem De Sitter's, which found a metric according to which the Universe should expand, contract, or oscillate. The first of these possibilities coincides with Edwin Hubble's discovery that the Universe is expanding.

5.6. The dynamism of spacetime.

The elements that make up spacetime are:

1, The four-dimensional manifold in whose "points" the set of events of the Universe and the topological structure that includes the positions of the events within the manifold and their changes in contiguity with respect to parts of the manifold, chosen as reference, by processes of deformation of the manifold (change of shape of the manifold) [52].

2, The metric or g_{uv} structure that, also, comprises the light cones or causal structure that, within the connection with speed c, determines the events that they can cause to others and these are [53].

3, The related structure or the tangent spaces defined in each event, as a result of the differentiation of the manifold. At each event, in tangent space, there are the light cones of the past and future. [Page 18, 35].

The spacetime is in its entirety (Manifold (Events + Topology) + Metric (Distances and angles + causal cones) + Affine structure (tangent spaces)) a geometric object that has the peculiarity that it is ¡dynamic¡, [54], but dependent since, due to its interrelation with matter, it continually reconfigures itself and, consequently, determines the change in its intrinsic geodesics, which, in turn, determines the change in inertial material movement, but that it can produce matter-energy is impossible due to its metric-geometric character.

`The spacetime curvature is somewhat dynamic, changing and appears coded in the metric tensor ($g_{\mu\upsilon}$), and is identified with the gravitational field. But the metric field is also responsible for the characteristics of the structures of spacetime (random structure, distance). The metric generates both the gravitational field structures and the time structure. The metric and of course the geometry of the space is dynamic. The geometry of spacetime is affected by matter in such a way that different distributions of matter produce different geometries, a characteristic called background independence [Page 1,37] [55], its coupling and the dynamics are described by the 10 Einstein equations.

´This gives us a vision of a dynamic, evolutionary spacetime. It is not a space like that of Galilean or Newtonian physics, which pre-exists bodies, which remains unchanged in the face of their presence or displacement. What emerges from the theory of General Relativity is that space is generated and modified because there are masses and they influence it. The distribution of matter, its densities, its location, its movements, determine the space itself. Space depends on bodies. In turn, the variations of the space influence them, act on them, and determine their distribution and movements' [56] [Page 2, 39].

Ether in General Relativity is thus dynamic and intrinsically metric in such a way as the immaterial geometric substratum of spacetime [57]

The dynamism of the geometry of spacetime constitutes a great difficulty in understanding the gravitational field as geometric and leads some, from the perspective of General Relativity, to see it as material [58]. It is that the dynamism of spacetime is not proper, since it is dependent on the dynamism of matter, which is intrinsic. If matter were static, spacetime would be Newton's, that is, it would remain immobile forever.

The geometric gravitational field, without being material, changes its configuration in its interrelation with the transformations of matter, which gives it its topology, and in the reconfiguration of the geometry of the gravitational field (g) there is no generation or consumption of energy, according to the equations of General Relativity [59], because they lack of the term t_{uv} in the impulse-energy tensor. Therefore:

Reconfigurations of T → Reconfigurations of g → No cause gravitational Wave → T

In this way, such dynamism of spacetime favors Relationism, but it is because the phenomenon of gravity (static gravitational field) is a purely geometric phenomenon.

5.7. Special Relativity is only valid in the events of General Relativity.

“While in Special Relativity one can only speak of relative velocities, in General Relativity one cannot speak of relative velocities, except for two particles in the same spacetime event, that is, at the same place in the same instant. The reason is that in General Relativity, the notion that a vector is a tiny arrow located in a particular event in spacetime is taken very seriously. To compare vectors at different events in spacetime, we must transport them over each other. The process of transporting a vector along a path without twisting or stretching it is called parallel transport. When spacetime is curved, the result of parallel transport, from one event to another, depends on the path taken. Indeed, this is what it means that spacetime is curved. Thus, it is ambiguous to ask whether two particles have the same velocity vector unless they are in the same spacetime event' [Page 2, 43]. Therefore, in the finite intervals of spacetime relative rectilinear motion is not possible since there are no orthogonal coordinate systems and of course the Lorentz transformation group, precisely valid in them, is meaningless. However, through any event, in any direction of spacetime, there is only one world line corresponding to the movement only influenced by gravity, these are the geodesics.

Force-free particles move with uniform acceleration within geodesics, and consequently uniformly accelerated motion is inertial motion in curved spacetime, which is similar to uniform rectilinear inertial motion in plane spacetime. But, in the curved spacetime, there are no Galilean inertial frames, since it is not possible to establish relative rectilinear movements within finite intervals, except in the same spacetime event, which is intercepted with Minkowski's tangent spacetimes.

However, without Galilean inertial frames, the uniformly accelerated inertial motion of bodies, in the gravitational field, within finite intervals, is a property of the curved geometry of spacetime, thus conserving, in General Relativity, the inertial motion as a geometric property of space time of Special Relativity, although Newton's first law is replaced by the law of geodetic motion. And there is a coordinate transformation, for finite intervals, which 'looks a lot like the Lorentz transformation group' [40]. Therefore, as Modern General Relativity correctly interprets it, it is in the curved geometry of spacetime that the principle of equivalence, in finite regions, between a uniform gravitational system (not homogeneous gravity) and a uniformly accelerated moving system that undergoes change in direction in curved spacetime. This implies that by changing an observer's frame of reference from a uniformly accelerated system, a uniform gravitational field can be created, as long as the accelerated system exists in a finite region where spacetime has positive curvature. If it were not for the curvature of spacetime, this equivalence principle would only be applicable, since particles in motion within a system uniformly accelerated, they would not follow geodesics, from when they are in a gravitational field and, therefore, they would not converge in the direction of the center of gravity [60], but would follow Euclidean parallels. According to the author, the uniformly accelerated motion [59] is the inertial motion, or geodesic motion, in the curved spacetime. Furthermore, in General Relativity, is an effect of spacetime curvature and not spacetime curvature an effect of gravity [Page 22, 44], as Einstein erroneously claimed.

The non-linear transformation group of the four coordinates, between a reference system existing in a finite interval of spacetime, animated with uniform acceleration, under the action of the gravitational field and an inertial system, in the sense of Special Relativity, existing in a quasi-empty interval of spacetime is performed using a rotational and Lorentz composition [40]. In this transformation, the linear coordinates of the inertial system are related to the non-linear coordinates of the accelerated one. Since the gravitational field constitutes inertia in the curved spacetime, that is, gravitation is inertia, it is worth that the events are encoded at the points of the inertial substrate.

It is paradoxical that the formulation of General Relativity is based on the principle of equivalence between inertial and gravitational masses that in curved spacetime is only valid in the same event since ¨Unlike any inertial field, the gravitational field has a unique property - All moving objects lean toward a center. If two rays are emitted perpendicularly between two ideally parallel mirrors, then in an inertial system they will move parallel to each other infinitely between the mirrors¨. "In the gravitational field with an analogous orientation of the mirrors, the rays will begin to approach." “The principle of equivalence of gravitation and acceleration can only be related to a point in space, that is, it is unreal this¨. ¨All the linear transformations of the Special Theory of Relativity and the General Theory of Relativity refer to empty space since real bodies (even as reference points) introduce non-linearity into the properties of space. For this reason, the difference in phenomena when passing to another coordinate system must be strictly studied at the same point in space and time. But how to place two different observers at the same point?” [Page 1, 45].

5.8. Einstein between Relationism and Substantialism.

General Relativity according to the majority consensus favors Substantialism, but Einstein (the young man) unsuccessfully pursued it as a relational physical theory of spacetime based on the Mach principle.

Einstein knew well about spacetime as a geometric entity (from the form) but ignored throughout his life what spacetime is ontologically (from the content). Einstein was able by means of the manifold (M) and the geometric tensor (g) to define spacetime as an abstract geometric entity that as such allowed him to define it, at the deep level of being, sometimes as a simple category of thought and other times as a Substantialism entity although without specifying its real nature. Einstein's first efforts were to define spacetime as a conceptual being and in his progress as a scientist, at the end of his life, as a real being [61].

Einstein had declared himself a relationist when, in his youth, according to Alysea Forsee, he said: `... time and space are modes by which we think and not conditions in which we live '[Page 1, 29]. However, Einstein (1920) argued that the g_{uv} metric was the physical support of inertia, similar to Newton's absolute space, which he called ether again (although, with a different meaning from Huygens), so that height half broke with Mach's Relationism since he also warned: `all the inertia, that is, the entire $g_{uv}$ field is determined by the matter of the Universe and not mainly by the limit conditions at infinity` [Page 166, 21]. Still old, back to his youthful vision, Einstein (1952) stated: 'entirely shun the vague word space of which we must honestly acknowledge we cannot form the slightest conception' [Page 1, 29]. But, finally, `I have returned to Newton's conviction that space and time are things, and not simply relations between things´ [Page 6, 7] [62].

A few months before his death, Einstein (1954) said: `In my opinion, the Mach principle should not be discussed further. He comes from a time when matter was thought to be the only physical reality', by which Einstein means that energy was not considered matter. "In such a state of scientific thought it is invalid to pretend that one is before a physical principle, the same can be said about Leibniz regarding his bases for his spacetime Relationism". Thus, Einstein ended by deciding in favor of Substantialism.

In the 1960s the Substantialism interpretation of spacetime was overwhelming, adopting the conception that the differential topological structure of manifold is an entity independent of material objects. Currently, the relational formulation of inertia, sought by Relationism, has not been reached, a question that was proposed by the young Einstein, who failed, according to the general consensus, so that the approach of Sophisticated Substantialism predominates, in order to eliminate indeterminism that, in General Relativity, introduces Substantialism, since the manifold (M) on which Substantialism is only based, does not have the properties or fulfill the paradigmatic functions of Newton's space and time. For manifold to achieve the ontological status of spacetime it must at least have the metric structure g (Sophisticated Substantialism thesis).

5.9. General Relativity is adopted by Sophisticated Substantialism.

In General Relativity we basically have the spacetime of events (manifold, M) and the material fields defined on them (momentum energy tensor, T).

The geometric properties that allow determining the spatiotemporal distances and the angles between two events, along any curve that connects them, is provided by the gravitational field g (metric + causal cones). This is a field, although geometric, since the information is from each event and exists continuously. Curves are the lines of the world. The spatiotemporal distances, along any line in the world, is obtained by adding the distances between its successive infinitesimally close events.

The general covariance of General Relativity is the freedom to describe the manifold (M) by means of arbitrarily chosen coordinate systems (passive covariance or passive diffeomorphism, in which the coordinates of the events of the manifold are renamed without any objective meaning) which, paradoxically, is equivalent to propagating the metric field (g) over the manifold in as many ways as there are coordinate transformation systems called active covariance, or active dipheomorphism, which is a transformation of coordinates that takes metric and material fields of some events to others within the lines of the world, deforming them during their transport, although, the fields at the exit remain the same as at the entrance and are observably indistinguishable, that is, the properties intrinsic to geometry, matter and such dynamics are invariant. such as curvature, spatiotemporal distances, rest masses or number of particles etc. Thus, General Relativity responds to the structure (M, g, T).

For primitive Substantialism it is the manifold (M) that is the container of the metric (g) and material (T) fields. And only types of fields (T) carry energy and momentum.

If an active dipheomorphism passes a material field (T) through a hole (empty spacetime, that is, M empty of T, it can happen that the material field that included a certain event in the input, for example, E in the output, continue to include it or not. For Substantialism the result implies two physical possibilities that violate Leibniz's so-called equivalence principle: `If two distributions of material fields are related by an active diffeomorphism then they represent the same physical system`. This makes General Relativity indeterministic, being that it is a recognized deterministic theory, although, paradoxically, its own foundation, spacetime Einstein, neither, its followers and much less those who have verified it have been sure about what spacetime is ontologically.

Indeterminism is the consequence of the hole argument, which Einstein (1913) used as a step to elaborate General Relativity, under the reworking of Earman (1986) and Norton (1988, 2003). ¨the argument is a direct consequence of the general covariance of General Relativity¨ [Page 3, 47] [63].

The consequence of the hole argument for Substantialism is that the events of the manifold by themselves lack ontological reality, that is, they lack primitive identity as since the debate between Newton and Leibniz had been established, and the solution found to save it, maintaining the determinism of General Relativity, it is to link the metric field (g) to the manifold (M), in such a way, it is the double (M, g) the container of T (material fields), with which the Substantialism affirms the semi-independent existence of spacetime structures with respect to matter since this, although it determines their curved geometry (gravitational field), is not the reason that they exist, since without matter, at least when it tends to zero, its geometry is rectilinear (Minkowski inertial field). Solution called Sophisticated Substantialism, SS [Page 1, 48]. Although the persistence of the points that initially support the ether is denied, it still survives as the geometric substrate of a non-empty spacetime [64].

SS is a doctrine that holds that, although the points of the space-temporal manifold do not have a robust existence, since they lack primitive identity, spacetime is a fully-fledged independent entity. Thus, SS argues, that the manifold lacking the basic spatiotemporal structures -such as geometry and inertia- must be counted on the double manifold + metric (M, g) as the independent spacetime [65].

However, despite Sophisticated Substantialism [66], the dilemma, posed by Rovelli, persists among themselves `the gravitational field is nothing but a local distortion of the geometry of spacetime (Substantialism) or the geometry of spacetime is nothing but a manifestation of the gravitational field (Relationism) [Page 145, 5]. In this way, Relationism is maintained in the debate by defending that the metric tensor (g) is a material field (geometric gravitational field + energy-moment). There is no space without matter, and spacetime structures, such as inertia and geometry, are relational entities.

Miguel Lorente, based on the presentations, on the Ontology of spacetime, made at the II congress of the group "Spacetime Society" (2006), held at the Concordia University of Montreal, in conclusion, wrote: "Spacetime remains an enigma for science and philosophy'.

5.10. Exotic applications.

From the solutions of the Einstein-Grossmann-Hilbert equations, due to the metric-geometric nature that they assign to gravity, as an aspect of spacetime, we obtain the Big-Bang as the origin of the Universe, black holes and wormholes, results that do not correspond to the physical phenomenon. In exchange for the Big-Bang, in the RTG of Anatoli Logunov, M. Mestvirishvili and others, the Universe cyclically oscillates between a maximum and a minimum density of matter-energy.

5.10.1. Black holes.

As a consequence of Newton's corpuscular theory of light and his equations on: motion, gravity and escape velocity, in 1783, John Michell formulated the existence of very massive stars, which would be invisible because the light, could not escape the gravity of them. In 1915, Albert Einstein demonstrated that light is indeed subjected to gravity and Karl Schwarzschild, in the application for a spherical body, which made the equations of General Relativity, confirmed that a star with a large mass and a certain radius, called the event horizon, its gravity would trap light. In 1930, Subrahmanyan Chandrasekhar determined the critical mass to be 1.5 times that of the Sun and, in 1939, Robert Oppenheimer discovered that the star's gravitational collapse could occur above it. In 1967 Stephen Hawking and Roger Penrose proved that any solution of the General Relativity equations for a collapsed star generates a singularity. In 1969 John Wheeler called the singularity a black hole.

However, in the RTG, the Hawking and Penrose theorems about occurrence of singularities do not apply. In such a way, super compact objects can exist, with such force of gravity that they prevent the escape of electromagnetic waves but lacking singularity, that Logunov calls them blackened objects.

According to the General Relativity equations, a black hole is physically defined by the 3 qualities of: mass, momentum and electric charge (Carter-Robinson's Uniqueness or Absence of Hair Theorem).

The black hole (rather, blackened object), according to astronomical observations, is classified according to its amount of mass in:

- Supermassive, with several million times the mass of the Sun. This black hole would be the center of galaxies with a spherical, ellipsoid or spiral shape and sucks matter in such a large amount that it cannot enter the hole and accumulates in a large disk of accretion (formation of a body from others), which due to its very high temperature becomes a quasar, whose nucleus is the black hole, which emits an enormous amount of radiation and produces the two magnetic fields of the hole relativistic jets (matter at a closed speed ac), above and below the disk.

- Stellar, greater than 1.5 times the mass of the Sun. This supposed hole would abound in galaxies. Also, according to astronomical observations there would be binary black holes rotating around each other. For example, the binary Black Hole in 3C 75, composed of two supermassive, 25 thousand light years distant, which are the nuclei of two merging galaxies, located in the Abell 400, cluster of galaxies (compiled by George Abell in 1950s), which are some 300 million light years away from each other.

The exact solutions of the General Relativity equations give 4 possible theoretical types of black holes. These are:

- Schwarzschild that does not rotate or have a charge.

- Kerr that rotates and has no charge.

- Reissner-Nordstrom that does not rotate and has a charge (with a low probability of existing).

- Kerr-Newman that rotates and has a charge (with a low probability of existing).

5.10.2. Wormholes.

From the conception of spacetime as the framework of all past, present and future events, it allowed Goedel to prove that General Relativity allowed time travel as long as the Universe was stationary. Goedel's solution does not represent the Universe since it is expanding. However, other solutions have been found that allow time travel. One is that of the two cosmic strings, in relative motion, at a closed velocity at c. The cosmic strings have theoretically emerged in attempts to unify Quantum Physics with General Relativity. These would be like strings, in the sense that they have length, but an infinitesimal cross section. In reality, they are like elastic bands, which would be under enormous tension, about one hundred thousand quadrillion tons. According to General Relativity, these could arise in the Universe, very closely to the Big Bang.

Another time travel solution is to move above c, within one position in space to another, from one end of the galaxy to the other. Thus it is required to bend both spacetime to create a small tube or wormhole, similar to a tunnel, on Earth, in 3 dimensions, connecting two places within a shorter distance to their link through the surface, in two dimensions These worms, or tunnels in the four dimensions of spacetime, could connect two extreme sides of the galaxy, and act as a shortcut, to get from one to the other and return through another hole before they had split. However, the worms would travel within a speed limited to c. The possible existence of wormholes was studied by Einstein and Rosen (1935), but they found that they were so unstable that they disappeared almost immediately. John Wheeler and Robert Fuller (1962) demonstrated that these holes were cut as soon as light fell on them. However, Kip Thorne (1988), due to a question from Carl Sagan, found that wormholes could be kept open, if there were matter with negative mass that he called "exotic". Such exotic matter could be due to a property of empty space known as "vacuum polarization." These holes are known as Thorne - Morris (one of his students with whom such an idea matured). Matt Visser (1989) found that wormholes could be stable without needing to be filled with exotic matter. Furthermore, he said that the holes could possibly have been created naturally since the creation of the Universe. Michael Morris, Ulvi Yurtsever, and Kip Thorne (1988) demonstrated that, if a wormhole were created and kept open, it would be turned into a time machine, to travel through spacetime, and causation could be violated. Matt Visser, Sayan Kar and Naresh Dadhich (2003) found that the existence of a wormhole with an extremely small amount of exotic matter is possible, which curves spacetime negatively in the opposite way that normal matter gives it a positive bend.

What the Goedel Universe, the cosmic string spacetime, and wormholes have in common, is that they exist so distorted and curved that the journey back in time is possible.

Therefore, General Relativity allows time travel, a consequence of the enduring of events and the eternalism of spacetime when, as the author proposes, in this essay, time is generated in the evolution of matter, that is, geometrically in the external variation of the three dimensions of space that is inherently inherent to it and, therefore, it is the temporal succession of a three-dimensional entity, which always exists in transit and only leaves its mark on the past in the In the form of radiation, for example, on Earth we always have the presence of the Sun's electromagnetic footprint, as this was approximately 8.3 minutes before, also, its gravitational footprint.

The eternalism of the relativity of spacetime leads to the enduring that events physically exist in eternity and, therefore, we can return to them forever, for example, meet our birth eternally. This is physically impossible both by the law of conservation of impulse and energy and by the law of entropy, since matter when it becomes past ceases to exist as it was and in its present form is something else, although the information remains electromagnetic and gravitational, and all other radiation produced by matter, about what it was like, unless the entropy was reversed and will go into reverse and, thus, the arrow of time, really in the tail was another point. What is possible is time travel, which is not time travel.

5.11 Notes

[31] Interpretation of gravity, according to General Relativity, made by the author in his essay: "Gravity is a force", in 2006.

[32] The generally covariant formalism had been developed only in 1901 by Ricci and Levi-Civita, and the first real use of it in physics was Einstein's formulation of general relativity. This historical accident made it natural for people (including Einstein, at first) to imagine that general relativity is distinguished from other theories by its general covariance, whereas in fact general covariance was only a new mathematical formalism, and does not connote a distinguishing physical attribute. For this reason, some people have been tempted to conclude that the requirement of general covariance is actually vacuous. [Page 1, 31].

[33] In General Relativity, the gravitational field is represented by the metric of spacetime. Gravity is identical to properties of a dynamic geometry [Page 3, 30].

[34] ``The force of gravity defined as changes in the gravitational field from place to place in Newtonian mechanics, was replaced by changes in the geometry of space from place to place in spacetime measured by the degree of curvature at each point´ [Page 1, 29].

[35] The spacetime metric is the field. Spacetime plays a dual role in this theory, because it constitutes both the dynamic object and the context within which the dynamics are defined. This self-referential aspect gives general relativity certain characteristics different from any other field theory. The self-referential quality of the metric field equations also manifests itself in their non-linearity. Under the laws of general relativity, every form of stress-energy gravitates, including gravitation itself. This is really unadevoidmable for a theory in which the metrical relations between entities determine the "positions" of those entities, and those positions in turn influence the metric. This non-linearity raises both practical and theoretical issues. From a practical standpoint, it ensures

that exact analytical solutions will be very difficult to determine. More importantly, from a conceptual standpoint, non-linearity ensures that the field cannot in general be uniquely defined by the distribution of material objects, because variations in the field itself can serve as "objects". [Page 1,31].

[36] The energy tensor can be regarded only as a provisional means of representing matter. [Page 1,31].

[37] `Something geometric, the tensor guv has to be proportional to something non geometric the tensor T_{uv}´ [Page 1,32]

[38] Einstein concluded that "in the general theory of relativity, space and time cannot be defined in such a way that differences of the spatial coordinates can be directly measured by the unit measuring rod, or differences in the time coordinate by a standard clock ... this requirement ... takes away from space and time the last remnant of physical objectivity" [Page 1, 31].

[39] Determines that spacetime is curved, therefore, the time acceleration of a three-dimensional volume, which expresses the fact that, according to the theory of universal gravitation, a spherical mass of gas with time reduces its volume, with an acceleration equivalent to 4Gπρ, as a consequence of the reciprocal attraction of the gas molecules. (Wikipedia)

[40] It is the acceleration of the surface enclosed by said volume (Wikipedia) or curvature of the surface of spacetime.

[41] ´The Einstein equation only contains ten pieces of information, although you need 20 to specify the curvature tensor. So, the Einstein equation doesn't let you reconstruct the complete curvature tensor´ ´In 4 dimensions, it takes 20 numbers to specify the curvature at each point. 10 of these numbers are captured by the Ricci tensor, while the remaining 10 are captured by the Weyl tensor '. ´In general relativity, knowing all about the sources (the stress-energy tensor T) isn't enough to tell you all about the curvature´ `There's extra information in the fields beyond just what the sources of the fields can tell you. ´ ´ (For example, in electromagnetism you can specify that no electromagnetic waves are zooming in from infinity. That's enough to give you a unique solution to the fields given the sources. For general relativity, you can perform similar feats, although it's technically trickier) ´. `The Weyl part of the curvature has to do with gravitational radiation: the Weyl tensor carries information about the kind of curvature that's independent of the source distribution, sort of like electromagnetic waves are fields that propagate independently of whatever sources are around.´, ´ When we are in truly empty space, there's no Ricci curvature´ `But there can be Weyl curvature due to gravitational waves, tidal forces, and the like. Gravitational waves and tidal forces tend to stretch things out in one direction while squashing them in the other´ [Page 1, 27].

[42] Represents the change in the shape of a spherical volume in ellipsoid that occurs in a curved spacetime.

[43] The Ricci effect does not exist, but the Weyl effect does.

[44] In a spherically symmetrical field the cloud will become lengthened in the radial direction and shortened in the normal directions. This variation in the shape is characterized by the Weyl tensor, which in general may be non-zero even when the Ricci tensor vanishes. [Page 1, 31].

[45] According to Thorne (1994) “spacetime curvature and tidal gravity are the same thing expressed in different languages, the former in the language of relativity, the later in the language of Newtonian gravity.

[46] It may seem that conceiving of gravity purely as tidal effect ignores what is usually the most physically obvious manifestation of gravity, namely, the tendency of objects to "fall down", i.e., the acceleration of the geodesics relative to our usual static coordinates near a gravitating body. However, in most cases this too can be viewed as tidal accelerations, provided we take a wider view of events. For example, the fall of a single apple to the ground at one location on Earth can be transformed away (locally) by a suitable system of accelerating coordinates, but the fall of apples all over the Earth cannot. In effect these apples can be seen as a spherical cloud of dust particles, each following a geodesic path, and those paths are converging and the cloud's volume is shrinking at an accelerating rate as the shell collapses toward the Earth. The rate of acceleration (i.e., the second derivative with respect to time) is proportional to the mass of the Earth, in accord with the field equations [Page 1,31].

[47] `Einstein defined the gravitational field to be identical to the so-called metric tensor´. ´Before Einstein, the metric tensor was a purely geometric quantity that expresses how to determine the distances between points in space.´ `Einstein's appropriation of the metric tensor so that it also represented the gravitational field led to an inevitable, logical conclusion: If you took away the gravitational field, this meant that "guv" would be everywhere and for all time equal to zero, but so too would the metric for spacetime. Spacetime would lose its metric, the distance between points in the manifold would vanish, and the manifold itself would disappear into nothingness' [Page 1, 29].

[48] In empty spacetime, (where the term "empty" means the absence of matter or electromagnetic energy, but obviously not the absence of the metric / gravitational field) [Page 1,31].

[49] Dr. Sergei Kopeikin, in Friedman's case, refers to his solution of Einstein's equations for the plane Universe.

[50] Einstein's original presentation in his famous paper "The Foundation of the General Theory of Relativity", which was published early in 1916. He notes that for empty space, far from any gravitating object, we expect to have flat (ie, Minkowskian) spacetime [Page 1,31].

[51] “The need for regarding inertial spacetime as an ether came after noticing that empty spacetime, despite being unobservable and unalterable, displayed physical properties, such as providing a reference for acceleration via its geodesics” [Page 2, 18]. "Einstein called Newtonian space and the metrics of special and general relativity ethers." [Page 8, 18]. "Einstein himself said" the ether of General Relativity is a medium which by itself is devoid of any mechanical and kinematical property but at the same time determines the mechanical (and electromagnetic) processes." [Pages 5-6, 16].

“The description is realized by the spacetime points, since these geometric objects perform the localization of fields but they cannot be observed or influenced themselves as expressed by the diffeomorphism invariance postulate of general relativity. Therefore, we call spacetime points the geometric ether” “Not only did general relativity change the very notion of ether, but also that of empty spacetime. It is another feature of g (x) that it depends on the spacetime coordinates (geometrically speaking, on its points), so that it cannot consist of an absolute background associated with empty spacetime as η in special relativity. On the contrary, the metric field g (x) constitutes an intrinsic content of spacetime" [Page 11, 18]. "Via the Einstein equations, not only that the distribution of matter-energy constrains the spacetime itself but also that solutions described by a vacuum (a null stress-energy tensor) are endowed with a complex geometrical structure. In a certain sense we can see now that the synthesis between matter and space, contained and container, is actually achieved in the modern concept of the vacuum which is both" [Page. 6, 16].

[52] Properties possessed by the manifold itself are its dimension and its topological structure. [Page 6, 36].

[53] Distances, intervals, volumes, past and future - are properties of the metric. [Page 5, 36].

[54] The basis of Einstein's general theory of relativity is the audacious idea that not only do the metrical relations of spacetime deviate from perfect Euclidean flatness, but that the metric itself is a dynamical object. In every other field theory, the equations describe the behavior of a physical field, such as the electric or magnetic field, within a constant and immutable arena of space and time, but the field equations of general relativity describe the behavior of space and time themselves. [Page 1, 31].

[55] ¨The absence of an externally prescribed geometry is known as the principle of background independence¨ [Page 1, 38].

[56] `The metric itself is a dynamic object. In every other field theory, the equations describe the behavior of a physical field, such as the electric or magnetic field, within a constant and immutable arena of space and time, but the field equations of general relativity describe the behavior of space and time themselves. The spacetime metric is the field´ [5.8, Page 1, 40].

`Matter affects the dynamics of the gravitational field and is affected by it through the non-trivial geometry that the latter defines. General relativity is not a theory of fields moving on curved background geometry; general relativity is a theory of fields moving on top of each other [Page 2, 41].

[57] ¨The nature of this new ether underwent yet another change with the theory of general relativity. According to Einstein the ether was now spacetime's dynamic and intrinsic metric content. This was so significant a change that it modified the very ideas of ether and empty spacetime. By making metric spacetime alterable, it actually put an end to its status as genuine ether. And by making the metric field a content of spacetime, it did away with empty spacetime, since now to vacate spacetime means to be left with nothing at all¨ [Page 2, 18].

"Ridding spacetime of its geometry, it is not nothing which remains but the spacetime points themselves". "As known the results of Einstein so-called hole argument: spacetime points are not physical either, so that they could not constitute truly empty spacetime in any physical sense" [Page 11, 18].

[58] Such an implication is the consequence of a debatable interpretation that the gravitational field has energy and momentum. In my opinion, in the theory of General Relativity, the gravitational field

is dual: geometric as spacetime (static gravitational field) and material as gravitational wave (dynamic gravitational field).

[59] Or, according to the author's theory in 5 dimensions, since the 4 dimensions of spacetime intervene in the generation of the gravitational wave, as occurs from binary stars [42]. However, also, 4D energy must be generated, which comes from reconfigurations of the spacetime in which its 4 dimensions partially enter. This energy must be added to known matter. Therefore, according to the author, according to General Relativity, it is not that the gravitational field (g, geometric field) is ambiguous (geometric-material), but that due to its dynamics and interrelation with matter (T) it produces matter. (the geometry is converted into energy-moment that is going to stop and increases T), that is, there are two g fields: the geometric or gravitational field and the material gravitational (radiation). However, according to the hypothesis of this essay that spacetime is the structural geometric property of dynamic matter, the material transformation could occur in 5D, under the assumption that the configuration of dynamic matter itself, that is in 4D, reconfigure what would generate power in 5D.

[60] Suppose you drop a small ball of instant coffee when making coffee in the morning. The grains of coffee closer to the earth accelerate towards it a bit more, causing the ball to start stretching in the vertical direction. However, as the grains all accelerate towards the center of the earth, the ball also starts being squashed in the two horizontal directions. [Page 6, 43]

[61] `Einstein himself was a relationist as a young man, a champion of Leibniz, but became in his mature years more and more of a Substantialism finally admitting, in his old age, that one could better forget all about Mach's Principle´ [Page 6, 7].

[62] `The gravitational field in space free of ordinary matter, as represented by the metric guv itself, can be said to carry genuine energy and momentum, this is a powerful argument for adopting the Substantialism view of spacetime '[Page 187, 46 ]. `The energy momentum tensor T_{uv} represents the matter fields, the only stuff 'that really exists according to the relationist. But if $T_{uv} = 0$ empty space can carry genuine energy-momentum of the gravitational field, then it (the empty space) should be counted as real also, and spacetime itself as represented by g_{uv} should be considered substantial and real' [Page 188, 46].

[63] `According to Earman and Norton (1987), Einstein’s hole argument shows that spacetime substantialists are committed to a radical form of indeterminism. The only way to save the possibility of determinism is to endorse a relationist interpretation of the geometry of spacetime. Many philosophers have since disagreed (Brighouse 1994, Butterfield 1989, Hoefer 1996, Maidens 1993, Maudlin 1990). A frequent response is that one can regard all isomorphic models of general relativity as representing the same physical possibility (Leibniz Equivalence) and regard spacetime as a basic, substantial and concrete entity´ [Page 1, 8].

[64] ¨In fact, one is left with something: the spacetime points; However, these had been denied physical reality by Einstein’s hole argument. From this standpoint, Einstein concluded that empty spacetime cannot possess any physical properties, i.e. that empty spacetime does not exist¨ [Page 2, 18] ¨ending with its new form of an immaterial, geometric substratum¨ [Page 3, 18].

[65] `A modern-day substantialists think that spacetime is a kind of thing which can, in consistency with the laws of nature, exist independently of material things (ordinary matter, light, and so on)

and which is properly described as having its own properties, over and above the properties of any material things that may occupy parts of it.´ [Page 2, 8].

[66] `Sophisticated Substantialism is defended as a response to the hole argument. It is also shown to be an interpretation of spacetime that is compatible with a range of approaches to canonical quantum gravity´ "Recently Belot and Earman (2000) have claimed that this "sophisticated form of Substantialism "lacks a" coherent and plausible motivation " (2000). They suggest that philosophers should take account of the link between different interpretative stances towards the spacetime of classical general relativity and distinct approaches to overcoming the technical and conceptual problems of canonical quantum gravity. They claim that only straightforward Substantialism and Relationism underwrite interesting programs. I suggest (Oliver Pooley) that the opposite is the case that a manifold of distinct approaches to quantum gravity involve a form of sophisticated Substantialism. By way of illustration I discuss those of Julian Barbour and Carlo Rovelli, both discussed by Belot and Earman. [Page 1, 8].

6. Spacetime according to Logunov.

In 1987, in the spirit of Poincaré's special relativity, Entwurf theory and quantum field physics theories, Logunov, Loskutov, and Mestvirishvili presented the Relativistic Theory of Gravitation, later revised, also, with the participation of Gershtein, in the following terms:

"Within the framework of SRT (Theory of Special Relativity), which describes phenomena in inertial and non-inertial frames of reference, with the help of the principle of geometrization that reflects the universality of gravitational interaction with matter, and with the introduction of the mass of graviton, we will succeed in unifying Poincaré's (1904) idea of the gravitational field as a physicist in the spirit of Faraday-Maxwell with Einstein's idea of the Riemannian geometry of spacetime. It is this principle of geometrization that will help us find a gauge group without displacements that will allow us to construct the Lagrangian density of the appropriate gravitational field. All this has led us to the Relativistic Theory of Gravitation (RTG), 1989, which has all the laws of conservation, as occurs in all physical theories. "

"In this theory, due to geometrization, the total energy-momentum tensor of matter and the gravitational field is the source of the gravitational field, just what Einstein wanted when building the theory of gravitation (in Entwurf theory). In what follows we will see that the rather general physical requirements lead us to an unequivocal construction of the complete system of equations for a massive gravitational field. The equations in this theory differ considerably from the Hilbert-Einstein equations, as it retains the notion that inertial coordinate systems and gravitational forces differ from the inertia principle in that they are caused by the physical field".

"The Relativistic Theory of Gravitation with the mass of graviton is a field theory to the same extent as classical electrodynamics, so it could be called classical gravidinynamics" (Logunov, 1995).

Einstein was unable to solve in scientific terms the problem he encountered in Entwurf theory with the Galilean Minkowski pseudo-Euclidean spacetime geometry, because it was based on the relativity principle of Galilei's motion, which although it allowed him to treat gravity as a gifted force of energy-impulse in a similar way to the Lorentz type electromagnetic force, that is, the effect of the static gravitational field, but which required a positive curvature geometry, of the Riemann class, for the equations to give the anomaly of the Mercury's orbit and the deflection of the electromagnetic wave, propagating in the vicinity of the Sun, although, at the cost of the geometrization of gravity, because Riemann spacetime does not support gravity with energy-impulse.

It is necessary to clarify that the Euclidean space is orthonormal in 3 dimensions, while Minkowski's orthonormal space is pseudo-Euclidean because it is in 4 dimensions.

It was seven decades after Logunov solved Einstein's problem of Entwurf theory, taking in exchange for the Galilean Minkowski pseudo-Euclidean spacetime geometry defined by orthogonal axes, the Poincaré Minkowski pseudo-Euclidean spacetime geometry, based on the principle of relativity of Galilei universalized to both inertial and non-inertial frames by Poincaré, who within the Minkowski collection of spaces, by deformation of the axes until they bend, achieves identity with the semi-Riemannian spacetime of geometry used by Einstein in General Relativity, called, in the Relativistic Theory of Gravitation, effective Riemann spacetime.

Logunov realized that the Minkowski space can be taken in curvilinear coordinates: "Minkowski space supports description in both the inertial coordinate system (e.g., the Galilean coordinate) and the non-inertial (accelerated) coordinate system. From a mathematical point of view, it is quite obvious, since a wide class of admissible coordinate systems (including the curvilinear) can be introduced in Minkowski´s space" (Logunov, 1995).

Logunov chooses Minkowski's space in curvilinear coordinates because energy-matter is subject to gravity, which according to Einstein-Hilbert determines its geodetic movement. In Wheeler's words, matter tells spacetime how to curve and this tells matter how to move: "The principle of geometrization is introduced, according to which the interaction of a gravitational field with matter is achieved, in view of the universality of this interaction, by adding the gravitational field Φ^{uv} to the y^{uv} metric tensor of Minkowski's spacetime in density of the Lagrangian of matter according to the following rule:

$LM(\hat{y}^{uv}, \Phi_A) \rightarrow LM(\hat{g}g^{uv}, \Phi_A)$

Where

$\hat{g}g^{uv} = \sqrt{-g}\, g^{uv} = \sqrt{-y}\, y^{uv} + \sqrt{-y}\, \Phi^{uv} \equiv \hat{y}^{uv} + \acute{\emptyset}^{uv}$

and Φ_A are the material fields. By matter we understand all its forms except the gravitational field. According to the geometrization principle, the motion of matter under the action of a gravitational field Φ^{uv} in Minkowski spacetime with a y^{uv} metric is equivalent to the movement in an effective Riemann spacetime with a g^{uv} metric. The Minkowski spacetime metric tensor and the gravitational field tensor in this spacetime are primary concepts, while the Riemann spacetime and its metric tensor are secondary concepts, due to their origin to the gravitational field and their universal action on matter through Φ_A. Riemann's effective spacetime is literally of field origin, thanks to the presence of the gravitational field. Einstein was the first to suggest that spacetime is Riemann rather than pseudo-Euclidean. He identified gravitation with the Riemann spacetime metric tensor. But this line of reasoning led to both the rejection of the gravitational field and the physical field possessing an energy-momentum density and the loss of the fundamental laws of conservation. The principle of geometrization, based on Minkowsky's notions of spacetime and a physical gravitational field, introduces the concept of an effective Riemann spacetime and finds its indirect reflection in Einstein's idea of a Riemann geometry" (Logunov and Mestvirishvili, 1989).

Logunov distinguished: "First the relativity principle was applied only to the mechanical phenomenon. But then Henry Poincaré formulated it as the universal principle for all physical phenomenon" (Logunov and Mestvirishvili, 1985). The Galilean Minkowski pseudo-Euclidean space-time geometry corresponds to the relativity principle applied only to the mechanical phenomenon while the Poincaré Minkowski pseudo-Euclidean spacetime geometry corresponds to the universal principle of relativity for all physical phenomena.

Poincaré's contributions to the relativistic conception were more universal than Einstein's, since he was the one who introduced relativistic mechanics, formulated the principle of relativity for all physical phenomena and found the Lorentz transformation group, which he could extend to all the forces of nature and introduced spacetime with its invariant ds^2 interval, specified by Minkowski in relative space and time, allowing to deduce that non-inertial reference systems can exist together with inertial ones, therefore, as different systems, question made by Logunov. Since when formulating: "all physical phenomena occur in spacetime, whose geometry is pseudo Euclidean", it allowed the introduction of the metric tensor $\gamma_{\mu\nu}(x)$ in the Minkowski space in arbitrary coordinates and introduce the gravitational field, separating the forces of inertia of gravity.

In his writings, Logunov exposes his conception of Poincaré Minkowski pseudo-Euclidean spacetime geometry: "Since the construction of the Relativistic Theory of Gravity (RTG) is based on the theory of Special Relativity (SRT), we will discuss the latter in more detail, and in doing so we will examine Henri Poincaré's and Albert Einstein's approach.

This analysis will allow a deeper understanding of the difference between these approaches and will allow us to formulate the essence of the theory of relativity.

When analyzing the Lorentz transformations, H. Poincaré showed that these transformations, together with all the spatial rotations, form a group that does not alter the electrodynamic equations. Richard Feynman wrote the following about this:

> "Precisely, Poincaré proposed to investigate what could be done with the equations without altering their form. It was precisely his idea to pay attention to the symmetry properties of the laws of physics".

H. Poincaré did not limit himself to studying electrodynamics; he discovered the equations of relativistic mechanics and extended the Lorentz transformations to all the forces of nature. The discovery of the group, named by H. Poincaré the Lorentz group, allowed him to introduce spacetime in four dimensions with an invariant later called the interval:

$d\sigma^2 = (dX_0)^2 - (dX_1)^2 - (dX_2)^2 - (dX_3)^2$. (α)

Precisely from the above, it is absolutely clear that time and spatial length are relative. Later, Herman Minkowski made a further development in this direction, since he was the one who introduced the concepts of temporal and spatial intervals.

Following exactly H. Poincaré and H. Minkowski, the essence of the theory of relativity can be formulated as follows: all physical phenomena occur in spacetime, whose geometry is pseudo-

Euclidean and is determined by the interval (α). Here it is important to emphasize that the geometry of spacetime reflects those general dynamic properties, which represent what makes it universal. In four-dimensional space (Minkowski space) a fairly arbitrary frame of reference can be adopted:

$X_\nu = f_\nu (x_\mu)$,

making a mutually unequivocal correspondence with a Jacobian that differs from zero. Determining the differentials:

$dX_\nu = \partial f_\nu / \partial x_\mu \, dx_\mu$,

and substituting these expressions in (α) we find:

$d\sigma^2 = \gamma_{\mu\nu} (x) \, dx_\mu dx_\nu$, where:

$\gamma_{\mu\nu} (x) = \varrho_\sigma \, \partial f_\sigma / \partial x_\mu \, \partial f_\sigma / \partial x\nu, \; \varrho_\sigma = (1, -1, -1, -1)$ (β)

It is quite evident that the transition to an arbitrary reference system did not take us beyond the limits of pseudo-Euclidean geometry. But it follows that non-inertial reference systems can also be applied in SRT. The inertial forces that arise in the transition to an accelerated frame of reference are expressed in terms of the Christoffel symbols of Minkowski space. The SRT representation derived from the work of H. Poincaré and H. Minkowski was more general and turned out to be extremely necessary for the construction of RTG, since it allowed the introduction of the metric tensor $\gamma_{\mu\nu}$ (x) of the Minkowski space in arbitrary coordinates and thus made it possible to covariantly introduce the gravitational field, by separating the inertial forces from gravity.

From the point of view of history, it should be noted that in his previous works, "The measurement of time" and "The present and future of mathematical physics", H. Poincaré discussed in detail the problems of the constancy of speed of light, of the simultaneity of events at different points in space determined by the synchronization of the clocks with the help of a light signal. Later, on the basis of the principle of relativity, which he formulated in 1904 for all physical phenomena, as well as in the work published by H. Lorentz the same year, H. Poincaré discovered a transformation group in 1905 and named it the group by Lorentz. This allowed him to give the following essentially accurate formulation of the theory of relativity: the equations of physical processes must be invariant with respect to the Lorentz group. Precisely this formulation was given by A. Einstein in 1948:

> "With the help of Lorentz transformations, the special principle of relativity can be formulated as follows: The laws of nature are invariant with respect to the Lorentz transformation (that is, a law of nature should not change if it refers to a new inertial frame of reference with the help of the Lorentz transformation for (x, y, z, t)".

The existence of a group of coordinate transformations in time means that there is an infinite set of equivalent (inertial) frames of reference related by the Lorentz transformations.

From the invariance of the equations it is trivially deduced that the physical equations in the x and x′ frames of reference, related by the Lorentz transformations, are identical. But this means that any phenomenon described in the reference systems x and x' under identical conditions will give identical results, that is, the principle of relativity is satisfied in a trivial way. Certain, even prominent, physicists understood this with difficulty not long ago, while others have not even been able to".

“H. Poincaré's detailed investigation of the Lorentz group invariants resulted in his discovery of the pseudo-Euclidean geometry of spacetime. Precisely on this basis, he established the four dimensions of physical quantities: force, speed, momentum, current. H. Poincaré's first short paper appeared in reports from the French Academy of Sciences before A. Einstein's work was even submitted for publication. That work contained a precise and rigorous solution to the problem of the electrodynamics of moving bodies and, at the same time, extended the Lorentz transformations to all-natural forces, of whatever origin they might be".

"A. Einstein advanced towards the theory of relativity from an analysis of the concepts of simultaneity and synchronization for clocks at different points in space based on the principle of constancy of the speed of light. Each ray of light travels in a "resting" frame of reference with a certain speed V, regardless of whether this ray of light is emitted by a body at rest or by a body in motion. But this point cannot be considered a Principle, since it implies a certain choice of frame of reference, while a physical principle clearly should not depend on the method of choice of frame of reference. Essentially, A. Einstein followed H. Poincaré's early work with precision.

However, within this approach it is impossible to reach non-inertial reference frames, since in these reference frames it is impossible to take advantage of clock synchronization, so the notion of simultaneity loses meaning and, in addition, the speed of light it cannot be considered constant.

In a frame of reference in process of acceleration the proper time $d\tau$, where

$$d\sigma^2 = d\tau^2 - s_{ik}dx_i dx_k,\ d\tau = \gamma_{0\alpha}dx_\alpha / \sqrt{\gamma_{00}},\ s_{ik} = -\gamma_{ik} + \gamma_{0i}\gamma_{0k} / \gamma_{00}$$

It is not a full differential, so the timing of clocks at different points in space depends on the timing path. This means that such a concept cannot be applied to frames of reference in the process of acceleration. It should be emphasized that the coordinates in the expression (β) have no metric significance, by themselves. Physically measurable quantities must be constructed with the help of coordinates and metric coefficients $\gamma_{\mu\nu}$. But all this was misunderstood for a long time in the SRT, since it was common to adopt the approach of A. Einstein, instead of H. Poincaré and H. Minkowski. Thus, the starting points introduced by A. Einstein were exclusively limited and partial in nature, although they could create an illusion of simplicity. It was precisely for this reason that even in 1913 A. Einstein wrote:

> "In the usual theory of relativity, only linear orthogonal transformations are allowed."

Or somewhat later, in the same year, he writes:

> "In the original theory of relativity, the independence of the physical equations from the specific choice of the reference system is based on postulating the fundamental invariant $ds^2 = Pdx^{2i}$, whereas now the topic is to build a theory (the theory of Relativity General is implicit), in which the role of the fundamental invariant is performed by a linear element of the general form $ds^2 = X_{i,k}\ g_{ik}dx_i dx_k$ ”.

A. Einstein wrote something similar in 1930:

> "In the theory of Special Relativity only coordinate changes (transformations) are allowed that provide the quantity ds^2 (a fundamental invariant) in the new coordinates that are in

> the form of the sum of the differential squares of the new coordinates. Such transformations are called Lorentz transformations".

Thus, it is seen that the approach taken by A. Einstein did not lead him to the notion of spacetime exhibiting pseudo-Euclidean geometry. A comparison of H. Poincaré and A. Einstein's approaches with the SRT construct clearly reveals that H. Poincaré's approach is deeper and more general, since precisely H. Poincaré had defined the pseudo-Euclidean structure of spacetime. A. Einstein's approach essentially restricted the limits of the SRT, but since the SRT exposition in the literature generally followed A. Einstein, the SRT was long considered valid only in inertial reference systems. Minkowski's space was treated as a useful geometric interpretation or as a mathematical formulation of SRT principles within Einstein's approach. Let us now turn to gravity. In 1905, H. Poincaré wrote:

> "... that forces of any origin, for example, the forces of gravity, behave in the case of uniform motion (or, if you wish, under Lorentz transformations) precisely like electromagnetic forces."

This is precisely the path we will follow. A. Einstein, having noted the equality of inertial and gravitational masses, was convinced that inertial and gravity forces are related, since their action is independent of the mass of a body. In 1913 he concluded that, if in the expression (α)

> "... we introduce new coordinates x_1, x_2, x_3, x_4, with the help of an arbitrary substitution, then the movement of a point relative to the new frame of reference will proceed according to the equation
>
> $\delta \{Zds\} = 0$, y $ds^2 = X_{\mu,\nu}\, g_{\mu\nu} dx_\mu dx_\nu$"

and further noted:

> "The movement of a material point in the new reference system is determined by the quantities $g_{\mu\nu}$, which according to the previous paragraphs must be understood as the components of the gravitational field, as soon as we decide to consider this new system as at rest."

Identifying in this way the metric field, obtained from (α) with the help of coordinate transformations, and the gravitational field is without physical foundation, since the coordinate transformations do not take us beyond the framework of pseudo-Euclidean geometry. From our point of view, it is not allowed to consider a metric field as the gravitational field, since this contradicts the very essence of the field concept as physical reality. Therefore, it is impossible to agree with the following reasoning by A. Einstein:

> "The gravitational field" exists "with respect to system K 'in the same sense as any other physical quantity that can be defined in a given frame of reference, even though it does not exist in system K. There is nothing strange here, and it can be easily demonstrated with the following example taken from classical mechanics. No one doubts the "reality" of kinetic energy, since otherwise it would be necessary to give up energy in general. However, it is clear that the kinetic energy of the bodies depends on the state of movement of the reference system: by an appropriate choice of the latter it is obviously possible to provide the kinetic energy of the uniform movement of a given body to assume, at a certain

moment, a positive or zero value set in advance. In the special case, when all masses have equal value and equally oriented velocities, it is possible, by appropriate choice of the reference system, to make the total kinetic energy equal to zero. In my opinion the analogy is complete".

As we see, Einstein gave up the concept of the classical field, like the Faraday-Maxwell field that has energy-impulse density, in relation to the gravitational field. Precisely this path led him to the construction of GTR, to the gravitational energy that is not localizable, to the introduction of the pseudo tensor of the gravitational field. If the gravitational field is considered a physical field, then, like all other physical fields, it is characterized by the energy-impulse tensor $t_{\mu\nu}$. If in some frame of reference, for example, K ', there is a gravitational field, this means that certain components (or all of them) of the tensor $t_{\mu\nu}$ differ from zero. The tensor $t_{\mu\nu}$ cannot be reduced to zero by a coordinate transformation, that is, if there is a gravitational field, then it represents a physical reality, and it cannot be annihilated by a choice of the reference system. It is not correct to compare such a gravitational field with kinetic energy, since the latter is not characterized by a covariant quantity. It should be noted that such a comparison is not admissible, also, in GTR, since the gravitational field in this theory is characterized by the Riemann curvature tensor. If it differs from zero, then the gravitational field exists, and cannot be annihilated by a choice of reference system, even locally" (Logunov, 2002).

"At the beginning of the century, H. Poincaré wrote in his book" Science and hypotheses "that:

> "Experience plays a necessary role in the origin of geometry, but it would be a mistake to conclude that geometry, at least partially, is an experimental science. If it were experimental, it would have only a temporal, approximate, and very approximate meaning."

Then he continued:

> "Geometry studies are only particular <<groups>> of displacements, but the general notion of group exists first in our minds, at least in the form of possibility."

> "Under this choice, the experiment gives us a direction, but does not make it mandatory; it shows which geometry is more convenient for us rather than which geometry is the most correct."

If we follow this stream of Poincaré thoughts, then guided by fundamental physical principles such as the conservation laws of energy-momentum and angular momentum, we must use the pseudo-Euclidean geometry of spacetime as a basis. This choice is not only convenient, but truly unique up to the moment that conservation laws are enforced. In 1921, A. Einstein wrote in his book "Geometry and Experiment":

> "The question of whether this continuum has Euclidean, Riemannian, or any other structure is a physical question and the answer may be given by experiment, rather than by choice agreement on the basis of pure convenience."

In principle, it is true, however, a question arises: what experimental facts are needed for us to characterize geometry unambiguously? In our opinion, the fundamental laws of conservation of energy-momentum and angular momentum can be taken as such, since they reflect general dynamic properties of matter. This brings us to the pseudo-Euclidean geometry of spacetime, as the simplest.

Therefore, in establishing the structure of spacetime geometry, one should naturally proceed from the fundamental physical principles obtained through the generalization of numerous experimental data, relating to different forms of matter, rather than from particular experimental facts (for example, light and motion of test bodies).

Minkowski space has a profound physical meaning, since it defines the universal properties of matter, such as energy, momentum and angular momentum" (Logunov and Mestvirishvili, 1989).

However, solved Einstein's problem in Entwurf theory by Logunov was not completely solved What is gravity? Logunov did not altogether break with Einstein-Hilbert by incorporating the principle of geometrization as a secondary cause although the graviton as the primary cause of gravity, separated by the author as the intrinsic cause, since the principle of geometrization should not have been applied without understand the role played by the medium through which celestial mechanics occurs, that neither as regards the electromagnetic wave nor matter move in space as such, as is the general belief, but in the space of the quantum vacuum which is curved by its gravitational interaction with the great mass structures of the cosmos and it is the curvature of the quantum vacuum that apart from what the graviton has already done to it, ends up forcing energy-matter to finish moving. Nor, it was answered What is spacetime? Since Logunov was philosophically caught in the Substantialism - Relationism dilemma according to his statement:

"Minkowski's space cannot be considered as existing a priori because it reflects the properties of matter and, therefore, is indispensable from there. Although formally, only due to the independence of the space of the forms of matter, sometimes it is treated abstractly, forgetting matter" (Logunov, 2002).

7. Quantum spacetime and quantum gravity.

With the aim of unifying General Relativity with the theory of the quantum field [67], quantum gravity has been formulated, which seeks to describe everything [68] in the Universe in terms of the quantum field, yet the Universe as a quantum system [Page 1, 49].

Quantum gravity is associated with the Planck scale since its explicit quantum-mechanical effects are confined to it. This scale, in mks, has 1.61 10^{-35} meter long and 5.36 10^{-44} second time unit [Page 58, 20] [69].

Quantum gravity, similar to General Relativity, has a space-temporal description but in exchange for causality (total determinism) it obeys to relations of indetermination [Page 368, 50]. These were introduced, in 1927, by Werner Heisenberg, as a basic law of all physics on the Planck scale, in which the parameter values, which naturally and structurally represent the static and the dynamic (canonically conjugated), fulfill that its product is equal to or greater than Planck's constant h, which is the "quantum of action". These parameters are pairs, composed of a term that indicates a spatial or temporal location, and another term that indicates a dynamic or energetic state, and whose product has the physical dimension of "action". This is defined as a length, that is, a spatial extension, multiplied by the impulse, so it represents a dynamic state. On the other hand, the physical dimension of the "action" is defined as the product of a time interval and the corresponding energy value. [Page 369, 50]. Thus, quantum physics encompasses the two aspects in an inseparable unit: the static (location in space) and the dynamic (spacetime motion). Therefore, there is a link between the parameters of space-temporal locations and the dynamic-energetic parameters (impulse and energy states), so that the more one term of the relational is accentuated, the more the other term is diluted, complementary to the first, and vice versa [Page 374, 50].

Quantum theory does not discuss the principle of real determination, by laws and causes, but the space-temporal description that is no longer deterministic. According to Heisenberg, it is not a "crisis of causality", but it is replaced by a "non-space-temporal mathematical scheme". The consequence is that determination ceases to be a total and universal determinism. [Pages 370-371, 50]. On the other hand, even if all the data of a current state of the world were known, which is not possible, by Heisenberg's uncertainty relations, however, future states could not be calculated as certain facts, but only as trends more or less likely. Therefore, the clear distinction between future and past, which did not exist in classical physics, is introduced into the dimension of time: the future is the time of the future, of the possibilities and probabilities that can still be modified and altered; while the past is the past tense, time of the consummated and definitively determined facts [Pages 380-381, 50] [70]. On the other hand, while presentism is incompatible with Special and General Relativity, it is not incompatible with Quantum Gravity, provided that it is based on a fixed background, which occurs in some of its theories [Pag 1, 52] and the Universe is conceived as three-dimensional, although, changing in time, as a consequence of the fact that change is a fundamental aspect of reality [Pag 2, 52].

Currently, in quantum physics, the vast majority of physicists follow the line of the Copenhagen School, whose main representatives are Niels Bohr and Werner Heisenberg. The experimental basis is the dual nature of light and matter. That is, both the electromagnetic field and the material field manifest in two different or irreducible aspects or forms: the wave aspect and the corpuscular aspect [Pages 377-378, 50].

Regarding quantum gravity, its fundamental objective is to unify Quantum Physics (Quantum Mechanics-Special Relativity) with General Relativity [Pag 1, 53], by describing the gravitational interaction of matter-energy under Quantum Theory Relativistic Fields (TCCR).

TCCR covers the domain between the scales of the atom and Planck and is based on the Standard Model of Particles that presents the particles that make up matter-energy and the forces, through which interactions take place and the fundamental processes of nature occur.

The particles of the Standard Model of Particles are assumed as points (0 dimensional) with spin, in a four-dimensional spacetime. Particles over time move in space along the lines of the World [Page 1, 54] [71].

TCCR explains matter from fermions, which are detectable particles, endowed with mass, have a fractional spin, and are subject to the exclusion principle. TCCR explains the energy and non-gravitational interactions of matter-energy, that is, the weak and strong electromagnetic forces, from the bosons and gluons; which have whole spin, lack mass, and are subject to the superposition principle; except W +, W- and Z0 that have mass. The difference between energy and forces is that the energy particles are detectable (real particles) while the force particles are undetectable (virtual particles) [72].

Quantum gravity explains the gravitational interaction of matter-energy from the virtual graviton, an undetectable particle without mass, it has spin 2 and is subject to the superposition principle, also, it involves the quantization of spacetime. Therefore, in quantum gravity, spacetime is assumed to be discrete in nature, consisting of quanta [73].

In quantum gravity the definition, from General Relativity, of an event as a point in the four-dimensional manifold is meaningless, so the event would be an extended object without structure (field) [Page 53, 58].

In quantum gravity came the term of the fabric of spacetime that makes a race to supposedly resolve its nature. Among other theories, in Abhay Ashtekar (Institute of Gravitational Physics and Geometry, Pennsylvania State Univ., 1985) and others formulated the fabric of spacetime “as a network of links that carry quantum information about areas and volumes. These links can close on themselves by forming loops (which have nothing to do with the "strings" of string theory). Loops are quantum and define a minimum unit of area (the unit of area on the Planck scale) in a similar way to how quantum mechanics applied to a hydrogen atom defines a state of minimum energy for its electron. This unit of area cannot be curved too much so that curvature singularities such as those predicted by Einstein gravity inside black holes or in the Big Bang cannot be produced” (Francis, 2013). Rafael Sorkin (Perimeter Institute, Waterloo, Canada, 1987) and others proposed the random sets which "are mathematical points connected by causal links, connecting past with future" (Francis, 2013).

7.1. Quantum facts about vacuum and motion established on an experimental basis.

The characteristics and properties of spacetime on the quantum scale are closely linked to the physics of the quantum vacuum, which is full of fields of all kinds, free of their sources, which behave like infinite collections of harmonic oscillators in ground state, which is that of lower energy, but due to the uncertainty principle they fluctuate randomly [Page 62-63, 20] [74].

Quantum vacuum is the smallest possible state of energy in a given field. Also, that of overlapping fields. Composed of virtual particles and absent of real particles [75].

In the absence of any gravitational field, on average the energy of a certain field (generally considered the electromagnetic field) is zero, however, the field has a residual energy known as zero point energy (ZPF) [76].

Quantum field theory has two formulations: Quantum electrodynamics (QED), which deals with the interactions between the components of matter (basically: electrons and positrons) and photons and Stochastic electrodynamics (SED), which refers to the interactions between the elementary particles and the ZPE. These theories are alternative explanations [77].

Furthermore, from the zero energy vacuum there is another vacuum which is the negative energy vacuum, which is generated by eliminating the electromagnetic waves that appear inside the uniformly accelerated or gravitational reference systems [Page 62, 20], which they are assumed due to the principle of equivalence between the uniform accelerated system and the gravitational system of General Relativity [78].

As a consequence, in the quantum vacuum the principle of relativity of motion is valid, but the principle of equivalence between an inertial system and another uniform accelerated is not valid, therefore, an observer cannot determine its speed by means of the oscillations of the quantum vacuum, that is to say cannot establish absolute motion, but you can determine if it is inertial or accelerated, depending on whether or not electromagnetic waves appear [Page 63, 20].

Gravity cannot be a property of spacetime curvature, as General Relativity maintains, that due to its general covariance, there cannot be privileged observers, so the total energy-momentum tensor, T_{uv}, (including the contribution of the gravitational field g) has to be identically null and ensures with respect to an observer the existence of an energy balance between the flow associated with matter ϕ (content in T_{uv}) and that associated with the gravitational field g (content in - $(c^4/8\pi G)\ G_{uv}$) in such a way that both flows are canceled [Page 70, 65] [79].

7.2 Quantum forecasts about spacetime

On the Planck scale, the geometry of spacetime would be subject to continuous fluctuations and the distinction between past and present would be blurred [Page 58, 20] [80].

Spacetime would adopt a foamy structure since it churns and foams like a turbulent ocean [Page 1, 67]. Therefore, events may occur in a different temporal order than the present, which is denied when it passes into the past and again when it is directed towards the future. Here irreversible time going in one direction would not count and Boltzmann formulated as the thermodynamic arrow of time [81] based on the second law of thermodynamics, according to which entropy increases in the direction of the future, not the past [Page 58, 20] [82].

The spacetime in the quantum vacuum is not the Minkowski plane, since the absolute vacuum does not exist, and the energy present on the Planck scale does intrinsically curved, that is, the geometric substratum of the inertial structure [83] foreseen by the Special Relativity does not appear. Intrinsically curved spacetime does not produce real particles, although it does emit and annihilate virtual particles [84]. The quantum vacuum brings together virtual particles without mass (such as electromagnetic vacuum, EV, made up of virtual photons), and virtual particles with mass (mass particle vacuum, MPV, made up, for example, of W +, W-, Z0. Thus, Minkowski's spacetime is an approximation in front of the microcosm, although zero energy density must be obtained for the typical vacuum, a necessary condition for it to be consistent with Einstein's Relativity [Page 64, 20].

Spacetime subject to gravity fields and, therefore, curved, on the Planck scale, has retraction with vacuum. With the variation of the curvature, there is the probability that the vacuum is excited, that is, the oscillator passes from the ground state to another excited state, and real particles appear randomly, whose energy comes from the spacetime itself, in direct proportion to the curvature and the speed with which its change occurs [Page 65, 20], which converts the curvature, gravitational field, into a quantum object, that is, it is quantified in real gravitons (dynamic gravitational field), the same as the spacetime, although it is strictly quantified quanta of spacetime, whereby the gravitational field and spacetime become two different realities, one physical and the other geometric [85].

If spacetime is quantified it ceases to be the continuum of General Relativity. And the quantum effect of the gravitational field ceases to be a geometric property of the curvature of spacetime and becomes material. This contradiction dissolves if spacetime is quantified in the virtual graviton as long as it was a geometric object. This is the unification strategy that is currently followed by the forces of the Standard Model of Particles and gravity on the quantum scale.

7.3. Quantum theories of gravity.

The two main existing theories of quantum gravity are: Superstring M, the most widely accepted, and Loop quantum gravity (LQG). In these theories, the particles of the Standard Model de Particles stop being points and are replaced by vibrant nodes of a geometric nature, since these theories are widely recognized as geometric [86].

These theories of quantum gravity keep the dispute between Substantialism and Relationism. Superstring M is substantialists while Loop quantum gravity is relationist [87].

Although superstring M has sought to formulate it as a relationist, its bases are clearly substantialists. ¨The idea is that M theory, if it exists, would be background-independent and have all the different background-dependent string theories as different solutions to it¨ [Page 6, 8] [88]. And, despite the fact that M has been able to include the dynamic metric space, this does not mean that it is no longer considered Substantialists, since with sophisticated Substantialism, background-independent is no longer a unique feature of Relationism, although it does not admit background-dependent.

Despite the favoritism enjoyed by the M theory, with the discovery, in 1998, of the existence of dark energy, it is Loop Quantum Gravity that incorporates it well while M does not [89].

7.3.1. Theory M.

M conserves, on scales higher than Planck's, the spacetime (M, g_{uv}) of General Relativity, although, quantized and the event turned into an extended object (field) without structure.

In M theory, spacetime (M, g_{uv}) constitutes the "brane", which is a discontinuous geometric object, with 3 spatial dimensions and 1 of time. The "brane" would be embedded in the "bulk", which is an extra space, which does not exist in General Relativity, of d dimensions (six or seven dimensions). The ¨bulk¨ exists on the Planck scale and is not accessible.

The metric space of the "brane" was initially Minkowski's static of Special Relativity (η_{ij},) and nowadays it is the dynamic of General Relativity (g_{uv}), therefore, background-independent, in the geometric sense.

Unlike General Relativity, which has a single "brane", there can be several "branes" in M.

M, based on string theory, explains ¨all particles and forces arise from the vibrations of extended objects. These include one-dimensional objects (hence the name "strings") [Page 4, 8]. A rope is a small loop of discrete irregularity of the "brane", a small discrete defect in spacetime that forms a rope. It is under tension and vibrates, like an ordinary string, in an infinite number of ways¨ [Pag 1, 54] [90].

M replaces the particles of the Standard Model of Particles with the vibrations of the open strings that can only be propagated in the "brane". Only the vibrations of the closed strings (graviton) propagate in the "brane" and in the "bulk".

Bosonic particles are different modes of vibration of open strings. These modes of vibration are characterized by various quantum numbers such as mass, spin etc.

The gravitational interaction is caused by the modes of vibrating, of the closed strings, which correspond to the virtual graviton, which carries the force of gravity.

To include all of the fermion-boson particles, supersymmetry is required, which is the symmetry that can interchange semi-integer spin particles, such as electrons and quarks, with integer spin particles, such as photons, gravitons, and W particles [Pag 1, 73] [91].

The particles of the Standard Model of Particles (because they are open string excitations) would exist confined to the surface of the "branes" while the graviton (because they are closed string excitations) would be the only one that would also exist in the "bulk". The fact that the graviton scatters, also, in the ¨bulk¨ would be the cause of the weakness of the force of gravity [92].

M is a theory that explains the origin of the strings and unifies the five existing superstring theories, which are ¨background-dependent¨, and are based on different symmetries, with names like E(8)xE(8) and O(32) [Pag 1, 73].

The five superstring theories (type I, type IIA, type IIB, HE and HO) are different aspects of M, defined as their different limits in 10 dimensions, since these five theories are equivalent. ¨M-theory is described at low energies by an effective theory called 11-dimensional supergravity¨ [Pag 7, 74].

M in explaining matter-energy from spacetime and being space geometric implies that the origin of matter-energy is geometric.

M has given rise to various proposals from "braneworlds" depending on the number of "branes" and the structure of the "brane" such as, for example, the two "brane" that would be: a "brane" embedded at each end of the "Bulk", thereby doubling (M, g_{uv}) of General Relativity. This model is quite popular. The proposed "braneworlds" seek to offer the best explanation of the observed Universe, under the perspective of a geometric theory of the whole and of the totality of the known cosmological physical phenomena (Big-Bang, black holes, matter and dark energy, etc.).

String theory has led to the formulation that still has very little credibility and is, rather, considered fiction of the parallel and multiple Universes.

7.3.2. The theory "Loop quantum gravity" (LQG).

LQG removes g_{uv} from (M, g_{uv}) from General Relativity. Therefore, the manifold (M) remains devoid of the background metric space, whereby the quantum spacetime is at the fundamental level [93].

LQG assumes the spacetime, the manifold (M), of discrete composition, since “there exists an elementary minimum volume size, (about 10^{-35} m) and an “elementary minimum time step (about 10^{-43} s)” [p. 7, 77] [94].

Therefore, in LQG the texture of spacetime is “a network of some minimal elements called spins” [Page 7, 77], one-dimensional loops, or preons with length and width [95]. Particles become states "of these spins, not being something different from space itself" [Page 7, 77], without the need for supersymmetry or extra dimensions, although, if required, they can be incorporated [97].

The geometry of the network is twisted that is defined by graphs that are connections between vertices and edges of the spins, and evolve to new structures. "On the other hand, since the connections in a graph can be very complicated, depending on the type of ties that are built between the edges that join two vertices, this diversity of ties gives rise to the different families of elementary particles" [Page 1, 79]. “The ties are knotted together with the formation of edges, surfaces and vertices, just like the soap bubbles assembling together. That is, the spacetime itself is quantized. Splitting a tie, if successful, forms two ties, each with the original size” [Page 1, 79]. Thus, the particles are the braids tangled differently in spacetime, which would then be the source of matter and energy. And since spacetime is geometric, then matter-energy is, in the first instance, geometry.

However, because the network changes everywhere at every moment, it requires a structure-mechanism of quantum superposition that gives persistence to the particles. This would be analogous to "qubit [97]", which at the same moment can be in two states. In LQG each quantum of space is replaced by something analogous to a "qubit". The calculations show that the "qubit" resistance would preserve quantum braids in spacetime, and explains how particles can have a very long lifespan in the midst of quantum turbulence [Page 1,79].

LQG is a ¨background-independent¨ theory [Page 5, 8] and Carlos Rovelli has introductorily reformulated quantum mechanics, from the relational perspective [Page 3, 41] [98]. Indeed, in LQG, with the inclusion of the invariance of dipheomorphism, the relational notion of spacetime has been adopted in the Quantum Field Relativistic theory [99].

LQG, since 1998, has acquired relevance for being able to incorporate dark energy, of recent discovery [100].

7.4. Notes.

[67] Unification of Special Relativity with Quantum Mechanics.

[68] All particles transport energy and gravitational, electromagnetic, weak and strong forces.

[69] ¨Planck’s units are to represent the physical scale of things relevant to a theory of quantum gravity, or at which processes relevant to such a theory occur¨ [Page 4, 51].

[70] The law of entropy, the second principle of thermodynamics, known before quantum theory, goes in the same direction. [Page 381, 50].

[71] Actually, particles with mass at rest possess volume and, therefore, are three-dimensional, as verified by the first photograph of the electron obtained and published in Nature. Jonathan Underwood, a physicist, regarding the technique used, said ¨allows physicists to record a three-dimensional image of the orbitals of electrons in molecules¨ [Page 1, 55]. “Quantizing fields leads to a description of arbitrarily many identical particles, bosons or fermions (in three spatial dimensions). [Pag 6, 56]. Therefore, the Standard Model is a simplification of reality. And ¨Relativistic Quantum Field Theory is a mathematical scheme to describe the sub-atomic particles and forces¨ [Pag 2, 57].

[72] The author finds TCCR weak with respect to gluon, which should have a long range since it lacks mass and to bosons with mass that must be subject to the exclusion principle and thus should not act as the quanta of the weak force.

[73] ¨At the Planck scale. The most surprising aspect of this picture is that on that scale, space is not continuous but made up of discrete elements. There is a smallest unit of space: Its minimum volume is given roughly by the cube of the Planck length [Page 3, 51].

[74] “The vacuum is not empty. The vacuum state –defined as the ground state of the system- is alive with the oscillations of all the virtual particles of the Universe” “When it is left undisturbed, the system in its ground state does show any signs of life; the vacuum state remains the vacuum state. Every perturbation, however, produces excitations of the system” [Page 1, 59]. “The quantum vacuum may in certain circumstances be regarded as a type of fluid medium, or ether, exhibiting energy density, pressure, stress and friction. Vacuum friction may be thought of as being responsible for the spontaneous creation of particles from the vacuum state when the system is non-stationary” [Page 1, 60].

[75] “In the same way that in quantum mechanics it is impossible for a particle to have zero values of both the coordinate and the momentum, also in Quantum Field Theory it is impossible to find a state in which there are simultaneously no photons and no quantized electromagnetic field (virtual photons) or electrons and no electron-positron current. There is never a truly “empty” vacuum state” [Page 10, 16]. "Empty space has been replaced with that of a vacuum state, defined to be the ground (lowest energy density) state of a collection of quantum fields." [Page 1, 81].

[76] “A peculiar and truly quantum mechanical feature of the quantum fields is that they exhibit zero-point fluctuations everywhere in space, even in regions which are otherwise empty (i.e. devoid of matter and radiation).” [Page 1, 61]. "This electromagnetic field, which is always present even if no matter or charged particles are present and the temperature is absolute zero, represents the lowest state of the electromagnetic field." ¨The zero-point field is the ground state of the electromagnetic field. ¨ ¨Sometimes the zero-point field, ZPE, is described as consisting of virtual or very short-lived photons.¨ ¨The presence of zero-point fluctuations has been verified experimentally with very accurate measurements of the Lamb Shift, other atomic energy level shifts, the magnetic moment of the electron, and the Casimir force .¨ [Page 1, 62].

[77] “The QED approach originated with Planck's first theory in 1901 in which he made an assumption. This assumption was that charged point particle oscillators had energy which came in discontinuous units. There was no physical reason why, but the assumption gave results which agreed with experiment” “Planck published his second theory in 1911. This achieved exactly the same results as the first theory, but there was a physical reason for these results - namely the existence of the Zero Point Energy (ZPE), which was positively established in 1925 by Mulliken's experiments. The ZPE was thereby the root cause of quantum phenomena. Historically, we know that physicists who followed Planck's second paper developed the SED approach” “The ZPE is therefore an integral part of both QED and SED physics. For the moment, let us follow SED physics which considers the vacuum at the atomic or sub-atomic level to inherently contain the turbulent sea of randomly fluctuating electro-magnetic fields or waves of the ZPE. These waves exist at all wavelengths longer than the Planck length cutoff, the vacuum itself breaks up and becomes granular” [Page 7, 63]. “QED requires the vacuum to be filled with virtual particle pairs flipping in

and out of existence like a sort of quantum foam. Indeed, virtual photons also pop in and out of existence as they are emitted and then absorbed by various particle processes. The QED approach assigns much of the vacuum energy density to these virtual particles. Because of this incessant activity on the atomic scale, the vacuum has been described as a “seething sea of activity”, or “the seething vacuum. SED approach inevitably requires virtual particles to exist also” [Page 11, 63].

[78] ¨Haisch, Rueda and Puthoff (1994) argued that the elementary constituents of matter, such as electrons and quarks, when accelerating through the electromagnetic zero-point field, experience a Lorentz-type force. This force acts against the acceleration¨ [Page 5, 64].

[79] Rueda and Haisch (1998) reiterated that inertia is a kind of electromagnetic drag that affects charged particles undergoing acceleration through the (electromagnetic) ZPF, and connected this again to the existence of a gravity-like force as originally envisioned by Sakharov (1968)¨ [Page 8, 64].

[80] ¨Reversibility in time is required if we wish to see a quantum superposition principle norm of all states is then preserved ¨ [Page 2, 66]. However, in black holes: ¨At first sight they render time reversibility impossible¨ [Page 2, 66].

[81] Earlier Eddington had used the term arrow to characterize the directionality of time.

[82] Experience establishes that, in isolated systems, the entropy never decreases spontaneously (the system has less disorder), which is not because theoretically it is not possible since all the physical equations within physics Classical, they are symmetrical with respect to time but because in reality it is highly improbable. On the other hand, cosmology based on the Big-Bang principle establishes that the Universe is in expansion that determines the "cosmological arrow of time". This principle of the arrow of time is valid for matter whose constituent particles are subject to exclusion while in energy and in forces not since they are subject to superposition.

[83] As consequence, the author deduces the model (T, M, g). This intrinsic curvature would lack, in terms of the macrocosm, of importance and is different from the curvature of spacetime generated extrinsically by the mass-energy of the bodies according to the model (M, g, T) that corresponds to the Macrocosm.

[84] “The quantum vacuum consists of virtual particles randomly appearing and disappearing in free space” “The quantum vacuum is an everchanging collection of virtual particles which disappear after their short lifetime Δt to be replaced by new virtual particles that suffer the same fate, the process continuing ad infinitum” [Page 1, 68].

[85]. “If the field is non-stationary, this dramatically changes the physics described above, in particular rapid changes in the external field (or boundary) can lead to the important phenomenon of particle production from the quantum vacuum. The variation in time of the external field perturbs the zero points modes of the vacuum and drives the production of particles. These are generically produced in pairs because of conservation of momentum and also of other quantum numbers (e.g. in the case of production of fermions, the pairs will actually be particle-antiparticle pairs)” [Page 21, 16].

[86] ¨The first road is the road of string theory, which seeks progress through the geometric concepts of strings, membranes, deca- and Endeca dimensional metric spacetimes, etc. [Page 42, 69]. "String theory does not find fault with its thoroughly geometric character" [Page 44, 69]. The second road is the road of loop quantum gravity, which seeks progress through the geometric concepts of loops of space, spin networks, spin foams, etc.¨ [Page 43, 69]. Loop quantum gravity as a straightforward quantum theory of geometry. [P. 45, 69].

[87] ¨Much of the argument between string and loop theorists is a continuation of this debate" [Page 5, 8].

[88] ¨Many string theorists now say that the main problem in string theory is to find M theory and give string theory a background-independent form. But the funny thing is that not many string theorists have tried to work on this problem. The problem is that all their intuition and tools are based on background-dependent theories¨ [Page 6, 8].

[89] ¨The discovery over the last couple of years that most of the energy in the Universe is in a form that Einstein called the cosmological constant. The cosmological constant can be interpreted as indicating that empty space has a certain intrinsic energy density. This is a hard thing to believe in, but the cosmological data cannot now be explained convincingly unless one assumes that most of the energy of the Universe is in this form. The problem is that string theory seems to be incompatible with a world in which a cosmological constant has a positive sign, which is what the observations indicate. This is a problem that string theorists are thinking and worrying very hard about. They are resourceful people, and maybe they'll solve it; but as things stand at the moment, string theory appears to be incompatible with that observation¨ [Page 6, 8].

[90] ¨Strings can be open or closed, and have a characteristic tension and hence vibrational spectrum. ¨ [Page 1, 70]. ´As the string moves through time it traces out a tube or a sheet, according to whether it is closed or open´ [Page 1, 71].

[91] ¨In order to include fermions in string theory, there must be a special kind of symmetry called supersymmetry, which means for every boson there is a corresponding fermion. So, supersymmetry relates the particles that transmit forces to the particles that make up matter¨ [Pag 1, 72]. ¨enhancement of the symmetries of the Standard Model: supersymmetry. This symmetry, which puts fermions and bosons into single multiplets¨ [Pag 65, 57]. ¨These symmetries tie together particles usually considered constituents of matter (like quarks and electrons) with the quanta of forces (like photons and gluons) ¨ [Pag 5, 8].

[92] The observable Universe could be a 1 + 3-surface (the "brane") embedded in a 1 + 3 + d dimensional spacetime (the "bulk"), with Standard Model particles and fields trapped on the brane while gravity is free to access the bulk.¨ [Pag 1, 75]. ¨open strings, which describe the non-gravitational sector, are attached at their endpoints to branes, while the closed strings of the gravitational sector can move freely in the bulk. Classically, this is performed via the localization of matter and radiation fields on the brane, with gravity propagating in the bulk. "We understand the weakness of gravity as due to the fact that it" spreads "into extra dimensions and only a part of it is felt in 4 dimensions. [Pag 6, 75].

[93] ``In loop quantum gravity we assume that the identification between the gravitational field and the metric-causal structure of spacetime holds, and must be taken into account, in the quantum

regime as well. Thus, no split of the metric is made, and there is no background metric on spacetime. We can still describe spacetime as a (differentiable) manifold (a space without metric structure), over which quantum fields are defined. A classical metric structure will then be defined by expectation values of the gravitational field operator. Thus, the problem of quantum gravity is the problem of understanding what is a quantum field theory on a manifold, as opposed to quantum field theory on a metric space '[Page 19, 76].

[94] "Spacetime also turns out to be discrete, described by a structure called a spin foam." [Pag 4, 8].

[95] "A network of abstract links connecting these volumes of space", "these links could curl over each other to form braid-like structures". “At every moment, quantum fluctuations crumple the network of spacetime links, squeezing them into a jumble of ups and downs. These structures are so ephemeral that they last approximately 10^{-44} seconds before transforming into a new configuration” [Page 1, 78].

[96] "Space only has three dimensions and there is no supersymmetry" [Pag 5, 8]. "If the world does have higher dimensions and supersymmetry, that could be incorporated into loop quantum gravity" [Pag 5, 8].

[97] The "qubit" is a computer technology product, which constitutes the storage unit of the physical memory of quantum computers and can be both in the two binary states (0 and 1). The "qubit" replaces the "bit" of digital computers, which can only be in one state (0 or 1). "A qubit is a linear superposition of the logical states 0 and 1." [Page 3, 80].

[98] The (active) diffeomorphism invariance of General Relativity - the formal expression of the general covariance of the classical theory, interpreted in Loop Quantum Gravity as a gauge invariance. "Because active diffeomorphism invariance is a gauge, the physical content of [general relativity] is expressed only by those quantities, derived from the basic dynamical variables, which are fully independent from the points of the manifold." (Rovelli, 2001). [Pag 8, 30].

[99] ¨In order to take Einstein's principle of background independence seriously one must generalize quantum theory. One such generalization which leads to a candidate for a quantum gravity theory is LQG. In LQG, at each instant of time, geometry is concentrated on one dimensional structure, called graphs, which can be arbitrarily complicated. A graph is simply a network of one dimensional, oriented line which is linked together at their end points to form a kind of mesh¨ [Pag 1, 38]. `We define quantum states that correspond to loop-like excitations of the gravitational field, but then, when factoring away diffeomorphism invariance, the location of the loop becomes irrelevant. The only remaining information contained in the loop is then its knotting (a knot is a loop up to its location). Thus, diffeomorphism invariant physical states are labeled by knots. A knot represents an elementary quantum excitation of space. It is not here or there, since it is the space with respect to which here and there can be defined. A knot state is an elementary quantum of space '[Pag 21, 76].

[100] Loop quantum gravity incorporates a positive cosmological constant extremely well. [Pag 6, 8]

8. Spacetime a phase of matter.

In the 'spacetime-mass' theory of Lizandro Reyna, Frank Ghassemi and Julian F. Sparrow of Sacred Earth University, presented to the American Physical Society in Long Beach, California in April, 2000, San Francisco (1989), Washington DC (1990), and Columbus, Ohio (1998), it is argued that spacetime is really a phase of matter, with a mass equivalent, thus representing a gigantic amount of mass and gravitation. Thus, all matter in the Universe floats in the fluid of spacetime and, at the same time, matter is being transformed into spacetime [Page 1, 81].

This theory maintains that the disintegration of the Proton and other elementary particles, without being able to detect its transformation into energy and / or other particles, thereby violating the principle of field-matter conservation, actually transform into spacetime [101].

The authors of the 'spacetime-mass' theory state that because empty space does not exist, therefore, space and mass (mass-energy) are the same, which is reciprocal in that the mass is space, but at the same time mass and space are different [102].

How can the contradiction of mass-space occur, simultaneously the same and different? Well, the spacetime-mass theory is substantialist, therefore, it is ¨background-dependent¨. In other words, the answer is based on another contradiction: empty space as topological space [103], container if it exists.

How can the contradiction of mass-space occur, simultaneously the same and different? Well, the spacetime-mass theory is substantialist, therefore, it is ¨background-dependent¨. In other words, the answer is based on another contradiction: empty space as topological space [103], container if it exists.

The container spacetime is made of curved geometric particles that serve as a container for the particles of energy, forces and matter [104]. The specificity of this theory, spacetime-mass, is that geometric particles are the lowest state of existence for particles with mass. Consequently, the mass-energy is transformed into geometric particles and vice versa. And the container spacetime is a phase of matter.

8.1. Notes.

[101] “As it is well known, GUTs are theories that explicitly violate conservation of baryon number, allowing the interesting new possibility of proton decay. According to the Ghassemi’s theory when the proton decays, it melts in space - time” [Pag 1, [82].

[102] “It is impossible to talk of a mathematical empty space in physics. From this statement it must be inferred that mass and space are to be the same. But space and time are inherent from special relativity, then we would have spacetime-mass” “At this step arise the question, how spacetime is to be mass and reciprocally?” [Pag 1, [82].

[103] “To answer this question, it is necessary to give some structure to spacetime and being so I set up the following hypothesis: There are only two kinds of elementary particles being the building blocks of spacetime: The first one , whose topological structure has positive gaussian curvature and the second one whose topological structure has negative gaussian curvature. According to this, from such building blocks matter is to be made. Say, if we take a container and remove everything from

inside it - every atom, every photon - there will be the topological particles postulated above. If we want to remove such topological particles, it will be impossible since they define the structure of spacetime itself. It will only be possible to shrink or stretch via compactification or decompactification processes. There are no gaps between our topological particles since it is assumed that it is impossible to talk of a mathematical empty space in physics" [Page 1, 82].

[104] "Spacetime (filled with topological particles) and particles with virtual masses and ordinary masses all them inside our space - time - mass" [Page 1, 82]. "Topological particles from which matter is to be created fill the spacetime and are to be the building blocks of spacetime" [Page 1, 82].

9. The intrinsic spacetime dimensions of matter-field.

The author exposes his own vision about matter-field and spacetime based on current knowledge, his various works and on the RTG of Logunov and his team of scientists.

The Universe is dynamic matter-field [105]. However, matter-field as a philosophical category is Matter for being objective in that they exist independently of consciousness.

Matter-field always exists in the wave-particle structure. Matter with mass at rest, subject to the principle of exclusion and the field without mass at rest, subject to the principle of superposition. However, the weak field is made up of bosons with mass at rest; therefore, this field is one of transition between them.

The structure of energy-matter and vacuum is based on the standard model of particles, still in development, originated, between 1970 and 1973, from a relativistic theory of quantum fields, in the framework of symmetries and the unification of interactions of the weak, strong and electromagnetic forces, the gravitational pending, due to the geometric character that General Relativity gives it, although, trying to incorporate it.

Matter and fields are the two forms of material existence among which there is transformability, since matter can become a field and vice versa, except with the metric-geometric field of gravity, of General Relativity, for which we must reject it and replace it with the gravitational field of the RTG, which like all other fields is material, since it has impulse-energy and obeys the fundamental law of the nature of conservation of impulse-energy.

The gravitational field of General Relativity differs fundamentally from RTG, since it is not an energy distribution but a metric distribution, nor a transmitter of gravitational interaction, but rather a curvature of spacetime, neither real but geometrodynamic.

For his part, the author differs from RTG, which despite being a Gaussian theory, includes the curvature of spacetime, as an intrinsic partial cause of gravity, which would help explain celestial mechanics and other phenomena such as the deflection of the electromagnetic wave, partially the Shapiro delay, the effect of gravitational lenses, etc., of astronomical order. The author totally excludes spacetime as a factor of gravity. For the author, absolutely every material being has spacetime, since it is its intrinsic structural geometric property [Pages 8-9, 112], [Page 2, 113], and because it is material, vacuum is not excepted. Then, the spacetime of the interstellar vacuum curves due to the fact that the quantum vacuum, when it gravitationally interacts with the large massive stellar structures, the vacuum curves, in such a magnitude that it produces effects in celestial mechanics, which are manifested as effects of the curvature of spacetime falsely assumed to exist in itself [Page 9, 114], [Page 3, 115].

9.1. Matter.

Matter is characterized in that all its structures are aggregations, organized in discontinuous objects, of fermionic particles, that is, particles with mass, which can be measured in their relative state of rest. Fermions are composed of:

- Hadrons are particles made up of the elementary particles of six types of quarks. There are two kinds of hadrons: the baryons made up of three quarks that are the positively charged proton and the uncharged neutron. And the mesons made up of a quark and an anti-quark, therefore, of very short existence.

- Leptons are elementary particles, which are differentiated by their mass, with a negative charge on the electron, muon and tauon. And without charge the electron neutrino, muon neutrino and tauón neutrino.

The most relevant structures of matter, at the level of the microcosm, are free particles in quasi-empty regions, plasma, molecules and Einstein-Bose condensation. Within the molecular structures are: gas, liquid and solid.

Matter has three essential properties: spin, mass, and charge. Matter has inertia, density, conductivity, phase transition points between states and shape when it becomes in the field. The phase or shape changes occur without changes in identity or properties; therefore, no new substances are produced, except in nuclear, that is, non-chemical transformations, in which other elements can appear from a radioactive element.

The component particles of matter are usually in mechanical motion, except at 0 Kelvin absolute when they remain at rest. In any case, movement occurs in the space belonging to a material state or form, provided by nature as a medium of mechanical movement and, in general, of its becoming. Also, as bodies in the structures of the macrocosm.

Because matter has volume, for example, "the electron is the most perfect sphere in the Universe, although it also presents a slight distortion due to its electric dipole moment" (Nature, 2011), its movement occurs in spacetime, that is , in four dimensions (x_1, x_2, x_3, t) of an existing medium, which, whenever it is, a state of matter, implies displacements of masses of water or air by the macroscopic mobile; the movement of the cosmic macrostructures of matter such as stars, galaxies, clusters, etc., occurs in the quantum vacuum, as outer space, and frame dragging occurs. The elementary particles move in the quantum vacuum that can be the one inside the fermionic structures, but also in the external quantum vacuum.

9.2. Field.

The quantum field is a distribution of energy, present in each point position of the three-dimensional space of the vacuum as a continuous material medium, that is, where matter does not exist, but the superposition of fields does, and depends or not on time. Such a vacuum can be within the structures of matter or as the interplanetary, interstellar and intergalactic vacuum, in general, in the outer vacuum in the Universe.

The non-time dependent field are static fields: in electromagnetism, the electric and magnetic fields, and in gravity they would be the gravitoelectric field and the gravitomagnetic field (by analogy with electromagnetism). While the time-dependent field is the dynamic, quintessentially wave field, which in electromagnetism is electromagnetic waves and, in gravity, would be gravitational waves. The difference is that while the static field has energy, the dynamic field transports it through waves.

As the static field is continent it is because the field has space and as the dynamic field is subject to propagation the field has spacetime [106].

The field is manifested by forces of interaction, mediated through the field, between the constituent particles of matter (hadrons and leptons that are components of fermions) or within the constituent particles of the field itself (bosons and gluons).

According to quantum theory, the most important material forms of the field are: gravitational, electromagnetic, weak and strong fields. At very high temperature the fields electromagnetic and weak are unified into the electroweak, which must also occur with the strong and gravitational in be a single field not yet achieved in the laboratory but which must occur at maximum density of matter.

The field is manifested by interaction forces on the constituent particles of matter, through elementary particles with spin and without mass or electric charge that are the bosons:

- Higgs that gives part of the mass to the fermions since the rest comes from energy mainly from the gluons.

- gluons of the strong force that remain confined with the quarks in the protons and neutrons and these in the atomic nuclei. But, at very high temperature a plasma of quarks and gluons is produced.

- W +, W-, Z0 bosons of the weak force that produce nuclear decay processes. These are the only ones that have mass.

- photons of the electromagnetic force.

- gravitons of the gravitational force according to RTG.

In the quantum theory of supergravity, by symmetry, anti-bosons such as gluino, photino and gravitino are introduced.

Photons and gravitons can be virtual, because they exist during the period of uncertainty, and not be directly detectable, in static fields or they can be real and detectable, in dynamic fields and with the Higgs boson they make up the external quantum vacuum. In contrast, gluons and bosons W +, W-, Z0, only exist in the inner quantum vacuum in the atom.

Static fields are 3-vectors at each point (x_1, x_2, x_3) in the region of space where forces act. Thus, in the electric field the electric force or Lorentz force acts, in the gravitational field the gravitational force acts, etc.

The electromagnetic dynamic field as it constitutes the propagation, with speed c, invariant for all inertial observers, of the vibration of the normal ortho coupling between the planes of the electric and magnetic fields, is necessarily defined in the 4-dimensional Minkowsky's spacetime (x_1, x_2, x_3, t) [107]. For its part, the gravitational wave, according to RTG, would propagates in the 4-dimensional Lorentz spacetime (x_1, x_2, x_3, t) [108], as the structural geometric property of the vacuum, which curves as a consequence of its gravitational interaction with the macrostructures of matter, on the astronomical scale (author's thesis), which maintains identity with Poincare Minkowski pseudo-Euclidean spacetime, since "all physical phenomena occur in spacetime, whose geometry is pseudo-Euclidean" (Logunov, 1989), and that by introducing the metric tensor $\gamma_{\mu\nu}$ (x) in Minkowski space, therefore, in arbitrary coordinates, the gravitational field, like a physical field, separating inertial forces from gravity.

Dynamic fields can exist in several phases that correspond to the spectrum of their wavelengths, for example, the electromagnetic field presents gamma rays, X-rays, ultraviolet light, visible light, infrared light, microwaves, and radio waves.

9.3. Quantum vacuum.

Overlapping fields compose the quantum vacuum configuring the material medium that constitutes most of the Universe, since it is, first of all, quantum vacuum and, secondarily, matter.

The quantum vacuum mainly exists as the so-called outer space, which the ancients considered to be an absolutely empty space, like nothingness, a vision that continues even today, under the erroneous conception of the space itself, the foundation of the philosophical school of Substantialism.

The fundamental constituent fields of the quantum vacuum are:

- The cosmic electromagnetic microwave wave field (CMB) that serves as the background for the entire Universe [Page 73, 98]. This field comes from when the Universe was 380,000 years old and was around 3,000 degrees K, in the period of recombination when electrons and protons formed atoms, electromagnetic radiation was produced, that is, "the light was made" and appeared inhomogeneities, that is, regions of different density. In the pristine photo obtained, in 2013, by the Planck probe, after three years of collecting the CMB radiation, by detecting at 6 frequencies, used to debug the photo, since it was launched in 2009, the emptiest regions, They are red spots, because they are hotter, while the densest, also, the coldest, are blue spots, which constituted the embryos of macrostructures such as planetary systems, galaxies and cluster of the current Universe with a temperature of about 2.7 degrees k. This early state of the Universe corresponds exactly to Mukhanov's 1981 model of the origin of cosmic macrostructures from the quantum vacuum.

- The Higgs scalar field that entirely permeates the Universe and gives mass to fermionic particles, through its interaction with its boson.

- The fields that result from the disintegration of matter [118].

Quantum vacuum, in the macrocosm, constitutes the empty space between stars, where the density is 10^{-24} g/cm^3, in extremely empty regions of space with a density of 10^{-33} g/cm^3 and on average in the Universe with a density of 10^{-30} g/cm^3 [21]. On the other hand, in the microcosm, atoms are mostly quantum vacuum representing more than 99.999 percent of the total volume. This means that the fields, configured as quantum vacuum, dominate matter from afar. Therefore, material reality is primarily a quantum vacuum. The vacuum has spacetime, since the vacuum, experimentally detectable, has all three spatial dimensions (x_1, x_2, x_3) and its fluctuations and expansion occur, additionally, in the temporal dimension, that is, in 4 dimensions (x_1, x_2, x_3, t).

In 1916, Walther Nernst, based on quantum field theory and Planck's law for the radiation of a black body, postulated that the vacuum is not empty, that is, devoid of matter and radiation, but it is a medium that he believed was full of radiation, which contains a large amount of energy. Around 1925, with developments in quantum electrodynamics (QED), the energy density of vacuum gained credibility, as the electromagnetic field is treated as a collection of quantized harmonic oscillators, and unlike a classical harmonic oscillator, which may be completely at rest and zero energy, each quantized harmonic oscillator has zero-point energy that does not fade (DeWitt, 1967). Ernst Pauli pointed out about the gravitational effects of such zero-point energy. In the General Relativity equations, this vacuum energy is represented by the cosmological constant Λ, which implies an expanding Universe. In 1927 Lemaitre built a non-static model of the Universe with a cosmological constant. In 1930, Paul Dirac considered vacuum as an infinite sea of particles with negative energy. During that decade, models similar to Lemaitre referred to the so-called age problem, but the most accurate measurements of the Hubble constant nullified them.

In 1948, the effect of vacuum energy that Casimir theoretically discovered was experimentally confirmed in Philips' labs. Casimir energy is pure vacuum energy; real particles are not involved, only virtual particles (DeWitt, 1996). The Casimir effect is a small attractive force acting between two parallel closed conductive plates without load. It is due to the vacuum quantum fluctuation of the electromagnetic field. All fields, in particular electromagnetic fields, have fluctuations. This effect shows that emptiness is not really empty. It is full of virtual particles, which are in a continuous state of fluctuation. The virtual particle-antiparticle pair is created out of a vacuum and annihilated again in a vacuum during the uncertainty span explained by Heisenberg. Therefore, these virtual particles are created in fluctuations of quantum vacuum, during the temporary change in the amount of energy at a point in vacuum space. Virtual photons are the dominant virtual particles, but other particles are also produced. Since the vacuum is like a superposition of many different states of the electromagnetic field, the creation and subsequent absorption of a photon by the vacuum implies that the vacuum fluctuates (Nguyen, 2003). The particles of the standard model include an additional coupling of their constituent fields to the Higgs fields that play a crucial role in both the construction of the theory of mass generation from massive particles. The Higgs boson was experimentally confirmed by CERN on July 4, 2012.

In 1967, Zel'dovich calculated the contribution of quantum fluctuations to the cosmological constant, without having resolved why the zero-point energies of the fields do not generate a large cosmological constant. So, he assumed that zero-point energies, as well as higher-order electromagnetic corrections, are effectively zeroed out. In 1968, Zel'dovich denoted that zero- point particle energies cannot be ignored when gravitation is taken into account. In the late 1960s, Petrosian, Salpeter, and Szekeres reintroduced the cosmological constant to explain some peculiar observations of quasars that indicate unconventional expansion of the Universe, but later data on quasars nullified it (Rugh and Zinkernagely, 2000).

In the mid-1970s, Linde, Dreitlein, and Veltman pointed out the connection between cosmology and the spontaneous symmetry breaking mechanism invoked in electroweak theory. In 1977 Bludman and Ruderman argued that the energy density of vacuum was very large at the time of symmetry breaking. Around 1980, with the advent of inflationary cosmology, he stimulated a greater interest in vacuum energy with cosmological effects.

Currently, the estimated energy for the ground state (the state of vacuum) from the Standard Particle Model is in terms of the individual contributions of each particle to vacuum. Thus, the vacuum energy density receives contributions from both the fermion particles and field sources, as well as from any quantum field that may exist (DeWitt, 1967). Therefore, according to the general assumptions of quantum physics and quantum field theory, the vacuum in the Universe is a collection of quantum fields, especially electromagnetic waves of low energy, random in phase and amplitude and propagating in all possible directions. Everywhere the space of the quantum vacuum exhibits zero-point fluctuations, even in regions devoid of matter and radiation. These zero point fluctuations of quantum fields, as well as other vacuum phenomena of quantum field theory, give rise to a huge vacuum energy density involving a huge cosmological constant, not in terms of General Relativity but from vision of the quantum theory, known as the problem of the cosmological constant still unsolved (Rugh and Zinkernagely, 2000), (Oldershaw, 2009). "Quantum field theory and General Relativity have really different attitudes towards the energy density of vacuum. The reason is that quantum field theory is only concerned with energy differences. If you can only measure the energy differences, you cannot determine the energy density of the vacuum, it is just a matter of convention. To the best of our knowledge, the energy density of vacuum can only be determined by experiments involving General Relativity, that is, by measuring the curvature of spacetime" (Baez, 1999). So, "the energy density in General Relativity is very close to zero, which is almost indisputable, while in quantum field theory the most credible response is not determined" (Rafelski and Muller, 1985).

The state of the vacuum exists, within a region of its space, where the lowest possible energy can be reached, giving the evolutionary limit conditions of the physical system. But it can correspond to a local minimum of energy, since there are two vacuum states according to their energy. One is the true vacuum, which is the lowest energy minimum, and the other is the false vacuum that corresponds to one of the other minimums. When does it have the absolute lowest minimum energy? By taking all the states? If there are two local states of minimum energy vacuum separated by a potential barrier, they can remain almost unlimited time, since there is no flow between them, but if the transition from false vacuum to true vacuum is activated, then there would be an explosion" (Rafelski and Muller, 1985).

In 1981, Gennady Chibisov and Viacheslav Mukhanov, authors of the theory of the quantum origin of the structure of the Universe, published their theoretical discovery that at present the structure of the Universe on the scale $\leq 10^{-27}$ cm are quantum fluctuations, which produced originally the spectrum of inhomogeneities, such as galaxies and their clusters, in the early Universe (Chibisov and Mukhanov, Lebedev Physics Institute, 1981), when he was 379,000 years old, and for the first time due to the formation of atoms, at the end of the stage of recombination, electromagnetic radiation was produced, which today constitutes the cosmic microwave background. The numerous experiments, during the era of high-precision cosmology, characterized by the use of COBE satellites, in 1992, NASA's WMAP, in 2003, and completed by the Planck mission, in 2013, measured the temperature fluctuations of the cosmic microwave background. This background radiation, CMB, was discovered experimentally by Penzias and Wilson in 1965. The measurements are in good agreement with the predictions of Chibisov and Mukhanov, therefore, definitively confirmed, which assures us that everything in our Universe originated from of quantum fluctuations. CMB measurements have firmly demonstrated the quantum origin of the structure of the Universe, regardless of any alternative theory to inflation. Chibisov and Mukhanov, in the context of the model of Alexei Starobinsky, my president in group DE1 A - B - C - Dark Energy and the Accelerating Universe, MG15, Rome, 2018, from the “Landau Institute for Theoretical Physics”, of eternal inflation of the Universe, that is, the volume of the Universe is inflated from a given instant, accelerated expansion can amplify the initial quantum perturbations to enough values to explain the large-scale structure of the Universe. A few years later, Mukhanov developed the general theory of inflationary shocks, valid for a wide class of inflationary models, including chaotic inflation, but with very low probability for a cyclical Universe like that of Stephen Hawking and Roger Penrose, who sees, in the Hawking points of the CMB, "the final remnant of a black hole that evaporated in the previous eon" (Penrose, 2018), as proof of the existence of a pre-current Universe, not a strong argument, since expert cosmologists they affirm it is the effect of the “curvature of light when passing near a massive object” (BBC News Mundo, 2018); another thing is Logunov's oscillating cyclic Universe where, due to the rebound, caused by negative gravity, in the contraction process, without reaching the “Big Crunch”, in which it would have collapsed into a singularity, an inflationary Universe may exist, although not eternal; the rebound model is recently defended by Paul Steinhard (Der Spiegel, 2019), professor of the “Albert Einstein” chair at Princenton University. Mukhanov's approach has become the standard method of investigating inflationary perturbations. It begins with a reminder of the simple Newtonian approach to the theory of density perturbations in an expanding Universe, then extends this investigation to General Relativity, and ends with the quantum theory of production and the subsequent evolution of inflationary disturbances of the metric "(Mukhanov, Ludwig-Maximilians-Universitat Munchen, 2005), "Adopting a curvature scalar disturbance as a physical variable" (Mukhanov and Chibisov, Lebedev Physics Institute, 1981). In 2008, Mukhanov said: "G. Chibisov and I was fortunate to discover that quantum fluctuations could be responsible for the large-scale structure of the Universe, we hardly thought that one day it would be possible to verify this prediction experimentally. We wrote an article where we derived the spectrum of metric cosmological perturbations generated in one stage de Sitter's accelerated expansion (the word inflation had not been invented at this time) from quantum fluctuations. The spectrum turned out to be logarithmically scale dependent. Our results were obtained for the first gravity-based inflation model R^2, which is conformally equivalent to a model with a scalar field” (Mukhanov, Ludwig-Maximilians-Universitat Munchen, 2008). In this way, Mukhanov's model can be classified within the scalar-tensor theories that emerged from 1961 with Robert Dicke and Carl Brans and that are really alternatives to General Relativity such as bimetric theories and RTG. At Mukhanov's presentation of the discovery, I attended his keynote address, at MG14, Rome, 2015.

Although, Mukhanov's model of fluctuations in the quantum vacuum only explains the appearance of large structures from the time when there were already atoms, therefore matter, it would be extensible to the past, but fluctuations such as the temporal change in the amount of energy of the zero point, in the space of the quantum vacuum, subject to the Heisenberg uncertainty principle. Mukhanov on this matter has stated, in a telephone interview with the Spanish newspaper El País, when he won, together with Hawking, the “Frontiers of Knowledge Award for Basic Sciences”, from the BBVA foundation: “We came to the idea that the same [quantum] physics that is responsible for the structure of matter on very small scales, of atoms, may also be responsible for the structure on a large scale." (Mukhanov, 2016). Going back even further in the early Universe, which implies extraordinary temperatures, the plasma of bosons and quarks will be kept and, even earlier, at the threshold itself, in which the contraction process was reversed, due to the appearance of the negative gravitational force, according to the Universe model oscillation of Logunov, one would only have bosons, because by the superposition principle they are the ones that could exist in the state of maximum density, which geometrically implies a spacetime, although not zero, consequently they lack of singularity, if close to said collapse, which never occurs. Thus, the matter in the structures of the quarks and subsequent hadrons and leptons, would also have originated from fluctuations in the super dense bosonic quantum vacuum [Page 121, 98], which Mukhanov defines as: “The minimum deviation from the state of rest it's called quantum fluctuation. ". Of course, the field came before matter. Furthermore, the mass of matter equals the energy of the field, since $E = mc^2$. That is, matter and field have structural unity and constitute the same quality of energy-mass, of the field-matter. They differ in their density since matter is extremely concentrated energy and the field is energy with very little density [Page 208, 99]. The mass is energy, mainly, united by the action of the Higgs field [Page 1,100], present in the vacuum as a component of it. The quantum vacuum, from which matter comes, is in no way nothing, Aristotle was right when he said if the vacuum was nothing it would not exist.

9.4. The particle-wave duality.

In 1909, based on Planck's radiation quantum, Einstein formulated that the structure of the electromagnetic field was dual: electromagnetic photon-wave that, in 1923, was verified by Arthur Compton and, in 1924, Louis de Broglie extended it to matter in proposing the electron-wave duality, demonstrated, in 1927, by Paget Thomson. Currently, wave-particle duality is a "concept of quantum mechanics according to which there are no fundamental differences between particles and waves: particles can behave like waves and vice versa" (Hawking, 2001).

Field and matter particles are dual. Structurally they constitute the particle-wave unit [109]. As particles they have definite physical limits and have a certain position in spacetime. As waves they are extended entities in spacetime that propagate in all directions of space [110].

In the field the particles appear as excitations of the waves while in matter the waves appear as excitations of the particles [111].

"The corpuscular nature of electromagnetic radiation is revealed when studying its interaction with matter (emission and absorption, photoelectric effect, Compton effect, creation and annihilation of pairs, etc.). On the other hand, its wave nature is manifested by the way it propagates, giving rise to interference and diffraction phenomena. This situation can be described by saying that electromagnetic radiation is a wave that, when interacting with matter, exhibits corpuscular behavior. Also, it can be said that it consists of particles (the photons) whose movement is determined by the propagation properties of certain waves that are associated with them” [P. 53, 92].

The particle-wave duality leads to two different approaches: One privileges the wave while the other privileges the particle [112]. With the discovery, in 1834, by John Scott Russel, of the soliton the theory arose that only waves exist since the particles would be solitons. But, despite this reductionist tendency of thought, nature is dual.

9.5. The four dimensions of the field-matter.

The field-matter intrinsically has the geometric structural property of volume. This is its geometric structure has the three dimensions of: latitude, longitude and altitude (x_1, x_2, x_3). These dimensions are the geometric property associated with the mere static existence condition of the field-matter, which has the potential to serve as a container for other structures.

The quantum vacuum is par excellence the fundamental continent of all the other structures of the field-matter. Quantum vacuum as an overlay of electromagnetic, gravitational, and Higgs fields is quintessentially the continent of all other matter-field structures. But also, the matter differentiated according to its states serves as a container (for example, the solid state serves to contain the liquid and gaseous states), although ultimately, it is contained in the quantum vacuum, since. its three dimensions (x_1, x_2, x_3) are the spatial geometric property of the field-matter. Since space means continent. This property serves both to contain and to contain itself, since the quantum vacuum is also self-contained.

The movement of translation and/or rotation of matter and the variations of the field from a geometric point of view cause, the field-matter to come out of its three-dimensional continuum and generate a fourth dimension. This is a mathematical law of geometric N-dimensional spaces: if N leaves its continuous N, in a direction k contained in a continuous (N + 1), then the geometric space of (N + 1) dimensions is generated [Page 2, 101]. Thus, the moving field-matter has four dimensions (x_1, x_2, x_3, t). The fourth dimension (t) corresponds to the intrinsic dynamic reality of the existence of the field-matter. Therefore, the fourth dimension is the temporal geometric property of the intrinsically dynamic field-matter, since time means becoming of the existent.

9.5.1. In four dimensions as particles.

The particles in the field are packed energy [113], lacking resting mass, while the particles of matter are packed mass. However, the weak field whose particles are like matter is excepted.

The force-carrying field particles are the gauge virtual bosons. Wave particles are real bosons and matter particles are fermions.

The energy packages (bosons) of the fields as well as the particles of matter (fermions) are described in three-dimensional spaces (x_1, x_2, x_3) and when they are considered in motion in four dimensions (x_1, x_2, x_3, t) [114].

While the particles of matter have been "seen" and unequivocally possess volume, the particles of the field have not, which has allowed speculation about their dimensions; virtual because they are directly undetectable and real because they exist confined to the Planck scale; in addition, the gluon that does not exist free, at the current temperatures, but always within the hadrons, since it exerts the force that unites the quarks that make up the hadrons.

Particles without mass at rest, as is the case of the photon (by analogy also gluon and graviton), for some authors would be particles devoid of volume, that is, null-dimensional, as points, in a fourth-dimensional spacetime [115]. However, for Maxwell the photon has two dimensions; “Maxwell's

19th century concept: the photon is a circle. B $^{(1)}$ and B $^{(2)}$ exist" but not B $^{(3)}$ [Page 9, 84]. And, for most, the photon does have volume, since "B $^{(3)}$ is the angular momentum multiplied by a constant, and is the longitudinal component of the photon" [Page 3, 84]; therefore, "the photon exists in three dimensions. The U $^{(1)}$ geometry only describes two. B $^{(3)}$ describes the third" [Page 4, 84]. Thus, "the photon has a 3rd spatial dimension" [Page 9, 84]. And since the photon, only exists, in movement has four dimensions (x_1, x_2, x_3, t).

9.5.2. In four dimensions as waves.

In Quantum Mechanics due to the uncertainty principle, according to which it is impossible to fix the position and momentum of a particle at the same time, in the most usual, probabilistic or Copenhagen interpretation, by means of a probability function it is assigned to each point in space and at each instant, the probability that a reference particle is in a certain position at that instant, so "the movement of a particle is governed by a wave function" [Page 8, 96] [116]. In the most modern formulation, the wave function is interpreted as an object, representing an element of Hilbert space, of infinite dimension, that brings together all the possible states of the system.

"Quantum mechanics describes the instantaneous state of a system (quantum state) with a wave function that encodes the probability distribution of all measurable, or observable, properties. Some possible observables on a given system are energy, position, moment, and angular momentum. Quantum mechanics does not assign definite values to observables, but rather makes predictions about their probability distributions. The wave properties of matter are explained by the interference of wave functions. These wave functions can be transformed over time. For example, a particle moving in empty space can be described by a wave function that is a wave packet centered around some middle position. As time passes, the center of the packet can move, change, so that the particle seems to be located more precisely elsewhere. The time evolution of wave functions is described by the Schrödinger equation" [P. 9, 96].

The value of the wave function ψ (x_1, x_2, x_3, t) associated with a moving particle is related to the probability of finding the particle at the point (x_1, x_2, x_3) at time instant t. This probability is proportional to the square of its associated wave function $|\psi(x_1, x_2, x_3, t)|^2$

When we perform a measurement on an observable of the system, the wave function becomes one of the set of functions called proper functions, proper states, eigen-states ... etc. of the observable in question. This process is known as wave function reduction. The relative probabilities of that collapse over any of the possible eigenstates are described by the instantaneous wave function just before the reduction. For a particle in a vacuum, if the position of the particle is measured, a random value x is obtained. In general, it is impossible to predict precisely what value of x, although it is likely that a value close to the center of the pack wave will be obtained, where the amplitude of the wave function is large. After the measurement is made, the wave function of the particle collapses and is reduced to one that is highly concentrated around the observed position x" [Page 10, 96].

"Schrödinger's equation is deterministic in the sense that, given a wave function at a given initial time, the equation provides a concrete prediction of the function that will be obtained at any later time. During a measurement, the eigen-state at which the function collapses is probabilistic, not deterministic. So, the probabilistic nature of quantum mechanics is born from the act of measurement" [Page 10, 96].

The waves differ in waves from real massless particles called radiation waves and waves from mass particles known as waves of matter.

The real photon, as spherical waves, has volume and they propagate in four dimensions (x_1, x_2, x_3, t). The same is said of gravitational waves that would propagate in four dimensions [117]. For its part, the waves of particles with intrinsic volume, that is, the particles of matter, propagate in four dimensions (x_1, x_2, x_3, t). About virtual particles, their waves would be evanescent, which also propagate in four dimensions (x_1, x_2, x_3, t).

9.6. Notes.

[105] “A field is a physical continuum which has no rest mass” [Page 39, 83].

[106] "The field moves forward and has existence in all dimensions" [Page 2, 84].

[107] “Clearly, to every point x_μ of Minkowski spacetime M we associate a value of the vector potential A_μ. The vector potentials are ordered sets of four real numbers and hence are elements of R^4. Thus, a field configuration can be viewed as a mapping of M onto R^4, A: M → R^4“ [Page 1, 85].

[108] “An electromagnetic wave is a traveling wave which has time varying electric and magnetic fields which are perpendicular to each other and the direction of propagation, z.” [Page 1, 86].

[109] “a single particle behaves like a wave” [Page 3, 87].

[110] Essentially, wave / particle duality employs the notion that an entity simultaneously possesses localized (particle) and distributed (wave) properties. [Page 1, 88]. “The major significance of the wave particle duality is that all behavior of light and matter can be explained through the use of a differential equation which represents a wave function, generally in the form of the Schrodinger equation. This ability to describes reality in the form of waves is at the heart of quantum mechanics.” [Page 1, 89].

[111] “In his paper on the photoelectric effect, Albert Einstein showed that besides the familiar wave properties, light also have particle properties. And Louis de Broglie later published his "wave theory of matter," in which he said that besides the familiar properties of particles, small particles such as electrons can also behave like waves” “And since particles and waves have dual properties and can behave like each other; it has become the consensus that they must not be as different as they appear to be. ” [Page 1, 90]. “Historic experiments proving the wave-like and particle-like behavior of matter and forces” “The development of the standard model could not have happened without the application of particle-wave duality” [Page 1, 91].

[112] “a massive particle is a wave”, De-Broglie, [Page 8, 87]”. An invisible wave pattern, evidently shaped as an electron-sized, spheroid "cloud", is the target of a laboratory measuring device which shoots x-rays. At the moment such a device makes contact with its target, the "probability-wave" cloud "collapses" to become a point-particle electron. The same thing happens naturally when an electron in its "wave nature" strikes any object”, The wave-collapse theory, [Page 8, 93]. “Other authors (notably Veltman, Weinberg) follow an opposite line of thought: particles are basic and fields are to be constructed in accordance with their properties and general principles. This latter approach appears to be essentially perturbative” [Page 7, 56]. "It is conventionally assumed that a particle propagates as a wave" [Page 6, 88].

[113] "Einstein described light as: consisting of a finite number of energy quanta which are localized at points in space, which move without dividing, and which can only be produced and absorbed as complete units." [Page 2, 94].

[114] "quantizing fields leads to a description .. of bosons or fermions (in three spatial dimensions)". "Interactions are described by differential equations at a point in space and time. They only refer to the immediate neighborhood of that point through derivatives of finite order, usually only up to second order" "A typical example is given by the electromagnetic field interacting with electrons, which are described by the Maxwell equations and the equations for the Lorentz forces acting on the electrons" [Page 6, 56]. "Field theory is based on the existence of spacetime" [Page 7, 56].

[115] "All of the photon's dimensions, volume, length, width, height and weight are equal to ideal zero" [Page 38, 83]. "The energy within the photon exists in a certain state" "there is no" back end "to the photon" "the energy would not be effectively diverted there" "the photon's energy would be concentrated and directed towards the front of the photon" "A particle that was devoid of a back end but came to a point at the front" [Page 4.95].

[116] "The most common interpretation is that the wave function represents the probability of finding a given particle at a given point. These probability equations can diffract, interfere, and exhibit other wave-like properties, resulting in a final probabilistic wave function that exhibits these properties as well. Particles end up distributed according to the probability laws, and therefore exhibit the wave properties. In other words, the probability of a particle being in any location is a wave, but the actual physical appearance of that particle isn't" [Page 1, 89].

[117] The author has proposed the theory that the gravitational wave whenever it was the disturbance of spacetime would propagate in five dimensions (see 42). Nasa defines it as the disturbance of space, while Caltech as the disturbance of spacetime.

10. Conclusions.

In the 3rd century BC, the Greek thought conceived the space naked, like absolute emptiness in the atomism of Leucipo and Democritus, or occupied by the ether according to Aristotle for whom there was no emptiness since nature abhors it. In the Middle Ages, according to Descartes, the ether was composed of very small particles, which transmitted forces between objects, through the collisions of their particles, which would fill the space not occupied by solid bodies because there is no vacuum. Torricelli experimentally demonstrated the existence of a vacuum in Descartes' sense of ether, encouraging the survival of atomism. However, in 1678, Huygens with his wave theory of light, reestablished the ether (light source) as its propagation medium. In 1717, Newton defended the existence of a vacuum, but introduced (gravitational) ether as a stationary dim medium, composed of particles, with a variable density, denser in empty space than in the vicinity of massive bodies, to explain the gravitational effects; in any case, both as emptiness and as ether contained in its absolute space. In 1748, Le Sage proposed an ether consisting of small particles, called corpuscles, that flow in all directions with enormous speed. In 1801, Young said that ether is a gas at absolute rest. Due to the discovery of light polarization, in 1817, Fresnel introduced the theory of the transverse wave of light, and then Young proposed a periodic transverse displacement of ether particles. According to Fresnel, the ether became solid and rigid, but it allowed the free passage of celestial bodies, while the ether flowed through the interstices of material bodies even on the smallest scale; thus, the density of the ether in a material body was different from that of the free ether. Between 1828 and 1839, Cauchy proposed a dynamic ether, due to its changes in density and elasticity. Green noted that Cauchy's contractile ether would be unstable, tending to shrink until it disappeared. In 1845, Stokes partially coincided with Fresnel, since the ether would flow almost without obstacles through all the matter that in rotation or translation would drag the ether, therefore, the Earth would drag the ether. In the 1860s, Maxwell formulated the electromagnetic ether, as a quasi-elastic stationary medium, as the preferred frame of reference in which light would propagate with constant velocity in all directions. In 1887, with the Michelson-Morley experiment resulted constant the speed of light in a vacuum. In 1889, FitzGerald proposed that the forces that bind the molecules of a solid would be modified by the movement of the solid through of the ether in such a way that the dimension of the arm of the interferometer, in the Michelson-Morley experiment, would be shortened in the direction of movement that would neutralize the searched optical effect; the ether would not only change the course of objects (as gravitational ether would), but it would also change the size of objects; consequently, the ether would produce the relativistic effect of the contraction of the length of any object, this contraction would occur in the direction of movement and in proportion to the speed through the ether. In 1895 Lorentz improved the hypothesis of FitzGerald, who had perfected Maxwell's electromagnetic ether, by introducing the special motionless framework, where the laws of electrodynamics are valid; since the atoms of all solids are held together by electrical forces. The motion of a body, according to Maxwell's mechanics, superimposes on the electrostatic forces between the atoms a magnetic effect due to the motion; the result, according to Lorentz, would be a contraction of the body in the direction of movement that would be proportional to the square of the relationship of the speed of the body to the speed of light that would explain the Michelson-Morley experiment; this contraction of length leads to time dilation for all phenomena that obey Newton's laws and / or Maxwell's laws, in inertial frames, and both contractions lead to the Lorentz transformation between inertial frames. The electromagnetic ether would constitute the carrier substrate of the electromagnetic wave, would provide the special framework in which Maxwell's equations are valid, making gravitational ether an anachronistic concept, since like Maxwell's luminous ether, it would act as an interaction force on particles and bodies, putting them in contact and it would produce the gravitational effect. In 1905, in Special Relativity, Einstein adopted the relativity principle of Galilei's inertial motion and the Lorentz transformation in mechanics in exchange for the Galilei transformation, unifying the theories of Galilei-Newton and Maxwell, and ending with the special frame in which Maxwell's equations were valid, with which he explained the constancy of the speed of light in a vacuum, of the relativism of space and time as a function of speed, within the recently relativistic mechanics, definitely an effect of coordinates, suppressing the electromagnetic ether and determining the propagation of the electromagnetic wave as a property of space itself, consequently, as bare space that, in 1915, in General Relativity defined as a geometric field, returning physics to conception of the absolute emptiness of Democritus, which, however, pressed by Lorentz, provisionally called it relativistic ether, which, in 1938, he emphatically renounced, although, really since before 1905, since he had repeatedly described the ether as a great mistake of classical physics. Around 1930, with quantum field theory, the quantum vacuum totally permeates space. Therefore, the dilemma between Democritus and Aristotle has been overcome in his favor. The quantum vacuum is similar to Descartes' ether, but while it was fermionic the quantum vacuum is bosonic. However, General Relativity remains the paradigm of the science of physics.

10.1 But what is spacetime?

Spacetime is objective, that is, it exists independent of consciousness and is internally linked to material existence, which constitutes the necessary condition of its existence.

The separation between spacetime and matter occurs in thought, during the transition between the philosophical knowledge of the ancients to the scientist. They understood it the reverse of what it really is, that is, space and time as the condition of material existence and its movement, conception that remains valid today in Substantialism.

Such an investment, in the connection between matter and space and time, is inferred according to Euclid's geometry, constituted as a formal science before physics. This circumstance has made the science of geometry go ahead of the science of physics, until, with General Relativity, physics is geometrized.

The root of the separation between spacetime and energy-matter is epistemological and nonphysical. It was within such a conceptual framework that the physical science of Galilei and Newton was founded, therefore, that absolute space and time were defined, with action on the relative mechanical motion of matter, when determining the inertial structure for motion rectilinear, considering the spacetime itself, as bare space, later according to the General Relativity bare spacetime as a metric field, on the interplanetary, intergalactic, intercluster, etc. scale.

It was the Minkowski geometry, which made it conceptually possible, and the experiments of Michelson and Morley, carried out in the nineteenth century, on the constancy of the invariance of the speed of light, with respect to the changes in coordinates between the inertial reference systems, where it is measured, which required, in Special Relativity, the link between the mechanical movement of matter and spacetime be formulated, putting the limit c on speed, as a result of the deformation of spacetime with the highest speed, which results of the relativism between space and time, with the change of coordinates between inertial systems.

Einstein's search, in General Relativity, for equations that explain celestial mechanics and the propagation of the electromagnetic wave, in the interplanetary quantum vacuum of the solar system, which is curved by its gravitational interaction with the planets and the Sun, in a scenario of high conflict with Hilbert, without alternative Einstein had to adopt them from those imposed by Hilbert, having found them first, which necessarily required the Riemann tensor geometry N [121] and the variational calculation used by Hilbert that Einstein ignored and also that the quantum vacuum curves unknown by both. Such a strictly mathematical and geometric solution followed the Minkowski geometry of Special Relativity, which Einstein had allowed him to formulate, based on the physical equivalence between inertial mass and gravitational mass, and by means of coordinate changes, in the limit condition of his supposed "homogeneous gravity", the equivalence between all the movements of matter, of a mechanical nature, namely inertial, accelerated and gravitational.

According to General Relativity, due to the presence of energy-matter, spacetime curves, according to Riemann geometry, and determines that the geodesic structure is curvilinear. However, following Newton's tradition, the Universe has the Minkowski geometric configuration, which has its own geometry of straight lines and a rectilinear geodesic structure, in the limit conditions, both at infinity where the curvature becomes null as in the infinitesimal interval in tangent spacetime. In this way, spacetime manifests itself, that is, it appears to be the continent of the Universe or, in other words, of material existence, and creates the impression that spacetime is a substantial entity (Substantialism), which by adding the supposed conversion between spacetime and field-matter, this substantial entity becomes a material phase (of the spacetime-mass theory), coinciding with the conception of spacetime as a fluid supported by NASA and Caltech, a requirement to accept the frame drag and the supposed waves gravitational detected by LIGO. Also, the limit conditions make Relationism, which cannot explain the inertial structure in them, have to take refuge in the intrinsic dynamism of the particles and coincide to some degree with Substantialism, in its version of a material spacetime, contrary to nature of the geometric spacetime originating from the Einstein-Grossmann-Hilbert equations, although in the case of Relationism it is not the spacetime but the material gravitational field (Cala N: [122], Smeenk N: [123], 2006).

Substantialism and Relationism are identified in considering the gravitational field, in its most abstract expression, as "being-in-itself", that is, Relationism surrenders before Substantialism. But, Substantialism and Relationism differ with respect to spacetime, which, while for Substantialism is the structural geometric property of the gravitational field, in Rovelli's terms nothing, on the other hand, for Relationism spacetime is a simple category of thought, in which encoded, in its most abstract expression, "being-in-relation-with" (Hegel), in Rovelli's terms nothing. Thus, the controversy between Substantialism and Relationism came to naught N:[124]. This end is the consequence of the fundamental error committed by Substantialism and Relationism at the beginning of their dispute. The mistake of Relationism is to define space in relation to movement without answering the Universe in which it is contained. While the mistake of Substantialism is not answering what space is made of. Ultimately, Relationism implies Substantialism and both lack of response on the physics of spacetime.

The development of the theories of spacetime leads to Quantum Physics, in which gravity is intuited as material, as a material phase, of a corpuscular-wave nature. But, that, due to the need to unify it with General Relativity, the theories on Quantum Gravity are the elementary components of matter of geometric origin. Thus, the question of spacetime appears absurdly as follows:

On the Planck scale, spacetime, the assumed structural property N: [125] of the gravitational field, is not gravitation since it is different from spacetime. And in the macrocosm, the material spacetime, consequence of the drag of the frame and supposed gravitational waves, for Substantialism, serves to contain the other phases of the field-matter, a very cunning realization of nature that grants the privilege to the gravitational field that It possesses spacetime and it deprives to matter and to the other fields of spacetime, however, which are revealed, in all our experiences, magically with spacetime. Or for Relationism it is the no less cunning realization of nature, that from matter (energy-momentum tensor) generates a material field (gravitational field that has energy-momentum) to support and hide relationships of intrinsically dynamic matter, which are coded in the category of curved spacetime, and allow gravitation to appear as an intrinsically geometric force without being. What a cunning, not of nature, but of thought.

Thus, nature is uneconomical insofar as it squanders a material phase in containing the rest and absurd insofar as on the scale of the macrocosm gravity appears as the geometric gravitational field without being it and on the Planck scale as a material gravitational field by analogy with the fields. electromagnetic, weak and strong, but, from the unifying theories of Quantum Gravity, such as the effect of spacetime, quantized in geometric objects such as ropes or loops, which explain both the graviton and all the other particles of the Standard Model, that is, evaporated matter in geometry, although, disguised as material appearance, without either be. Ortega y Gusset had already said it, on Einstein's visit to Spain in 1923: "You geometrized physics." The consequences are ostensibly dramatic. Although, rather the result of the culmination of Felix Klein's Erlangen program.

Nature, which really only by mistake, wastes regains its optimizing tendency, if spacetime is no longer understood as the category that encodes the relational property of intrinsically dynamic particle configurations or as the framework in which physical events occur, but it is understood as the structural dimensional geometric property of the moving field-matter, subject in everything to the existence and becoming of the field-matter.

The instantaneous Universe has intrinsically space while the dynamic Universe has intrinsically spacetime.

The fact that the instantaneous Universe inherently has space is an argument of the devastating author of Relationism. Since, in this case, the existence of space is obtained from the transcendental relations of the Universe with its reality and not from Relationism between material objects, that is, it does not assume the existence of the two stories proper to the categorial relations; the `transcendental relations is one that belongs to the very essence of the related subject, that is, to its own strict entity. This is why the transcendental relation is a much deeper stratum than that of the categorial relation' [Page 15, 109] and for Relationism, as a physical theory, its negation of spacetime N: [126].

Also, the author accuses that only within codification, of relational material property, does live the possibility of seeing spacetime as material property. Any other claim by Relationism to see spacetime as a structural geometric property of dynamic matter, the author's thesis, would be a claim brought from the hair.

10.2 Spacetime has two basic structures.

Spacetime, constituting the dimensional structural property of field-matter in motion, exists in the expressions of the massless wave-particle of the field subject to the principles of superposition and uncertainty and particle-wave mass of matter subject to the principles of exclusion and determinism.

Therefore, there are two basic dimensional structures of matter with different properties, and spacetime on the Planck scale is different from spacetime on the atomic scale. Although on the Planck scale there is a mixture between past, present and future due to the superposition between quantum states, there is also a separation between them on the scale of the atom and higher.

These different structures of spacetime result from cosmogenesis that occurs not linearly but with ruptures, that is, with qualitative changes, such as, for example, the passage of material existence devoid of mass from the quantum vacuum to that which possesses it in matter , or the transition from the existing structures in the microcosm to those of the macrocosm.

10.3. The field-matter and its movement occur in the vacuum that contains everything.

Thus, it has that the Universe exists contained in the vacuum from which matter originated. More properly, the Universe exists contained in the energy of the vacuum and its fluctuations. Vacuum is the primary structure of the Universe. According to our lagging knowledge as it corresponds to the past, this vacuum is currently expanding. And, in general, it will always have that a phase of the field-matter, within a certain scale of the magnitudes of the spacetime dimensions, contains content and moves within other phases of the field-matter. Thus, the submarine within the water, the plane within the atmosphere, the rocket within the interplanetary vacuum, that being a quantum vacuum requires the rocket to contain the material that, according to the action-reaction principle, allows it to move fast, etc., All, finally, within the field of self-contained vacuum in itself.

As is apparent from cosmogenesis, matter at all scales of its organization, including at the galaxy cluster scale is the product of fluctuations in vacuum energy, which occurred during the era of inflation and subsequent conversion of the vacuum in matter during the braked expansion of the age of matter and correlative temperature drop, currently close to 0 degrees kelvin, below which it can no longer fall, except for nuclear temperature. In addition to the decelerated conversion of the vacuum into matter during the accelerated expansion that currently occurs in the dark energy era and the trend towards termination of this conversion during the super accelerated expansion of the phantom energy era (today it is discussed whether we are already in the era of phantom energy and if this era will end in the Big Rip, in which matter would end up disintegrating in a vacuum), but that in RTG will not occur because there will be a point of return, in which the contraction will begin due to reaching the minimum density limit.

From the spacetime perspective all cosmogenesis is contained in the spacetime of vacuum, of which spacetime is its structural four-dimensional geometric property and not the vacuum (energy and its fluctuations) property of space as defined in quantum mechanics. This vacuum is also a field. Thus, there is no mystery that the field itself and matter itself is the continent of matter and field, in all its forms and phases of its existence. And, ultimately, matter and its movement are self-contained. Matter and vacuum behave like an expanding fluid N:[127], which are transformed qualitatively, giving rise to new structures of material existence and, therefore, spacetime.

10.4. Why does spacetime curve, contract or expand, and is there frame drag?

Spacetime curves since the field-matter, of which it is its structural geometric property, curves and is curved since its component particles are subject to the interaction force of quantum gravitation.

The spacetime dimensions of the field-matter expand or contract in direct function of gravity as a physical interaction mediated through the graviton. "The physical gravitational force changes both the span and the increase in parameters of the amounts of space compared to the same amounts, in an inertial system of Minkowski space without gravitation" (Logunov, 2005).

Both the translational and rotational movements of the planets, within the field associated with the solar atmosphere, produce frame drag, since, in general, it is the physical field, not precisely the metric of General Relativity, the frame of the movement of the stars.

Of course, the field of vacuum, made of virtual particles and waves all-pervading manifold, has metric, which is no more than the spatiotemporal metric.

10.5. General Relativity a bad vision with good results.

As a consequence of great unsuccessful efforts, for nearly a century of work, carried out by various groups of scientists around the world, with the aim of unifying Quantum Physics and General Relativity, it has been said that one or both theories are wrong. At least, the General theory of Relativity is wrong, since this theory is essentially a theory about spacetime and as we have developed, in this essay, spacetime is not the structural property of the gravitational field, geometrically conceived as curvature, but that spacetime is the geometric property of the field-matter.

The nature of gravity remains mysterious in experimental terms, although, according to the nature of the other fields, it must be quantum as formulated by RTG. And, of course, gravity, too, intrinsically has spacetime.

The error in the conception of spacetime as a framework came from when the science of physics had not been separated from philosophy and in the time of the pre-Socratic philosophers the idea of space as a continent of matter was introduced. And, due to dialectical contradiction, that is, of the flow of thought between opposites, although, with logical unity, also, the error of the conception of spacetime as a relationist category. These errors lasted for more than 25 centuries.

However, the results of the experiments, with which General Relativity has been tested, coincide extremely well with their predictions. This is because on the scales of the atom and the macrocosm, where the experiments are carried out, it is very easy to supplant the virtual quantum material field by its metric, that is, the geometric spacetime, since the energy density of the vacuum field (ZPE) tends to zero and material existence tends to fade. Where the discrepancy between the quantum material field and the geometric field of Einstein's spacetime crucially arises is on the Planck scale, the units of which are so excessively small that the insignificant error in the measurements is of an extraordinarily immense magnitude with respect to these and so discrepancies remain hidden.

10.6. What happens in the decay of the Proton?

The disintegration of the Proton and other elementary particles without having been detected until now its transformation into energy and / or other particles, is not due to the fact that they transform into spacetime since it lacks physical reality and is only a simple geometric property of the field-matter. For example, the proton may decay into a neutral pion and into a positron as Dr. Sergei Krasnikov told me (E-mail: Sun, 24. Jun 2007 04:00:51 +0400).

10.7. Einstein's field equations really what they mean?

Einstein's field equations are deeply empirical and describe geometrically using the Ricci tensor, as in three dimensions, the spatial dimensions of matter are curved as a function of the mass-energy of a gravitation source, represented by the energy-impulse tensor, that is, as the shape of matter curves from an unknown physical process of virtual energy, of a material and quantum nature, which is gravity, intrinsically and very strongly associated with the magnitude of the mass-energy of its material content N:[128], but, also, taking the entire term $G_{\mu\nu}$, which gives the effect of the curvature of spacetime in celestial mechanics, bringing together in geometric terms the effect of the physical gravitational interaction with the effect of the curvature of the quantum vacuum, that is, force gravity + curvature of the quantum vacuum.

10.8. The velocity of matter during inflation.

In a fraction of a second, elapsed during inflation (probably, according to RTG from the rebound, when the contraction process stopped, due to the appearance of negative quantum gravity), the size of the Universe went from the size of a proton to the equivalent of a billion light years (about $9.4608 * 10^{21}$ kilometers) in such a way that, according to our conception of spacetime as the structural property of matter in motion, field-matter expanded with the speed of about $9.4608 * 10^{54}$ kilometers / second, which proves the existence in nature of speeds over c.

10.9. Quantum Vacuum Curvature Test

The electromagnetic wave is transmitted in the quantum vacuum and undergoes deflection, since this medium, through which it propagates, is curved. Thus, like the Shapiro delay, the gravitational effect of lenses, etc.

10.10. Proposed model of spacetime.

Spacetime Ċ Matter

Ontologically a single being

Form Ċ Content

Geometry ↔ Physics

Matter = (vacuum, energy-matter) or (field, matter) represented by $T_{\mu\nu}$

Geometry =

[1] Euclidean, M U Metric (η_{ik} t), Matter under Planck scale

[2] Minkowskiana, M U Metric (η_{ij}), Matter between <10^{-27} and Planck scale

[3] Pseudo Euclidean, M U Metric (γ_{ik} (x) identity g_{uv}), Matter 10^{-27} onwards

Assumptions:

If $T_{\mu\nu} > 0$, then matter is made up of real particles.

If $T_{\mu\nu} \approx 0$, then matter is made up of virtual particles.

Real particles and virtual particles propagate in x1, x2, x3, x4 dimensions.

Conventions:

(η_{ik}, t) according to Horava's space and time.

η_{ij} according to Minkowski spacetime, revised with Superluminal Relativity.

(γ_{ik} (x) identity g_{uv}) according to Logunov's spacetime.

Ċ is the proper structural subset.

M is the manifold

10.11. Notes.

[118] "We propose a new selection principle for distinguishing among possible vacuum that we call the" relaxation principle. " The idea is that the Universe will naturally select among possible vacuum through its cosmological evolution, and the configuration with the biggest filling fraction is the likeliest" [Page 1, 97].

[119] "The actual origin of the ZPE has several schools of thought. The first explanation is that the zero-point energy was fixed arbitrarily at the birth of the Universe, as part of its so-called boundary conditions. A second school of thought proposes that the sum of all particle motions throughout the Universe generates the zero-point fields and that in turn the zero-point fields drive the motion of all particles of matter in the Universe .. as a self-regenerating cosmological feedback cycle. On this second explanation the ZPE and atomic particles both require the existence of each other. However, if there is even a hint that all matter in the Universe is likely to undergo collapse without the ZPE, it becomes difficult to envisage how atomic structures emerged in the first place by the feedback mechanism. On this basis it would seem that something more fundamental is required as an origin for the continuing ZPE, even though the feedback mechanism may perhaps sustain the ZPE once formed. To that end, a consideration of the conditions pertaining at the inception of the Universe may be worth investigating. In order to do this effectively, it is important to realize that there is another aspect of the physical vacuum that needs to be introduced" [Page 16, 63].

[120] "With more or less than one time-dimension, the partial differential equations of nature would lack the hyperbolicity property that enables observers to make predictions. In a space with more than three dimensions, there can be no traditional atoms and perhaps no stable structures. A space with less than three dimensions allows no gravitational force and may be too simple and barren to contain observers" [Page 1, 102].

[121] Newton's mechanics can be formulated through tensors

, while for Relativity it is also necessary that Riemann's tensorial formulation is mandatory for General Relativity.

[122] "The interpretation of the dynamic gravitational field guv of GRT as an extended material object is mandatory" "Everything is matter in GRT and, therefore, spacetime does not claim - not even theoretically - independent existence" [Page 232, 5].

[123] "the metric tensor is a kind of substance that transports energy and momentum like all material particles" [Page 1, 108].

[124] Some have suggested, and others (Rynasiewicz 1996) have explicitly argued, that the debate is outmoded in the context of GR, and that the relationist and substantialist positions have become indistinguishable [Page 2, 36].

[125] Einstein's error since, as the author analyzed it, according to General Relativity it is the opposite, that is, the gravitational field is the structural property of spacetime.

[126] Yvon Sauvageau says: `Once has realized that the Universe can be apprehended as a single body (finite or infinite), one should perceive that the absoluteness of true velocities is not to be rejected offhand. An immediate corollary of Newton's theory is that, without any reaction, there is no action at all. If one considers the entire Universe as one single body to be acted upon, one immediately sees that no action can be done on it, as — by definition — there is no counterpart that can react. And who says no action says no acceleration. This implies that the Universe as a whole never experiences any acceleration (and consequently, no inertial effect). Therefore, we can operationally ascribe the constant velocity 0 to the Universe. All actions and reactions necessarily occur between proper subsets of the Universe. Thus, the Universe is absolutely at rest although it endlessly reshapes itself. In this informal view, Newton's thing is simply the totality of the Universe, and all absolute material motions are relative displacements of its parts with respect to itself. Both Mach's problem and Mach's attack are already answered, albeit informally. This extremely simple argument is quite sufficient in my view to put an end to the relational / absolute debate' [Page 5, 110].

[127] On large scales, the stress-energy tensor of the Universe is taken to be that of a perfect fluid since homogeneity and isotropy imply that there is no bulk energy transport.

11. Referencies

[1] Chinea Domingo. Sobre geometría y física. España.

[2] Jaume Carot. Geometría y física en espacio-tiempos axisimétricos. España. 2005.

[3] Gracia Bondía José M. Einstein y el Año de la Física. España. 2005.

[4] Smolin Lee. Loop quantum gravity. 2003.

[5] Cala Vitery Favio Ernesto. De la relatividad de la inercia a la geometrodinámica intrínseca: Una interpretación relacional del Espacio-tiempo. España. 2006

[6] Weinert Friedel. Relationism and Relativity. Germany. 2006.

[7] Atkinson David. Spacetime. USA. 2004.

[8] Pooley Oliver. Spacetime Realism and Quantum Gravity. England. 2000.

[9] Konstantinov F. El espacio y el tiempo. Cuba. 1986.

[10] Pérez H. y Solbes J. Implicaciones de la evolución histórica de algunos conceptos en la enseñanza de la Relatividad. España. 2006.

[11] Lacroze Federico. El tiempo en la filosofía contemporánea. 1998

[12] Gibson Ian. Time, Objects, and Identity. England. 2007.

[13] Felder Gary. Bumps and Wiggles: An Introduction to General Relativity. USA. 2003.

[14] Von Glasersfeld Ernst. Thoughts about Space, Time and the Concept of identity. Germany. 1984.

[15] Morones Ibarra Rubén. La evolución de los conceptos de espacio-tiempo. Ingenierías, Enero-Marzo 2004, Vol. VII, No. 22. Mexico.

[16] Liberati Stefano. Quantum vacuum effects in gravitational fields: theory and detectability. Italy. 2000.

[17] Kuhne Rainer W. General Relativity Requires Absolute Space and Time. Germany. 2002.

[18] Meschini Diego, Lehto Markku. Is empty spacetime a physical thing?. Finland. 2005.

[19] Ferraro Rafael. Una verificación experimental de la relatividad general a escala terrestre. Astronomía y Física del Espacio. Volumen 9, No 49, Ciencia Hoy. Argentina. 1998.

[20] DeWitt Bryce. Gravedad cuántica. Investigación y Ciencia nº 89 Barcelona. 1984.

[21] Einstein Albert. El significado de la Relatividad. Colombia. 1986.

[22] Veverka A Frank. Gravity Probe B. 2004

[23]Gibson Ian, Pooley Oliver. Relativistic Persistence. England. 2006.

[24] Wikipedia. Filosofía del espacio y el tiempo.

[25] Balashov Yuri. Persistence and Spacetime: Philosophical Lessons of the Pole and Barn. Rusia. 2000.

[26] Díaz Pazos Patricio. Abstracciones sobre la Relatividad. El concepto de espacio en la Relatividad General. 2003

[27] Baez John. General Relativity Tutorial. The Ricci and Weyl Tensors. USA. 2004.

[28] Gómez Cesar. Realismo y Racionalidad: Filosofía de la ciencia en Albert Einstein. El Basilisco, número 7. España. 1979.

[29] Odenwald Sten. Why is the gravitational field of the Universe another name for spacetime?. USA. 1997.

[30] Hedrich Reiner. Quantum Gravity: Has Spacetime Quantum Properties?. Germany. 2009.

[31] Brown Kevin. MathPage. Reflections on Relativity. The field Equations. USA. 1994-2009.

[32] Freund Peter. Physics and Geometry. USA. 2004.

[33] Waite David. Modern Relativity. Chapter 4 Starting GR. The Metric and Invariants of GR. 2005.

[34] Barbón José Fernández. Geometría no conmutativa y espaciotiempo cuántico. España. 2005.

[35] Martin Keye and Panangaden Prakash. A domain of spacetime intervals for General Relativity. USA. 2004.

[36] Baker David J. Spacetime Substantialism and Einstein's Cosmological Constant. USA. 2004.

[37] Rickles Dean and French Steven. Quantum gravity meets structuralism interweaving relations in the foundations of physics. USA.

[38] Thiemann Thomas. The fabric of space: spin networks. German. 2006

[39] De Lucas Javier. Ecuación de campo de Einstein. España. 1988.

[40] MathPage. Reflections on Relativity. USA.

[41] Perez Alejandro. Introduction to loop quantum gravity and spin foams. Proceedings of the II International Conference on Fundamental Interactions. Brazil. 2004.

[42] Guillén Alfonso. La onda gravitacional en 5D. Colombia. 2006.

[43] Baez John and Bunn Emory. The Meaning of Einstein's Equation. USA. 2006.

[44] Brown Peter M. Einstein's gravitational field. USA. 2002.

[45] Arteja S.N. Crítica a los backgroundamentos de la teoría de la relatividad. El principio de equivalencia. Rusia. 2003.

[46] Hoefer Carl. Energy Conservation in GTR. Elsevier Science Ltd. Holanda. 2000.

[47] Lusanna Luca, Pauri Massimo. Explaining Leibniz-equivalence as difference of non-inertial appearances: dissolution of the Hole Argument and physical individuation of point-events. Italy. 2008.

[48] Norton John. Standford Encyclopedia of Philosophy. The Hole Argument. USA. 2008.

[49] Zinkernagel Henrik. The Philosophy behind Quantum Gravity. España. 2006.

[50] Strobl Wolfgang. ¿Hay indeterminismo en la nueva física ? España. 2007.

[51] Meschini Diego. Planck-scale physics: facts and beliefs. Finland. 2006.

[52] Monton Bradley. Presentism and quantum gravity. USA. 2005.

[53] Guillén Alfonso. La velocidad de la Gravedad. Chile. 2006

[54] Weinberg Steven. Partículas Elementales y las Leyes de la Física. Cambridge. 1999.

[55] Peplow Mark. Snapshot of an electron orbital. Nature doi: 10.1038/news041213-7. 2004.

[56] Smit Jan. Introduction to Relativistic Quantum Fields. Netherlands. 2007.

[57] Hooft Gerard't. The conceptual basis of quantum field theory. Netherlands. 2005.

[58] Mora Pablo. Formas de transgresión como principio unificador en Teoría de Campos. Uruguay. 2005.

[59] Bialynicki-Birula Iwo. Nonlinear Structure of the Electromagnetic Vacuum. Poland. 1987.

[60] Davies C W. Quantum vacuum friction. Australia. 2005.

[61] Rugh S.E, Zinkernagely H. The Quantum Vacuum and the Cosmological Constant Problem. Denmark. 2002.

[62] Maclay Jordan /Quantum Fields. ZPV Background. USA. 2000

[63] Setterfield Barry. Exploring The Vacuum.Australia. 2002.

[64] Wesson Paul. Zero-point fields, gravitation and new physics. Canada.

[65] Montesinos Merced. El problema del tiempo en la Relatividad General. Mexico. 2007.

[66] Hooft Gerard't. Dimensional reduction in quantum gravity. Netherlands. 1993.

[67] Astrocosmo. A horcajadas en el tiempo. La unificación de la gravedad. 2002

[68] Daywitt William C. The Source of the Quantum Vacuum. USA. 2008.

[69] Meschini Diego. A metageometric enquiry concerning time, space, and quantum physics. Finland. 2008.

[70] Stanford Encyclopedia of Phylosophy. Quantum Gravity. 2005.

[71] Herdeiro Carlos. M-theory, the theory formerly known as Strings. 1996 University of Cambridge. USA, 1996.

[72] Schwarz Patricia. So what is string theory, then? 2002. USA

[73] Kaku Michio. Una Introducción a la Teoría M. 2005

[74] Pierre John M. Superstrings. USA. 2006

[75] Maartens Roy. Brane-World Gravity. Living Rev. Relativity, 7, (2004),

[76] Rovelli Carlo. Loop Quantum Gravity. USA. 1998.

[77] Cárdenas Martín Santiago. El panorama de la Física actual. 2005

[78] Castelvecchi Davide, Jamieson Valerie. Tú estás hecho de espacio-tiempo. 2006.

[79] Lorente Páramo Miguel. Entra en crisis la teoría de más prestigio en la física teórica. España. 2008.

[80] Zizzi Paola. Spacetime at the Plank scale: The Quantum Computer View. Italy. 2003.

[81] Newsweek. The Force Needed for the Expansion of the Universe. USA. 1998.

[82] On the mathematical formulation of a topological model for the structure of elementary particles of physics according to the ghassemi's spacetime-mass theory of the Universe.USA. 2002

[83] Davydov Isai Shoulovich, Davydov Joseph. God Exists. Russia. 2000.

[84] Felker Laurence G. Las ecuaciones de Evans de la teoría del campo unificado. México.

[85] Fradkin Eduardo. General Field Theory. Introduction to Field Theory. USA. 2008.

[86] Kasap S. O. Optoelectronics. England. 1999.

[87] Folman Ron. Physics 3 for engineering. Israel.

[88] Murphy John. Quantum Theory and Wave/Particle Duality. New Zealand. 2000.

[89] Jones Andrew Zimmerman. Wave Particle Duality. USA. 2006.

[90] Byme Michael. The Duality of Nature: Why N Equals 10. USA. 1999.

[91] Aliza Malz. The Struggle for Particle-Wave Duality. USA. 2005.

[92] Gratton Julio. Introducción a la mecánica cuántica. Propiedades ondulatorias de la materia. Argentina. 2003.

[93] Perella Anthony Paul. Metaparticles. USA.2007.

[94] Rabinowitz Mario. Examination of wave-particle duality via two-slit interference.

[95] Zzimbe J. A Possible Alternative Solution to the Solar Neutrino Problem. USA. 2001.

[96] Palacios Plaza Benigno. La ecuación de Schrödinger. España.

[97] Karch Andreas, Randall Lisa. Relaxing to Three Dimensions. USA. 2005.

[98] Weinberg Steven. Los tres primeros minutos del Universo. España. 1993.

[99] Einstein Albert. La Física aventura del pensamiento. Argentina. 1974.

[100] Rincon Paul. God particle' may have been seen. England. 2004.

[101] Enciso Fernández Santiago. Contribución al Conocimiento de los espacios n-dimensionales.

[102] Tegmark Max. On the dimensionality of spacetime. USA. 1997.

[103] Reid David D., Kittell Daniel W., Arsznov Eric E., and Thompson Gregory B. The picture of our Universe: A view from modern cosmology. USA. 2002.

[104] Tassev Svetlin Valentinov. Quantum Field Theory of Scalar Cosmological Perturbations. USA. 2005.

[105] Castellanos Moreno Arnulfo. El espaciotiempo en la física. México.

[106] Hawking Stephen. El Espacio y el Tiempo se Curvan. España. 2007.

[107] Artime Miguel, Philips Tony. Entrevista a Paul Davies. Australia. 2004.

[108] Lorente Miguel. El espacio-tiempo sigue siendo un enigma para la ciencia y la filosofía. España. 2007.

[109] Zubiri Xavier. Respectividad de lo real. Trabajos de Seminario Xavier Zubiri, Pages 13-43. España. 1979.

[110] Sauvageau Yvon. Absolute spacetime is inherent to dynamics. Physics Essays, Volume 18 No. 3. USA. 2005.

[111] Byme Michael. Spatial Gravity. USA. 2000.

[112] Guillén, Alfonso. Spacetime structural property of the matter in movement. Contributed papers. Petrov 2010, Anniversary Symposium on General Relativity and Gravitation. Russia. 2010.

[113] Guillén, Alfonso. What is spacetime? Colombia. 2018.

[114] Guillén, Alfonso. Are dark matter and dark energy opposite effects of the quantum vacuum? Colombia. 2018.

[115] Guillén, Alfonso. The medium for motion: a critical clue to understand spacetime. International Journal of Modern Physics and Applications Vol. 1, No. 5. USA. 2015.