In General Relativity, gravity is effect of coordinates with change of geometry of spacetime

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Abstract

Einstein structured the theoretical frame of his work on gravity under the Special Relativity and Minkowski´s spacetime using three guide principles: The strong principle of equivalence establishes that acceleration and gravity are equivalents. Mach´s principle explains the inertia of the bodies and particles as completely determined by the total mass existent in the universe. And, general covariance searches to extend the principle of relativity from inertial motion to accelerated motion. Mach´s principle was abandoned quickly, general covariance resulted mathematical property of the tensors and principle of equivalence inconsistent and it can only apply to punctual gravity, no to extended gravity. Also, the basic principle of Special Relativity, i.e., the constancy of the speed of the electromagnetic wave in the vacuum was abandoned, static Minkowski´s spacetime was replaced to dynamic Lorentz´s manifold and the main conceptual fundament of the theory, i.e. spacetime is not known what is. Of other hand, gravity never was conceptually defined; neither answers what is the law of gravity in general. However, the predictions arise of Einstein equations are rigorously exacts. Thus, the conclusion is that on gravity, it has only the equations. In this work it shows that principle of equivalence applies really to punctual and extended gravity, gravity is defined as effect of change of coordinates although in the case of the extended gravity with change of geometry from Minkowski´s spacetime to Lorentz´s manifold; and the

gravitational motion is the geodesic motion that well it can declare as the general law of gravity.

KEYWORDS: Relativity, gravity, inertia, spacetime, law of gravity.

1 Introduction

Previous to General Relativity, three events occurred around to the Special Relativity are transcendent to the geometrization of gravity. The first event was in 1907 when Albert Einstein sought found a new physical theory based in "physical laws are independent of the state of motion" [1], using as frame the Special Relativity and the principle of equivalence between inertial and gravitational masses. The second was in 1908-1909 when Hermann Minkowski introduced "geometric methods and thinking into in Relativity theory" [2] inspired in the works of Felix Klein on the new geometries non-Euclidean in his Erlangen program. And the third event was in 1913 when Grossmann drove to Einstein to introduce the Absolute Differential Calculus into in the Relativity.

In the spacetime of Minkowski (4-M) orthogonal just as the space of Euclid but defined with ct as the fourth dimension and of such form, that c is la maximum possible speed while the space of Euclid allows speeds that can reach infinite value, Einstein generalized the principle of Galileo Galilei only valid in the inertial systems to any arbitrary system: accelerated and gravitational systems, as if the motion does not exist, based in that the bodies have inertial and gravitational masses; both numerically are equal, demonstrated among others by Galileo, Newton, Eotvos and CNES microsatellite. As consequence, the gravitational motion of a small test body is independent on its constitution and, therefore, it depends only on its initial position in spacetime and velocity, named weak equivalence principle (WEP).

Of other hand, derived of Erlangen program, the traditional algebraic instrument of support of physics was replaced by the geometric instrument. So, based in Special Relativity, "Minkowski pointed out that geometers had concentrated on the characteristic transformations of space. But they had ignored the groups of transformations associated with mechanics, those that connected various inertial states of motion. Minkowski proceeded to treat these groups in exactly the same way as the geometric groups. In particular he constructed the geometry associated with the Lorentz transformation. To begin, it was not the geometry of a space, but of a spacetime, and the notion of spacetime was introduced into physics almost as a perfunctory by-product of the Erlangen program. Moreover he found the spacetime had the hyperbolic structure now associated with a Minkowski spacetime. From this geometric perspective, the formulation of a theory that satisfied the principle of relativity in inertial systems became trivial. One merely needed to formulate the theory in terms of the geometric entities of the spacetime effect the various types of spacetime vectors Minkowski had defined-and the theory would be automatically Lorentz covariant" [2]. The Erlangen program sowed sinisterly in the physics the seed that with the General Relativity it gave as fruit the geometrization of gravity when adopting the Riemann´s geometry.

The bridge between Special Relativity and General Relativity was the Entwurf theory when Einstein associated with Marcel Grossmann introduced the Absolute Differential Calculus and, therefore, the tensors yet in the Minkowski´s spacetime, failing in obtain in the Newtonian limit the law of gravity of Newton.

However, the advent of the General Relativity was not the result of controlled and progressive adoption of the method and geometric thinking in the physics but of a conjunctural crisis arose of the fortuitous and hard competency between Hilbert, the best germane mathematician of the epoch, and Einstein during July and November of 1915 when they worked similar equations. Paradoxically, the use of the very advanced geometric apparatus of the absolute differential calculus in the Entwurf theory, away of serve to the geometrization of gravity, was for formulate gravity as a physical phenomenon of a specific class of the energy: the gravitational energy. So, Einstein was abandoned his conception initial of gravity as effect of coordinates. But, his desperate competency with Hilbert in the precise moment when his equations of Entwurf theory were failed, Einstein was caught by the game of Hilbert releasing all the power of his advanced tool that from then on it works autonomously a bit like as Aladdin that rubbing a magic lamp released to a unpredictable genius. Einstein in the Entwurf theory was six decades, ahead of his time when Logunov and Mestvirishvili formulated the Relativistic theory of Gravitation in the conception that Einstein had in that theory.

Remarkable of this history is whether well owing to his academic formation Einstein structured his scientific investigation initially inside of the frame of principles with the pass of nine years he cannot support them finalizing in a very powerful equations of very difficult operation. During this long time the fundamental concepts as spacetime and gravity never were conceptually defined but operationally.

The problem of the preservation of the principles in the final result has been object of study and valuation of great philosophers of the science as Norton, Earman and Glymour between others. And it seems that everything has already been said. However, in this work the author presents a new interesting interpretation of gravity, in General Relativity, i.e, punctual and extended gravity as effect of coordinates. Our study takes as object only the principle of equivalence of Einstein, EEP, and its evolution from Special Relativity to General Relativity. The result recovers the theoretical frame to General Relativity from the perfect application of EEP, now transcendent EEP and gravity is put out of its sad current geometric definition, passing gravitational motion to geodesic motion that would be the true law of gravity. The new problem is which EEP is inconsistent as was showed previously by Logunov [27] and the author [33] between others. But, our work well is justified because crucially shows that are unsustainable the theories that to name of the General Relativity assign energy and moment to the gravitational field.

2 In Special Relativity, gravity is an effect of coordinates

On "the happiest thought of my life", Einstein imagined that if he was in free fall would have no weight and he understood gravity as only acceleration, and through of the WEP he derive the called strong equivalence principle (SEP) compound of local Lorentz invariance (LLI) and local position invariance (LPI). LLI means that "the outcome of any local non-gravitational experiment is independent of the velocity of the freely-falling reference frame in which it is performed" [3]. And LPI means that "the outcome of any local non-gravitational experiment is independent of where and when in the universe it is performed" [3]. WEP more SEP is the Einstein equivalence principle (EEP).

Einstein generalized the Galilei principle to any uniformly translational accelerated system (accelerated uniform motion), homogeneous gravitational system and rectilinear uniform movement (inertial system). From EEP he obtained that any accelerated system can be considered as an inertial system although located in a gravitational field and this system, in free fall, as an inertial system.

The inertial motion, accelerated motion and gravitational motion are relative states [4], i.e., simple effects of change coordinates, as if acceleration, gravity and inertial motion did not really exist. So, rather the motion would arise from the perception of the observers of bodies in the spacetime according to his particular frame of reference respect others.

Of according with the observers the notion of motion arises of the relation between the bodies in their relative positions in the spacetime existing in itself, according to the substantivalism while for the relationism the spacetime arises of the geometric relations of position between them. However, both conceptions on spacetime coincide in the relative states of rest, rectilinear uniform motion, gravitational homogenous motion and accelerated uniform motion. And there would be the equivalence between:

1. The relative rest and the relative rectilinear uniform motion.

2. The relative rectilinear uniform motion and the relative gravitational homogenous motion.

3. The relative gravitational homogenous motion and the relative accelerated uniform motion.

Of course, from former equivalences is obtained the equivalence between:

4. The relative rectilinear uniform motion and the relative accelerated uniform motion.

Therefore, motion would be uncertain and in the background all kinds of movement the same thing. Thus, the laws of physics, Newton's laws and Maxwell's laws are the same in all reference frames independent of their state of motion (principle general of relativity) like if such preservation of the physical laws were a property of the spacetime (more credible as substantial spacetime). The motion arises of the illusory perception of the observers according to their relative coordinates respect to others. If according to their frames of reference there is change of coordinates then they are in relative motion with each other. In the contrary case they are in relative rest.

3 According EEP, Gravity effects

Einstein obtained theoretically from EEP that the static gravitational field becomes the speed of light no constant and curves its trajectory. Also, it changes running of the clocks and it must change length of the measuring rods. These changes are owing to the gravitational potential, in first approximation yet in terms of Newton.

"Equivalence hypothesis provides a means of deriving the properties of the gravitational field in a theoretical way" and "it leads to a dependence of the velocity of light in vacuum on the gravitational potential" [5], breaking with the constancy of this velocity, one principle of the Special Relativity. "The value of c at accelerated field and gravitational field is $c\left(1+\frac{\Phi}{c^2}\right)$". "Thus light rays do not propagate along the x-axis are bent by the gravitational field; it can easily be seen that the change of direction amounts to $a/c^2 \sin\psi$ per cm light path, where ψ is the angle between the direction of gravity and that of the light ray". Similarly, "a local clock located in a point P of gravitational potential Φ runs $\left(1+\frac{\Phi}{c^2}\right)$ times faster than a clock located at the coordinate origin" [4]. Too, Einstein established that gravitational potential affect in inverse proportion the electromagnetic wave-length. For example: "the wave length of light coming from the Sun's surface, which originates from such a producer, is larger by about one part in two millionth than that of light produced by the same substance on Earth" [6].

Of course, in Special Relativity the curve path of light propagating down gravitational field is not caused by curvature in the spacetime since this is plane, but by gravitational potential that until 1913 it believed circularly was caused by velocity of the light. In addition, the gravitational field exerts a force on any mass point. The force exerted, on a mass point in rest, is $-m\frac{\partial c}{\partial x}$ [6].

The changes in the running of the clocks and in length of the measuring rods are physical changes like in accelerated uniform motion while in the inertial systems, in relative motion, are always simple effect of change of coordinates between them.

The previous considerations make that it is not possible full equivalence between inertial systems and accelerated systems. Neither, gravitational static field can be a simple effect of change of coordinates because under its action it causes physical changes in the physical processes, in electromagnetic wave and it is exerted a force on the mass point. Else while in accelerated systems the curvedly of electromagnetic wave is only apparent, in gravitational systems it is real.

4 Severe restrictions for the application of SEP

The naive conception, on motion and gravity derived of EEP, had immediately problem in front of Newton and Special Relativity. SEP in Newtonian mechanics only is valid to first order, i.e., two test masses separate to a little distance at a gravitational potential Φ, they would have equal acceleration and they would be at relative rest. However, at a second-order since they are at different positions, they experiment different gravitational force, as the tidal force proportional to $\frac{\partial^2 \Phi}{\partial x_i \partial x_j}$

Of other hand, in Special Relativity, SEP is valid only to the uniformly accelerated field and homogeneous gravitational field, also known as uniform gravitational field, existing in infinitesimal lapses of spacetime 4-M, although space and time taken separately, because one second is 300 million meters. This severe limitation in the application of SEP is due to the relativistic effects predicted on the space of shortening of length and of dilatation of the time must be null. As well as preserve the constancy of the speed of the electromagnetic wave in the vacuum. Such changes occur in direct function to the velocity in the accelerated field and according to equivalence principle of the gravitational potential in the gravitational field.

5 Einstein undertook the quest for a physical theory of gravity although without renouncing EEP.

Einstein understood that the theory of static gravitational field only basing in EEP is insufficient, supposing the gravitational potential has something physical. It could be a phenomenon of the energy since it is associated to the speed of the electromagnetic wave. But, with the Absolute Differential Calculus, he reached contradictorily the generalization of the principle of relativity valid in the inertial systems to the accelerated systems. Such success was resulted of use of this mathematical apparatus that to Einstein permitted represent physical quantities as geometrical objects. Thus, Einstein replaced physical reality by its phantasmagoric geometric projection of its abstract background although at this moment due to methodological reason, i.e. modeling geometrically the reality.

"Einstein's 1911 and 1912 papers on gravitation develop a scalar theory of static gravitational field, in which the velocity of light plays the role of the gravitational potential. Accordingly, the theory could not be invariant under Lorentz transformations. The principle of equivalence was in outright contradiction with the Special Relativity, and no generalization seemed at hand which would save the principles of the latter.

When in 1912 Einstein undertook to master the tensor calculus with the help of his friend Marcel Grossmann, it may very well have been exactly because the new mathematical apparatus appeared to offer a means to save gravitational theory, the principle of equivalence and the principle of relativity all at once.

The Absolute Differential Calculus would permit the representation of quantities as geometrical objects, and would further permit the statement of relations between such quantities in such a way that they would hold in every frame of reference if they held in any" [7].

At last, the question that Einstein asked in 1907 was answered affirmatively, since until 1912, while velocity is relative, the acceleration was absolute due he had wrote that the principle of relativity no holds for accelerated systems. Therefore, “the principle of covariance would bring with it the generalization of the principle of relativity” [7].

Respect to relative accelerated system, in 1914, Einstein wrote: “The law of motion of the material point, and there with the whole of mechanics, indeed the whole of theoretical physics, were based by Galileo and Newton on the concept of acceleration. But a simple analysis shows that acceleration is accessible to observation only as relative acceleration with respect to other bodies, that we are only able to define a relative acceleration. It is therefore doubtful that the Galilean- Newtonian law of motion, which says that bodies exert a resistance to acceleration, says something about acceleration in itself (absolute acceleration, not relative acceleration). The new theory of gravitation avoids this inconsistency; according to this theory, inertia shows up as a resistance against the relative acceleration of bodies” [8].

Thus, Einstein obtained new success in the generalization of the relative principle similar to when this principle was made trivial in the inertial systems of the Special Relativity with the introduction of geometric methods by Minkowski into in Relativity theory.

6 Einstein abandoning EEP

In 1913, in the Entwurf theory by first time the tensor calculus was used in the Relativity. Einstein-Grossmann formulated the strong equivalence principle for the uniform curvilinear motion existing in 4-M, therefore, in terms of the homogeneous gravitational field, although its scope was limited, "to the infinitesimally extended", which leads to the bad concept of the straightness of any curve in the infinitesimal limit, or what is the same, something informally that the infinitesimal limit of the curve is the straight line.

The principle of equivalence embracing gravity required that the velocity of light not be constant. Einstein wrote: “the empirical fact that all bodies fall equally fast in a gravitational field suggests the idea that physical processes occur in exactly the same way in a gravitational field as they do relative to an accelerated reference system (equivalence hypothesis). Having taken this idea as a basis, I arrived at the result that the velocity of light is not to be regarded as independent of the gravitational potential. Thus, the principle of the constancy of the velocity of light is incompatible with the equivalence hypothesis; for this reason, the theory of relativity in the narrower sense cannot be brought into agreement with the latter. In this way I was led to view the theory of relativity in the narrower sense as valid only for regions within which there are no noticeable differences in the gravitational potential” [9].

“The invariant interval of Minkowski in differential form

$ds^2 = c^2dt^2 - dx_1{}^2 - dx_2{}^2 - dx_3{}^2$ i.e., $ds^2 = \eta_{\alpha\beta}dx_\alpha dx_\beta$ -aggregated by author- (Eq. 1)

where (x_1, x_2, x_3, t) are the space and time coordinates of an inertial frame of reference in a Minkowski spacetime. Transforming to arbitrary coordinates x_μ for $\mu = 1, \ldots ,4$ becomes

$ds^2 = g_{\mu\nu}dx_\mu dx_\nu$ (Eq. 2)

Einstein employed his principle of equivalence to interpret the matrix of quantities $g_{\mu\nu}$ that had arisen with the introduction of arbitrary coordinates. In the special case of the principle, the transformation from equation (1) to equation (2) is from an inertial coordinate system to a uniformly accelerated coordinate system. In that case, the matrix of coefficients $g_{\mu\nu}$ reduces to that of equation (1) except that c now is a function of the coordinates (x_1, x_2, x_3). That is, equation (2) becomes

$$ds^2 = c^2 (x_{1,} x_{2,} x_3)\, dt^2 - dx_1^2 - dx_2^2 - dx_3^2 \qquad \text{(Eq. 1′)}$$

According to the principle of equivalence, the presence of a gravitational field was the only difference between the spacetime of equation (1') and that of special relativity equation (1)" [2].

In consequence, the gravitational field instead of the line element $c^2dt^2 - dx_1^2 - dx_2^2 - dx_3^2$ is defined by a symmetric tensor g_{uv} with 10 components as the fundamental invariant. Therefore, it is the fundamental tensor or metric tensor. Thus, "the ten quantities g_{uv} characterize the gravitational field; they replace the scalar gravitational potential (p of Newtonian gravitation theory, and form the second-rank fundamental covariant tensor of the gravitational field. The fundamental physical significance of these quantities g_{uv} consists, i.e., in the fact that they determine the behavior of measuring rods and clocks" [10].

Einstein found the occurrence of the gravitational field connected with the variability of g_{uv}. When $g_{uv} = \eta_{\alpha\beta}$, i.e., the g_{uv} are constant values, it has a flat spacetime, that implies the vanishing of the Riemann tensor, fundamental condition for that the g_{uv} may be constants, also it requires the appropriate choice of the system of reference, referring to a determined finite lapse of the spacetime.

"Although Einstein describes the metric tensor as the quantities which describe the gravitational field he describes it is the Christoffel symbols which are defined as the components of the field" [11]. These symbols are equivalent to the field force in Newton and they are obtained as the second derivatives of the metric tensor. Therefore, the metric tensor is equivalent to the gravitational potential in Newton. Of other hand, the geodesic deviation is equivalent to the acceleration in Newton. These equivalences are evident in the Newtonian limit of General Relativity but no in the gravitational field stronger and they are justly an analogy owing to the radical conceptual difference of gravity as absence of force in General Relativity and effect of force in Newton.

In 1916, Einstein wrote: "If the $\Gamma^{\omega}{}_{uv}$ vanish, then the point moves uniformly in a straight line. These quantities therefore condition the deviation of the motion from uniformity. They are the components of the gravitational field".

"The relations of the four-dimensional vector calculus go over into those of the absolute differential calculus. According to this generalization, each system of physical equations includes the influence exerted by the gravitational field on the group of phenomena that correspond to the equation system in question" [5].

Einstein understood that in particular case the gravitational field can be described as effect of coordinates but it must be in general a phenomenon of the energy. Thus "every physical process must also generate a gravitational field, because quantities of energy correspond to it" [9]. Then, he sought that material process equations and gravitational field equations were generally covariant to express the laws of momentum and energy conservation taken both together but he declined immediately due to the impossibility to gravitational field equations that only admit linear transformation.

"These generalized equations are generally covariant. However, it proves logically impossible to set up equations for the determination of the gravitational field (i.e., of the g_{uv}) that are covariant with respect to arbitrary substitutions. With the laws of momentum and energy conservation taken as the starting point, we obtain the result that we can choose the reference system (to which the space-time "coordinates" x, y, z, t are referred) in such a way that only linear but, in contrast to the customary theory of relativity, arbitrary linear substitutions leave the equations covariant" [5].

7 Gravity cannot be a simple effect of change of coordinates

With the years of analysis on gravity, Einstein distinguished two manifestations of the phenomenon of gravity: The punctual and the extending in the spacetime. While the first can be explained as effect of coordinates, the second no. Of course, while the first is a particular case, the second is the general case.

At first, however, Einstein used a promising language in which he seemed to solve the problem of generalization through the principle of relativity, since he also distinguished between the principle of relativity in the narrow sense and this principle in the extended sense when both can be applied only to the specific case, because the principle of relativity really in an extended sense is not possible to make it correspond to the extended gravity case.

The scientific knowledge of any phenomenon of study only it is reached when it is explained in general the phenomenon. Therefore, it is not admissible that the particular case of gravity was used by Einstein as foundation of the explication of the case general of gravity which in essence is a phenomenon of the energy and not an apparent phenomenon of relative motion simple effect of coordinates.

On 29 September of 1913, "On the present state of the problem of gravitation", and ratified in 1915 and 1925, "Theory of the Relativity", Einstein had to give up his conception of gravity as effect of coordinates; he specifically wrote: "An physicist sharing our standpoint can characterize the gravitational field as "apparent" because by a suitable choice state of acceleration, he can bring it about that in a given spacetime point no gravitational field is present. But it is obvious that for extended gravitational fields this vanishing of the gravitational field cannot, in general, be achieved for a transformation. For example, it would not be possible to make the gravitational field of the Earth vanish by choosing an appropriate reference system" [9], [12]. "The field was later to become known as a permanent gravitational field. Permanent gravitational fields are not equivalent to uniformly accelerating frames of reference" [11]. With this declaration is clear that Einstein admitted that gravity exists and it is really a physical phenomenon.

Einstein adverted that "The theory of relativity (in the narrower sense) had to be replaced by a more general theory that contains the former as a limiting case" [9]. But the extended theory of relativity, constructed by Einstein, could not embrace the general case of extended gravity.

However, with the geometric power of Absolute Differential Calculus Einstein reached in the equations the general covariance that he presented to the final as the realization of the general principle of relativity supposedly encompassing the general case of extended gravity. Einstein highlights the independence of the g_{uv} of the choice of the spacetime coordinates x_v although in function of the x_v but which are determined by the physical process happenings in all of the rest of the universe according to named principle of Mach (principle of Einstein really because Mach said he was not his author), the relativity of the accelerated motion, the double relation, in both directions, between physical process and gravitational field and the fundamental law of conservation of energy and momentum taken together.

"The equation of motion of a mass point in a gravitational field that follows from the equivalence hypothesis can easily be written down in a form in which this law is totally independent of the choice of the variables that determine place and time. By leaving the choice of these variables a priori totally arbitrary, and thus not privileging any specific space-temporal systems, one avoids the epistemological objection explained above. In that law of motion there appears a quantity $ds^2 = g_{\mu v}dx_\mu dx_v$

which is an invariant, i.e., a quantity independent of the choice of the reference system (i.e., of the choice of the four space-time coordinates). The quantities g_{uv} are functions of x_1 .. x_4 and serve to represent the gravitational field.

With the help of the absolute differential calculus, which was developed by Ricci and Levi-Civita on the basis of Christoffel's mathematical investigations, it is possible, based on the existence of the above invariant, to replace the familiar systems of equations of theoretical physics by such equivalent systems (in the case of constancy of all of the g_{uv}) that hold totally independently of the choice of the space-time coordinates x_v. All such systems of equations contain the quantities g_{uv}, i.e., the quantities that determine the gravitational field. The latter therefore have an influence on all physical processes.

Conversely, the physical processes must also determine the gravitational field, i.e., the quantities g_{uv}. One arrives at the differential equations that determine these quantities by means of the hypothesis that the momentum and energy conservation laws must hold for the material processes and the gravitational field taken together. This hypothesis also restricts, after the fact, the choice of the space-time variables x, without, however, arousing again the epistemological doubts analyzed earlier. Because according to this generalized theory of relativity, physical properties peculiar to privileged spaces no longer exist. The course of all processes is governed by the quantities g_{uv}, which are in turn determined by the physical processes happenings in all of the rest of the universe.

The principle of the inertia and the gravitation of energy are completely satisfied in this theory. Further, the laws of motion of gravitational masses are such that it is not absolute acceleration (acceleration with respect to space) that appears as that which is decisive for the occurrence of inertial resistance, but instead-as must be demanded on the basis of the above considerations-acceleration with respect to other bodies. The theory of relativity in the broader sense does not signify the abandonment of the earlier theory of relativity, but rather a further development of the latter that seems to me necessary for the epistemological reasons I pointed out" [9].

8 Einstein elaborating a general theory on gravity

In this moment, Einstein determined the three methodological guides to elaborate a general theory on gravity based in the Poisson's equation:

1. The g_{uv} should be determined by the energy tensor of the matter and obtained from it.
2. Obtain general covariant equations since they would realize the principle general of relativity.

3. Preserve the law of conservation of the energy and impulse of material process and gravitational field together.

"The energetic behavior of a system is characterized by the energy tensor $\frac{T_{ov}}{\sqrt{-g}}$ (mixed tensor). Since energy and inertia on the one hand, and inertia and gravitation on the other hand, determine one another, we must demand that the gravitational field be determined by the quantities T_{ov}. Thus, we are to seek differential equations that are to be considered a generalization of Poisson's equation and which, therefore, permit the calculation of the g_{uv} from the T_{ov}; these equations must be generally covariant". But, "We have not succeeded in setting up this relation between the g_{uv} and T_{ov} in a generally covariant form"

"The gravitational field transfers momentum and energy to the matter. But if the conservation laws are to remain at all valid, we must demand that there be conservation laws … for the matter and the gravitational field taken together. Then there will have to be a system of equations of the form

$$\sum_{v} \frac{T_{\mu v} + t_{\mu v}}{\partial x_v} = 0 \qquad \text{(Eq. 3)}$$

where the $t_{\mu v}$ depend only on the g_{uv} and their derivatives. But, there not are generally covariant systems of equations of the type of equations (3). Instead, closer examination shows that such systems are covariant only with respect to linear transformations. By demanding that the field equations of gravitation be formulated in such a manner that the validity of the conservation laws finds expression in this formulation, we therefore restrict the choice of the reference system in such a way that only linear transformations lead from one justified system to another on" [14].

9 What is gravity?

In the Entwurf theory "Einstein interpreted the coordinate dependent c of equation (1') as representing a gravitational field and, more generally, the $g_{\mu\nu}$ of equation (2) as representing a gravitational field" [2]. "the ten quantities g_{ik} characterize the gravitational field; they replace the scalar gravitational potential (p of Newtonian gravitation theory"…"the stress-energy components of the gravitational field are not contained in them" …"the t_{ov} characterize the stress-energy components of the gravitational field in a manner analogous to the way in which the quantities T_{ov} characterize those of the material process" [10]… "the motion of the mass point is determined by the quantities g_{uv}" [13]… "In light of the remarkable fact that we recognize in the gravitational field a physical state of space"… "the gravitational field… is thus a physical state of space that simultaneously determines gravitation, inertia, and the metric" [12]. "The spacetimes represented by (1), (1') and (2) are all flat" [2]. So, according considerations arisen from Special Relativity Einstein had restricted the gravity as effect of coordinates to a special case therefore he must reach a general theory, which he sought inside of a material context. But, Einstein didn't know definitely what gravity is.

In the Entwurf theory Einstein had found that the $g_{\mu\nu}$ "influences the measuring bodies and clocks in a determinate manner" [6], i.e., the geometry or the metric in general is determined by the gravitational field, and he had stablished the momentum-energy equations for material process in relation to the gravitational field according:

$$\sum_{\mu\nu} \frac{\partial \sqrt{-g}\, g_{\sigma\upsilon} T_{\mu\nu}}{\partial x_{\nu}} - \frac{1}{2} \sum_{\mu\nu} \sqrt{-g} \frac{\partial g_{\mu\nu}}{\partial x_{\sigma}} T_{\mu\nu} = 0 \qquad \text{(Eq. 4)}$$

σ=(1,2,3,4) equations σ=(1,2,3) express momentum, σ=4 energy laws and $g = |g_{\mu\nu}|$. The equations are covariant with respect to arbitrary substitutions

"These equations represent in general the energy balance between the gravitational field and an arbitrary material process. The first term contains the space derivatives of the stresses or of the density of the energy flow, and the time derivatives of the momentum density or of the energy density", i.e. the effects exerted by the material process on the gravitational field; "the second term is an expression for the effects exerted by the gravitational field on the material process" [6]; "The course of all processes is governed by the quantities g_{uv}, which are in turn determined by the physical happenings in all of the rest of the universe" [9].

So in absolute contradiction with the now particular case of gravity as effect of coordinates in general the gravitational field acquires material reality that maybe it was obtained from the perspective of the theory on the electrostatic field, on the momentum transferred from this field to matter, that Einstein included in the Entwurf theory; of course, Einstein was breaking with gravity as a simple effect of coordinates and in particular as effect of c in function of the space coordinates [6] that led to Einstein to seek the generalization of the Poisson´s equation

$$\Delta\varphi=4\pi k\rho \qquad \text{(Eq. 5)}$$

in the terms in that would be the true relativistic theory on gravity, of such a way, the gravitational field is determined by stress-energy tensor $T_{\mu\nu}$.

Einstein using the method of the Poisson´s equation explicitly in the theory of the Relativity on gravity he introduced the following restriction: Generalized equations of material process are generally covariant while the equations for the determination of the gravitational field (i.e., of the g_{uv}) are linearly covariant. "With these restrictions on the reference system, one attains completely determinate equations of gravitation that satisfy all of the conditions that we may impose on the gravitational equations" [5].

10 In the transition to General Relativity, gravity is a phenomenon of the energy

In September of 1913, "On the present state of the problem of gravitation" Einstein fixed the frame to formulate a valid theory of gravitation as phenomenon of the energy. Its most basic postulates were.

1. Satisfaction of the law of conservation of momentum and energy that leads to seek the generalization of the Poisson´s equation $\Delta\varphi=4\pi k\rho$ of such form, that gravity field is determined by stress-energy tensor $T_{\mu\nu}$ and generated by $t_{\mu\nu}$ as it was stablished after.

2. Equality of the inertial and the gravitational mass of isolated systems.

3. Validity of the theory of relativity (in the narrower sense); i.e., the equation systems are covariant with respect to linear orthogonal substitutions (generalized Lorentz transformation).

4. The observable laws of nature do not depend on the absolute magnitude of the gravitational potential (or gravitational potentials). Physically, this means the following: the set of relations between observable quantities that one can determine in laboratory is not changed if I bring the whole laboratory into a region of a different (spatially and temporally constant) gravitational potential.

The enumeration that Einstein did of the postulates suggest as the more basic the law of conservation of momentum and energy since it would determine the physical character of the gravity theory. The other three postulates are components of the EEP therefore they determine gravity as effect of coordinates.

Of course, Einstein emphasized in the special importance of postulate 1 since he wrote: "All theoreticians will agree with one another that postulate 1 must be adhered to" [13].

In the Entwurf theory, Einstein and Grossman from the Poisson´s equation (5) had given material character to gravitational field, since they had written: "the gravitational equations are of the form:

$$\Delta_{\mu\nu}(\varphi) = k(T_{\mu\nu}+t_{\mu\nu}) \qquad \text{(Eq. 6)}$$

These equations satisfy a requirement that, in our opinion, must be imposed on a relativity theory of gravitation; that is to say, they show that the tensor t_{uv} of the gravitational field acts as a field generator in the same way as the tensor T_{uv} of the material processes" [6]. They warned: "An exceptional position of gravitational energy in comparison with all other kinds of energies would lead to untenable consequences". For example, one zero gravitational energy.

Immediately, they obtained the equations:

$$\sum_{\mu\nu} \frac{\partial \sqrt{-g}\, g_{\sigma\upsilon}(T_{\mu\nu}+t_{\mu\nu})}{\partial x_{\nu}} = 0 \qquad \sigma=(1,2,3,4) \qquad \text{(Eq. 7)}$$

Then, they wrote: "This show the conservation laws hold for the matter and the gravitational field taken together" [6].

The conception of Einstein on gravitational field as a phenomenon of the energy is clearly ratified in "On the present state of the problem of gravitation" when he wrote: "According to the theory of relativity, the inertial mass of a closed system (the latter being considered as a whole) is determined by its energy. According to 2, the same must also hold true for the gravitational mass. Thus, if the state of a system changes in an arbitrary fashion but without its total energy being changed, then the distant gravitational action of the system does not change, not even if a part of the energy of the system is converted into gravitation energy. The gravitating mass is determined by its total energy, including its gravitational energy" [13]. That Einstein ratified again in "On the Relativity Problem" when he wrote: "The energy of a closed system includes also the energy of its gravitational field; thus, the latter energy must itself contribute not only to the inertial but also to the gravitational mass of the system" [9]. Of course, the energy of the gravitational field is of the static gravitational field and no of gravitational waves.

In the equations (6) Einstein found that the tensor of gravitational energy $t_{\mu\nu}$ and the tensor of material process $T_{\mu\nu,}$ taken together, determining the gravitational field expressed through of $\Delta_{\mu\nu}$ (φ) that with equations (7) drove to "the coefficients g_{uv} as given functions of the x_{ν}. And these coefficients are to be understood as the components of the gravitational potential" [15].

This system of equations (6) was presented as the generalization of the Poisson equation, and although, Einstein would have wanted they were general covariant since he believed wrongly they were the generalization of principle of relativity, that he reached apparently in the General Relativity but the general covariance truly as the freedom to use arbitrary spacetime coordinate systems "is now shared by virtually all modern formulations of spacetime theories, including modern versions of special relativity and Newtonian spacetime theory" [16]. However, the Entwurf theory is covariant limited because $t_{\mu\nu}$ is only conceivable to through of linearly transformations. Thus, Einstein declared he could not demonstrate general covariance for those gravitational equations due they were obtained (beside the conservation law of energy really the true problem) from the covariance with respect to linear transformations.

Einstein supposed through of equivalence principle between a gravitational system and an accelerated system could sustainer them as permissible transformations with the general covariance. But in the Entwurf theory, Einstein had to leave definitely the general covariance through the hole argument, with the which Einstein "purported to demonstrate that any generally covariant gravitational field equations in the context of the Entwurf theory would violate physical determinism in a severe and striking manner" [17], which was declared later overcome in the General Relativity and accepted currently as active covariance due to John Earman, John Stachel and John Norton.

Einstein sought that the gravitational field cannot be determined completely by generally-covariant equations becoming indeterminist the theory. Thus, although, it would expect from the law of the conservation of the momentum and energy of the material process, equation (7), that the equations (6) of the gravitational field were general covariant, i.e, respect to arbitrary transformations; this setup is only covariant to arbitrary linear transformations. In reality, the true reason was that $t_{\mu\nu}$ is only possible of linear transformations. "In mid-1913 he published a compromise: a sketch of a relativistic theory of gravitation that was not generally covariant.

His failure to find an admissible generally covariant theory troubled Einstein greatly. Later in 1913 he sought to transform his failure into a victory of sorts: he thought he could show that no generally covariant theory at all is admissible. Any such theory would violate what he called the Law of Causality—we would now call it determinism. He sought to demonstrate this remarkable statement with the hole argument.

In its original incarnation, Einstein considered a spacetime filled with matter excepting one region, the hole, which was matter free. (So in this original form, the term "hole" makes more sense than in the modern version.) He then asked if a full specification of both metric and matter fields outside the hole would fix the metric field within. Since he had tacitly eschewed Leibniz Equivalence, Einstein thought that the resulting negative answer sufficient to damn all generally covariant theories" [16].

11 Einstein abandoned general covariance

Einstein and Grossman do not found general covariant equations for the gravitational field, and they warned as very important to the philosophy of the spacetime and the theory on the physics to establish any possibility of find them, being discarded with the hole´s argument owing that for obtain general covariance is required the tensor g_{uv} must be completely determined being impossible since a hole absent of matter would cause indeterminism eliminated with limited covariance. They wrote: "In a paper published in 1913 we based a generalized theory of relativity upon absolute differential calculus in a manner such that it also embraces the theory of gravitation. Two basically different kinds of systems of equations occur in this theory. For a gravitational field considered as given, we first established systems of equations for material (e.g., mechanical, electrical) processes. These equations are covariant under arbitrary substitutions of the space-time variables (coordinates) and can be considered as generalizations of the corresponding equations of the original theory of relativity. Second, we established a system of equations that determines the gravitational field insofar as the quantities that determine the material processes are given; and this system can be considered a generalization of the Poisson equation of Newton's theory of gravitation. In the original theory of relativity, there is no corresponding system of equations for this. In contrast to the equations mentioned above, we could not demonstrate general covariance for those gravitational equations. The reason is that their derivation was based (besides the conservation theorems) only upon the covariance with respect to linear transformations, and thus left it an open question as to whether or not there exist other substitutions that would transform the equations into themselves.

There are two reasons why the resolution of this question is of particular importance to the theory. The answer to this question gives, first, information on how far the basic idea of relativity theory can be developed; and this is of great import to the philosophy of space and time. And second, the judgment about the value of the theory from the point of view of physics depends to a high degree upon the answer to this question, as is shown by the following consideration.

The entire theory evolved from the conviction that all physical processes in a gravitational field occur just in the same way as they would without it, if an appropriately accelerated (three-dimensional) coordinate system would be introduced (hypothesis of equivalence). This hypothesis, which is based upon the experimental fact of the equality between gravitational and inertial mass, gains additional convincing force if the apparent gravitational field-which exists relative to the accelerated three-dimensional coordinate system-can be viewed as a real gravitational field; in other words, if acceleration-transformations (i.e., nonlinear transformations) become permissible transformations in the theory.

At first glance it appears desirable to look for gravitational equations that are covariant toward arbitrary transformations. However, in §2 of the present paper we will show by a simple consideration that the quantities g_{uv} which characterize the gravitational field cannot completely be determined by generally-covariant equations.

In the following we shall demonstrate that the gravitational equations established by us are generally covariant just to the degree imaginable under the condition that the fundamental tensor g_{uv} must be completely determined. It follows in particular that the gravitational equations are covariant with respect to quite varied acceleration transformations (i.e., nonlinear transformations)".

"§2. Remarks on the Choice of the Coordinate System

We want to show now that, completely independent of the gravitational equations we established, a complete determination of the fundamental tensor γ_{uv} of a gravitational field with given Θ_{uv} by a generally-covariant system of equations is impossible.

We can prove that if a solution for the γ_{uv} for given Θ_{uv} is already known, and then the general covariance of the equations allows for the existence of further solutions. Assume a domain L within our four-dimensional manifold such that no "material process" shall exist within L, i.e., where the Θ_{uv} therefore vanish. By virtue of the given Θ_{uv} the γ_{uv} are assumed determined everywhere outside of L and, therefore, also inside L (assumption a). Instead of the original coordinates x_v we now imagine new coordinates x_v' introduced in the following manner. Everywhere outside of L we have $x_v' = x_v$, but inside L at least for part of it and at least for one index let there be $x_v' = x_v$. Obviously, at least for part of L, this substitution achieves $\gamma_{uv}' = \gamma_{uv}$. On the other hand we have $\Theta_{uv}' = \Theta_{uv}$ everywhere, that is, outside of L, because for this domain $x_v' = x_v$, and inside of L because for this domain $\Theta_{uv} = 0 = \Theta_{uv}$. Therefore, if all substitutions would be permitted, the same system of Θ_{uv} would have more than one system of the γ_{uv} belonging to it, and this is a contradiction to assumption a)" [18].

Of course, Einstein argued that the indeterminism of the theory would drive to the violation of the law of cause-effect a very strong reason to discard the general covariance.

Thus, "It remains to find the differential laws that are satisfied by these quantities. The epistemological satisfaction of the theory that has been developed up to here can be seen in the fact that this theory complies with the principle of relativity in the broadest meaning of the word. Seen under a formal aspect, this is based upon the feature that the equation systems are general, i.e., covariant under arbitrary substitutions of the x_v. The demand that the differential laws of the g_{uv} must also be general-covariant appears therefore appropriate. However, we want to show that we have to restrict this demand if we want to satisfy the law of cause and effect. In fact, we shall prove that the laws that characterize the course of events in a gravitational field can impossibly be covariant in all generality." [9], [15].

12 The tensor $t_{\mu v}$ representing the energy of static gravitational field and the tensor $T_{\mu v}$ representing the material process must have the same character.

Too, in September of 1913, Einstein wrote: "We surely must demand that the conservation laws be satisfied for the material process and the gravitational field taken together. What this amounts to is that we demand the existence of expressions $t_{\mu v}$ for the stresses, the momentum and energy flow densities, and the energy density of the gravitational field, with together with the corresponding quantities $T_{\mu v}$ of the material process satisfy the relation " [13] that appears in (3), i.e.,

$$\sum_{v} \frac{T_{\mu v} + t_{\mu v}}{\partial x_v} = 0 \qquad \text{(Eq. 3)}$$

"If, from the standpoint of the theory of the invariants, $t_{\mu\nu}$ is to have the same character as $T_{\mu\nu}$, then the left-hand side of this equation cannot be covariant with respect to arbitrary transformations; it is probably so only with respect to arbitrary linear transformations" [13]; the equations (3) represent the conservation laws of momentum and energy for matter and gravitational field combined. "The $t_{\mu\nu}$ are those quantities, related to the gravitational field, which are in physical analogy to the components $T^{\mu}{}_{\nu}$ of the energy tensor (V-tensor). It is to be emphasized that the $t^{\nu}{}_{o}$ do not have tensorial covariance under arbitrary admissible transformations but only under linear transformations. Nevertheless, we call $(t^{\nu}{}_{o})$ the energy tensor of the gravitational field. A similar analogy applies to the components $\Gamma^{\nu}{}_{o\beta}$ of the field strength of the gravitational field." [15].

13 Formulation of General Relativity was a leap back of three years

The General Relativity did not arise of the ulterior development of the theory on gravity worked by Einstein until 1914 but of a profound personal crisis of Einstein in front of the hard competition, between July and November of 1915, with the best germane mathematician of the epoch David Hilbert; which working similar equations, threatened with overcoming him.

On November 18 of 1915, Einstein with the previous collaboration of his friend Besso had coincided, using his new general covariant equations, with the correct calculi of the then anomalous orbit of Mercury. Thus, his limited covariance, imperative for save gravitational field with stress-energy, was abandon although the principal cause was which under it the equations failed in the Newton´s limit. Therefore, now his new updated equations were working but the theory no.

The competition of Einstein with Hilbert was turned critic; on final they interchanged letters almost daily. In this desperate scenery was adopted definitely the general covariance. "Einstein struggled on for two years with his misshapen theory of limited covariance. Late in 1915, as evidence of his errors mounted inexorably, Einstein was driven to near despair and ultimately capitulation. He returned to the search for generally covariant equations with a new urgency, fueled in part by the knowledge that none other than David Hilbert had thrown himself into analysis of his theory. Einstein's quest came to a happy close in late November 1915 with the completion of his theory in generally covariant form" [16]**.**

In November 1915, Einstein declared practically the last three years lost due "a misjudgment". He had come back to the period when worked with Grossmann, previous to the Entwurf theory, when he understood general relativity as general covariance. Therefore the equations on the gravitational field would be covariant respect to all arbitrary change of coordinates.

"My efforts in recent years were directed toward basing a general theory of relativity, also for non-uniform motion, upon the supposition of relativity. I believed indeed to have found the only law of gravitation that complies with a reasonably formulated postulate of general relativity; and I tried to demonstrate the truth of precisely this solution in a paper that appeared last year.

Renewed criticism showed to me that this truth is absolutely impossible to show in the manner suggested. That this seemed to be the case was based upon a misjudgment. The postulate of relativity-as far as I demanded it there-is always satisfied if the Hamiltonian principle is chosen as a basis. But in reality, it provides no tool to establish the Hamiltonian function H of the gravitational field. Indeed, equation (8) which limits the choice of H says only that H has to be an invariant toward linear transformations, a demand that has nothing to do with the relativity of accelerations. Furthermore, the choice determined by equation (9) does not determine equation (8) in any way. For these reasons I lost trust in the field equations I had derived, and instead looked for a way to limit the possibilities in a natural manner. In this pursuit I arrived at the demand of general covariance, a demand from which I parted, though with a heavy heart, three years ago when I worked together with my friend Grossmann. As a matter of fact, we were then quite close to that solution of the problem, which will be given in the following. Just as the special theory of relativity is based upon the postulate that all equations have to be covariant relative to linear orthogonal transformations, so the theory developed here rests upon the postulate of the covariance of all systems of equations relative to transformations with the substitution determinant 1.

$$S_{\nu}^{\mu} \equiv 0 \qquad \text{(Eq. 8)}$$

$$H = \frac{1}{4} \sum_{\alpha\beta\tau\varrho} g^{\alpha\beta} \frac{\partial g_{\tau\varrho}}{\partial x_{\alpha}} \frac{\partial g^{\tau\varrho}}{\partial x_{\beta}} \qquad \text{(Eq. 9)}$$

Nobody who really grasped it can escape from its charm, because it signifies a real triumph of the general differential calculus as founded by Gauss, Riemann, Christoffel, Ricci, and Levi-Civita” [19]**.**

Einstein with the assistance of his friend the philosopher Schlick elaborated "the point argument coincidence" overcoming his hole argument that he built against the general covariance, i.e when he need the limited covariance presented the hole argument” and when he need the general covariance presented "the point argument coincidence" against “the hole argument”, therefore the arguments serve to brilliant minds for create or destroy conceptual anything, according to their circumstances and interests.

In addition, in a flash, Einstein acting as the best magician of all time due to its consequences in the physical theory, disappeared materiality of the gravitational field the other great obstacle, since Einstein accepting general covariance had that abandon the law conservation of energy of material process and gravitational field taken together. Thus, he had elect between general covariance and gravitational field having stress-energy definitely to favor of the first. In 1913, in the Entwurf theory, Einstein and Grossmann emphasized, that the gravitational field should have an energy-momentum tensor as any physical field and they had adverted that make it “there would be untenable consequences” [6]. To Einstein, from that moment it was not more importance.

Three years before, as mathematician and geometrician, Grossman “distinguished two types of tensors:

(a) Those whose components transformed as tensor under arbitrary coordinate transformations;

(b) Those whose components transformed as tensor under some limited set of coordinate transformations.

“To be generally covariant, the theory would have had to have a gravitation tensor of first type, but Einstein and Grossman offered a tensor of the second type. It followed that the field equations of the theory held only in a restricted set coordinate systems” [17].

Of course, as physicist, Einstein had chosen a tensor of second type to preserve the conservation law of the energy-momentum of the material process and the gravitational field taken together. “In addition to his causality argument, Einstein offered a second reason for abandoning general covariance. He had shown that as a consequence of equation

$$T^{ij}{:}j=0 \qquad \text{(Eq. 10)}$$

and the Einstein-Grossman field equation, a conservation law for the combined matter and gravitational fields holds in the form

$$[\sqrt{-g}(T_i^j+t_i^j)],j=0 \qquad \text{(Eq. 11)}$$

where t_i^j is the object Einstein interpreted as characterizing the energy content of the gravitational field. In his appendix, Einstein stated that (11) is covariant only for linear coordinate transformations (geometrically they preserve the straight lines and the planes). But once again the reasoning was unsound. If t_i^j, transforms like a (1, 1) tensor, then in general (11) would be covariant only under linear transformations. But in general t_i^j transforms like a tensor only for linear coordinate transformations. Since (11) is a consequence of generally covariant equation (9) and the Einstein-Grossmann field equations, its covariance is just as wide as the covariance of the field equations. The point should have been intuitively evident to Einstein. The principle of equivalence implies that it is always possible to 'transform away' the gravitational field at any point; thus, whatever the state of the field, one should always be able to find a coordinate system such that $t_i^j = 0$ at the chosen point. Thus, t_i^j cannot behave like a tensor under non-linear transformations" [7].

In 1915, due to his personal circumstances and interests, Einstein opted by a tensor of first type. "Einstein and Grossmann proceeded to develop essentially all the major components of the final general theory of relativity…. Just one eluded them. To treat the general case of the gravitational field, non-flat metrics must also be admitted and, in the final theory, the decision of which are admitted is made by the gravitational field equations. Einstein expected these equations to take the now familiar form

$$G_{\mu\nu}=k\ T_{\mu\nu} \qquad \text{(Eq. 12)}$$

where $T_{\mu\nu}$ is the stress-energy tensor and $G_{\mu\nu}$ a gravitation tensor constructed solely from the metric tensor $g_{\mu\nu}$ and its first and second derivatives. Einstein and Grossmann considered the Ricci tensor as their gravitation tensor-just a hair's breadth away from Einstein's final choice of the Einstein tensor. In their place, to the astonishment of modem readers, they offered a set of gravitational field equations that was not generally covariant" [2]. In the Entwurf theory using equations (6), they had reported that these equations failed to give the Newtonian limit in the case of weak, static gravitational field.

In the General Relativity, the field equations of gravitation (13) express $G_{\mu\nu}$ as the Ricci tensor, taking the form:

"$$R_{\mu\nu} =-kT_{\mu\nu} \qquad \text{(Eq. 13)}$$

since we already know that these equations are covariant under any transformation of a determinant equal to 1"....They "contains Newton's law as an approximation". But, in the equation (3) of conservation of the energy-impulse, $t_{\mu\nu}$ formulated as t_σ^λ and indicated properly as the "energy tensor of the gravitational field which, by the way, has tensorial character only under linear transformation" [19].

The motion of a material particle, free of the action of forces, is subject only to the action of the inertia and the gravitation moving inside of a geodesic. "We note that the equations of motion of a material point in a gravitational field take the form" [19]:

$$\frac{d^2 x_\tau}{ds^2}=\sum_{\mu\nu}\Gamma^\tau_{\mu\nu}\frac{dx_\mu}{ds}\frac{dx_\nu}{ds} \qquad \text{(Eq. 14)}$$

If it annuls all the components $\Gamma^\tau_{\mu\nu}$ of the gravitational field is equation becomes of one straight line.

From the theoretical perspective "Einstein's belief that the final form of his gravitational theory, as it emerged in late 1915 and early 1916, embodied a general principle of relativity is stated explicitly: "The general laws of nature are to be expressed by equations which hold good for all systems of coordinates, that is, are covariant with respect to any substitutions whatever (generally covariant)".

It is clear that a physical theory which satisfies this postulate will also be suitable for a general postulate of relativity. For the sum of all substitutions in any case includes those which correspond to all relative motions of three dimensional systems of coordinates.., this requirement of general covariance.., takes away from space and time the last remnant of physical objectivity..." [7].

Thus the equations (6) of the Entwurf theory

$$\Delta_{\mu\nu}(\Phi) = k(t_{\mu\nu} + T_{\mu\nu}) \qquad \text{(Eq. 6)}$$

were replaced by the equations (12) of General Relativity.

Therefore, in 1915, Einstein vanished $t_{\mu\nu}$, i.e, with the materiality of gravitational field. "The most important feature of the Einstein's equations is that the right part of equations (12) does not include the energy-momentum of the gravity field itself, and this corresponds the fact that in General Relativity the gravity is not a material field" [20].

"according to the general theory of relativity, gravitation occupies an exceptional position with regard to other forces, particularly the electromagnetic forces, since the ten functions representing the gravitational field at the same time define the metrical properties of the space measure"

"We make a distinction hereafter between "gravitational field" and "matter" in this way, that we denote everything but the gravitational field as "matter." Our use of the word therefore includes not only matter in the ordinary sense, but the electromagnetic field as well" [21].

Einstein returning to a point back in time in the line of development of his works on gravitation really constituted a leap in which he has also break with Minkowski's space-time model based on Euclidean geometry since it is not support general covariance and he adhered to the general Riemannian geometry where the differences in mass concentration within a cosmic distribution cause a non-homogeneous curvature in spacetime, with the greater curvature where the mass concentration is greater; thus, due general covariance of General Relativity, too Einstein had renounced to the Minkowski geometry [22]. Let's remember, the Riemann tensor, also named tidal force tensor, gives the spacetime curvature. If in a given lapse of spacetime, all the components of the curvature tensor vanish then that lapse spacetime is flat [11].

As in 1918, Emmy Noether showed that the symmetry of Minkowski space tensor is the cause of conservation of energy-momentum of a physical field and "Schrodinger (1918) showed that the mathematical object suggested by Einstein in his final general relativity for describing the energy-momentum of the gravity field may be made vanish by a coordinate transformation for the Schwarzschild solution if that solution is transformed to Cartesian coordinates. Bauer (1918) pointed out that Einstein's energy-momentum object, when calculated for a flat space-time but in a curvilinear system of coordinates, leads to a nonzero result. In other words, can be zero when it should not be, and can be nonzero when it should.

Einstein (1918) replied that already Nordstrom had informed him about this problem with $t_{\mu\nu}$. Einstein noted that in his theory $t_{\mu\nu}$ is not a tensor and also it is not symmetric. He also withdrew his previous demand of the necessity to have an energy-momentum tensor: "There may very well be gravitational fields without stress and energy density" [20].

In fact, Einstein and Grossmann (1913) came close to Noether's result when they wrote: "remarkably the conservation laws allow one to give a physical definition of the straight line, though in our theory there is no object or process modeling the straight line, like a light beam in ordinary relativity theory". In other words, they stated that the existence of conservation laws implies the flat Minkowski geometry. In the same article Einstein and Grossmann also emphasized that the gravity field must have an energy-momentum tensor as all other physical fields. However, in the final version of general relativity Einstein rejected this requirement in order to have a generally covariant gravity theory with no prior Minkowski geometry” [20].

“As it was noted 90 years ago by Hilbert (1917), Einstein (1918), Schrodinger (1918) and Bauer (1918) within Geometrical Gravity approach (General Relativity) there is no tensor characteristics of the energy-momentum for the gravity field” [20].

14 In General Relativity, gravity was geometrized

As in General Relativity is impossible to obtain a tensor for the energy and momentum of the gravitational field which satisfies the double condition:

1. When added to other forms of energy the sum is conserved,

2. It is independent of coordinate systems,

Instead, Einstein constructed a pseudo tensor for satisfy only the condition that the sum is conserved; too other physicists have obtained similar pseudo tensors but the problem is that pseudo tensors behave only as tensors with respect to linear transformations of frames of reference, i.e, pseudo tensors are not general covariant. A notable example is the Landau–Lifshitz pseudo tensor.

Although quite confused about relativity, José Ortega y Gasset was right when, perhaps with the intuition of an intellectual a little of fortune teller or by the influence of his close physicist friends, in 1923, in the visit of Einstein to Spain he said him “You will end up making physics a geometry” [23] and most of its current followers say: “Einstein geometrized gravity”.

“Can we extend the Principle of Relativity to accelerated reference frames? That is, can acceleration be made relative? Can we incorporate gravity into Special Relativity? That is, can it extend the "laws of physics" in the Principle of Relativity to include Newton's Law of Gravity? Einstein's solution to both: Geometricize the gravitational force: turn it into a manifestation of spacetime curvature” [24].

“The key idea of Einstein's theory of general relativity is that gravity is not an ordinary force, but rather a property of space-time geometry.

In Einstein's theory of general relativity, gravity is a distortion of space-time. Particles still follow the straightest possible paths in that space-time. But because space-time is now distorted, even on those straightest paths, particles accelerate as if they were under the influence of what Newton called the gravitational force” [25].

Einstein knew very well that to adopt the general covariance was at the cost of sacrificing the materiality of the gravitational field but its failure with the equations (6), of the Entwurf theory, that in the limit of the gravitational field weak did not give the equation of the gravity of Newton, within the arbitrary linear possible transformations at the Minkowski's spacetime, and harassed without ceasing by his powerful rival Hilbert, in that November of 1915, the suffering fragile man had to make “hara-kiri” to the scientist and without more, change to the Lorentzian manifold reaching now whether, in the equations of the gravitational field of the General Relativity, i.e. equations (12), in the Newtonian limit, to the Newton´s law of gravity. This sad episode in Einstein's life is somewhat similar to that of Galilei when he was condemned by the Inquisition to mural imprisonment because of his heliocentric theory from which he retracted to get his sentence commuted to house arrest for the rest of his life.

Who delivered the final equations first? Was Hilbert or Einstein? For a long time it was said that it was Hilbert 5 days before Einstein; from 1997, in a recent lapse, L. Corry, J. Renn, and J. Stachel wrote that was Einstein. However, a few years later, F. Winterberg refuted them. Both presented serious studies on the case from their contrary visions.

It is surprising that a public event happened almost a century ago, it is in dispute, indicating that the phenomenon of Einstein passed from the human to the divine, being its cause the high level of abstraction that requires the use of absolute differential calculus. The newly formulated General Relativity was said in the world only Einstein-Grossman and Eddington understood it. Today even the tensor of Riemann causes terror among some mathematicians and in other mathematician-physicists the equations of general relativity produce them the supreme state of happiness of nirvana.

Such dispute is irrelevant because the essential of the equations is their mathematical foundation, precisely where Hilbert was stronger, no the theoretical argument on the general covariance where the discussion was centered. Therefore, in their different applications, truly necessary was that the equations eliminate anomalies as, for example, the Mercury´s orbit and in the Newtonian limit, they delivered the Newton´s law of gravity, both requirements were satisfied.

Of other hand, today we know that there is not general theory of relativity but if the very powerful Grossman-Einstein equations [26] which were obtained from the absolute differential calculus of the 19th century and of the variational calculus, so hard to understand as of to work. Also, so distant that in the future they result as easy as the algebra whose origin goes back to the Babylonian mathematics of the 19th-16th centuries BC. More exactly, the Grossman-Einstein-Hilbert equations because it must include also the Hilbert contribution obtained from the variational calculus and called Einstein-Hilbert action that yields the Einstein field equations through the principle of least action.

As compensation to the sacrifice that personal circumstances and interests imposed on him, in pragmatic form, Einstein got the most out of the general covariance in the terms of general relativity principle and point-coincidence argument. Something similar, that to in spite of his deafness Beethoven continued composing. And as in the Fifth Symphony, the very human fury of the creation is capable of overcoming the force of fate. Then, Einstein wrote: “The general laws of nature are to be expressed by equations which hold good for all systems of coordinates, that is, are covariant with respect to any substitutions whatever (generally covariant).

It is clear that a physical theory which satisfies this postulate will also be suitable for the general postulate of relativity. For the sum of all substitutions in any case includes those which correspond to all relative motions of three-dimensional systems of coordinates. That this requirement of general covariance, which takes away from space and time the last remnant of physical objectivity, is a natural one, will be seen from the following reflexion. All our spacetime verifications invariably amount to a determination of spacetime coincidences. If, for example, events consisted merely in the motion of material points, then ultimately nothing would be observable but the meetings of two or more of these points. Moreover, the results of our measuring are nothing but verifications of such meetings of the material points of our measuring instruments with other material points, coincidences between the hands of a clock and points on the clock dial, and observed point-events happening at the same place at the same time.

The introduction of a system of reference serves no other purpose than to facilitate the description of the totality of such coincidences. We allot to the universe four spacetime variables x_1, x_2, x_3, x_4 in such a way that for every point-event there is a corresponding system of values of the variables x_1 ... x_4. To two coincident point-events there corresponds one system of values of the variables x_1 ... x_4, i.e. coincidence is characterized by the identity of the co-ordinates. If, in place of the variables x_1 ... x_4, we introduce functions of them, x'_1, x'_2, x'_3, x'_4, as a new system of coordinates, so that the systems of values are made to correspond to one another without ambiguity, the equality of all four coordinates in the new system will also serve as an expression for the spacetime coincidence of the two point-events. As all our physical experience can be ultimately reduced to such coincidences, there is no immediate reason for preferring certain systems of coordinates to others, that is to say, we arrive at the requirement of general covariance” [21] .

Thus, in the General Relativity, the geometrization of gravity was not because Einstein used the absolute differential calculus, or Riemann´s geometry, neither due to that metric tensor codifies the geometric dates of distance, angle, area, volume, parallel transport, light cone, geodesic, gravitational potential or curvature, i.e. all the set of dates relatives to geometric-casual structure of spacetime and obtainable from it. Gravity was geometrized because the metric tensor, as metric field, is also the same gravitational field, lacking of energy-impulse due to that no exist the correspond tensor of stress-energy $t_{\mu\nu}$ generator of it, violating the law of conservation of energy-impulse of the matter and gravitational field, taken together. The metric field is only geometric objects, in itself void of any physical content, in particular, as in Modern General Relativity, gravitational field is curvature in a Lorentzian manifold or rather in Einstein General Relativity is the gravitational potentials "$g_k = -(\text{grad } \Theta)_k$, $k = x_1, \ldots x_4$ i.e., $g_{\mu\nu} \leftrightarrow \Theta \quad \Gamma^k_{\alpha\beta} \leftrightarrow g_k$" [11]. As conceptually General Relativity does not respond: What is gravity? Therefore, there are possible various operational definitions.

15 Einstein advanced in six decades at its time

Closed six decades after of Einstein, the Russian group led by Anatoli Logunov and M. Mestvirishvili succeeded in developing the ill-fated theory on gravity that Einstein was working, between 1907-1914, before the maleficent competition arose with Hilbert, which was like when the fate touches our door to enter and get us out of the world, execution of the condemn imposed to the original sin of living by the universal law of the existential step from being to not be.

Let's remember, between 1905 and 1907, as Poincare and Minkowski, Einstein could not obtain the Relativistic theory of gravity, RTG, from the Special Relativity, despite the great efforts that he made, to formulate the Galilean law of inertia to all arbitrary frame of reference in absence of the strong equivalence principle, SEP. RTG was rejected during its formation due to impossibility of describing the gravity potential by a 4-vector since it was necessary a covariant, second-order, symmetric tensor on a Minkowski´s spacetime in Entwurf theory and on a Lorentzian manifold in General Relativity.

Also, let's remember, between 1907 and 1914, Einstein was abandoned SEP, recognizing the gravitational field as a physical field and not an effect of coordinates, more exactly as an energy phenomenon and determining it though the tensor of the material process, thus conserving integrally the law of energy, only possible in a Minkowski's spacetime. However, Einstein had the technical problem of that his equations of limited covariance not give in the limit to gravity equation of Newton, neither in their astronomic application the correct orbit of Mercury. Einstein had to adopt the Lorentzian manifold, i.e. a curved spacetime and the general covariance of the equations sacrificing the gravitational field as a material phenomenon and geometrizing gravity.

In 1986, the group of Anatoly Logunov and M. Mestvirishvili formulated RTG achieving the true generalization of Special Relativity, through of use a dualist structure of spacetime: Minkowski - Lorentzian manifold, of course without the inconsistent Einstein equivalence principle, EEP, [27], [33], keeping as primary the Minkowski´s spacetime, thus preserving the law of conservation of the energy and momentum, and materializing the static gravitational field, compound of virtual gravitons, generated from the tensor of matter, $T_{\mu\nu}$, more the tensor of the gravitational field itself, $t_{\mu\nu}$ although they used other notation. Through the overlapping secondary Lorentzian manifold, owing to the presence of the gravitational field in Minkowski space, is conserved the curved spacetime, consequently the general covariant equations, necessary to give in the limit to gravity equation of Newton and in their astronomic application the correct orbit of Mercury [27], i.e. a wonderful result of ingenuity and mathematical technique based in the absolute differential calculus, variational calculus and gauge formalisms. RTG was developed between 1984 and 1986. In 2004, with the collaboration also of S.S. Gershtein and N.P. Tkachenko, RTG was reviewed to explain the accelerated expansion of the Universe.

RTG arises of the relativity principle, the gauge principle and the geometrization principle realized through their equations. The Poincare-Minkowski´s relativity principle is applied for all the systems. Therefore, the Lorentz transformation it generalizes for the inertial systems or no. “The gravitational field is viewed in RTG as a real material (having zero rest mass) physical field in the Minkowski space possessing all the attributes inherent in other physical fields. It is described by the field of symmetric second-rank tensor $\phi^{\mu\nu}$ - Note of author; Einstein used $t_{\mu\nu}$, in Entwurf theory - with the representations corresponding to 2 and 0 spin states.” [27].

The geometrization principle is applied to obtain the Lorentzian manifold without geometrize gravity, because gravitational field changes really the Minkowskian spacetime making it curve. Too, eliminating the erroneous notion that in the infinitesimal limit the Lorentzian manifold becomes Minkowskian spacetime because it is impossible eliminate the curvature "the possibility of excluding the gravitational field in an infinitesimal region, is not correct since there is no way in which we can exclude the curvature of space (if it is nonzero) by selecting an appropriate reference frame, even with in a give accuracy" [27]. In the solution de RTG, the gravitational field make curve the Minkowski´s spacetime while in General Relativity is contrary because the primary spacetime is the Lorentzian manifold and, in such case, the Minkowski´s spacetime would be the subjacent secondary spacetime although as it was explained it is false by impossible. “The geometrization principle is a consequence of the initial assumption that a universal characteristic of matter — the density of the energy-momentum tensor — serves as the source of the gravitational field” [28]. “The geometrization principle, as a consequence of the universal nature of gravitational interactions and tensor nature of the gravitational field, introduces into the theory the secondary notion of the effective Riemannian space with the metric $g^{\mu\nu}$ specified (and this is a very important point) in one chart…This space has the purely field origin, the primary notion of the theory remaining the Minkowski space with the metric $g^{\mu\nu}$ and the gravitational field $\phi^{\mu\nu}$ in it. The geometrization principle of RTG is not the same as that of General Relativity because in the former theory as well as in other physical field theories all the physical quantities have the tensor rather than pseudo tensor nature and therefore, in particular, the energy density of the gravitational field cannot be made zero at a point by any coordinate transformations though the force action of the gravitational field onto the material point can be counterbalanced" [29]. "Thus, the effective Riemann spacetime is a peculiar carrier of energy-momentum" [27].

The gauge principle explains physical forces in terms of fields. In particular, the force of gravity would be owing to the gravitational field existents between the elementary particles of the matter and energy; this field arises from them, through of it these particles interact, exerting a mutual real force, and interchanged virtual gravitons which the gravitational field transports. The gauge invariance implies that in a transformation from one such field configuration to another no change the measurable quantities. Any kind of invariance under a field transformation is considered a symmetry, called gauge invariance or gauge symmetry. "The hypothesis underlying RTG asserts that the gravitational field, like all other physical fields, develops in Minkowski space, while the source of this field is the conserved energy momentum tensor of matter, including the gravitational field itself. This approach permits constructing, in a unique manner, the theory of the gravitational field as a gauge theory. Here, there arises an effective Riemannian space, which literally has a field nature. In GRT the space is considered to be Riemannian owing to the presence of matter, so gravity is considered a consequence of spacetime exhibiting curvature. The RTG gravitational field has spins 2 and 0 and represents a physical field in the Faraday–Maxwell spirit" [29].

Thus, "the RTG is constructed as a field theory of the gravitational field within the framework of Special Relativity theory. The starting point is the hypothesis that the energy-momentum tensor — which is a universal characteristic of matter — serves as the source of gravity. The gravitational field is considered to be a universal physical field with spins 2 and 0, owing to the action of which the effective Riemannian space arises. This permits to find the gauge group and to construct unambiguously the Lagrangian density of the gravitational field"..."The set of equations of this theory is generally covariant and form-invariant with respect to the Lorentz group"… "Here, it is necessary in the theory to introduce the graviton mass"..."gravitons do not travel in Minkowski space, like in linear theory, but in effective Riemannian space" …"An interesting picture arises consisting in that the motion of matter in Minkowski space with the metric $\gamma_{\mu\nu}$ under the influence of the gravitational field $\varphi_{\mu\nu}$ is identical to the motion of matter in effective Riemannian space with the metric $g_{\mu\nu}$" [28].

16 Aggregating new equivalence, in General Relativity, gravity is an effect of coordinates.

The great theoretical ambition of Einstein was explain gravity as an effect of coordinates, generalizing the Galilean principle of relativity to any class of motion, based in the physical fact of the equality between the inertial and gravitational masses, established with high accuracy in the Eotvos experiment, which achieved its best accuracy of 1 in 100 billion, in its last repetition.

However, closed to Entwurf theory, Einstein understood gravity would be other thing because the EEP is valid only where there is not gravity, i.e. in the Minkowski´s spacetime. Then, Einstein was in front of a double fundamental problem, what is homogenous gravity? Of other hand, in general, what is gravity?

Respect to homogenous gravity, there is no doubt; it is other name of uniform acceleration, also of inertial motion. But, in general, gravity could be the curvature of spacetime best that those gravitational potentials because it is a respond more convincing. The argument to favor of Einstein is based in "that spacetime curvature is a manifestation of gravitation since $R^{\alpha}{}_{\beta\mu\nu} \neq 0$ (spacetime curvature) implies $g_{\mu\nu} \neq \eta_{\alpha\beta}$ everywhere (gravitation) but $g_{\mu\nu} \neq \eta_{\alpha\beta}$ (gravitation) does not imply $R^{\alpha}{}_{\beta\mu\nu} \neq 0$ (spacetime curvature)" [11], that it would be the case of homogenous gravity when it is really effect of coordinates, therefore as other name of acceleration it satisfies $g_{\mu\nu} \neq \eta_{\alpha\beta}$. But, not when it is other name of inertial motion. In all case, homogenous gravity cannot be considered true gravity owing to the existence of the permanent or extended gravity, which it would be real.

However, in all case, it arise the problem: what is spacetime? Whose respond, inside of the lawmen category, remit to the strong philosophical dispute between the schools of the substantivalism and the relationalism where there are various definitions that, among the main, the author classifies in:

1. The philosophical theories supported by the mathematical model, $G_{\mu\nu} = k\, T_{\mu\nu}$, of the General Relativity are strictly restricted to:

- To dualistic idealist substantivalism, spacetime is a metaphysical fundamental entity, i.e., an entity immaterial whose curvature is the static gravitational field, i.e., a geometric property of spacetime; therefore spacetime and gravitational field are nothing.

- To idealist relationalism, spacetime is a thinking category that expresses metric relations codified in the static gravitational static field, which is a geometric field; therefore they are nothing.

2. The other theories that endow of materiality to spacetime or to gravitational field require of a mathematical model of the form $G_{\mu\nu} = k(T_{\mu\nu} + t_{\mu\nu})$, proper of the Entwurf theory. Let's remember that the Einstein equations of General Relativity are without the term $t_{\mu\nu}$:

- To monistic materialist substantivalism, spacetime is a special substance belonging to material substances whose curvature is the static gravitational field, i.e., a geometric property of material spacetime; therefore gravitational static field is nothing as in Schaffer, 2009; Turishev, 2011; Worden, 2012 and Delplace, 2014.

- To materialist relationalism, spacetime is a thinking category that expresses metric relations codified in the gravitational field, which is a dynamic material field; therefore spacetime is nothing, as indirectly in Lorentz, 1916; Weyl, 1918; Eddington, 1920 due to that they considered $g_{\mu\nu}$ generated by the relativistic aether and directly in Cala, 2006; Bain, 2014, etc., due to that they do not differentiate between the static gravitational field of the metric tensor and the dynamic gravitational field that would be of the energy-momentum tensor.

Of other hand, to the author the spacetime is the geometric structural form of the dynamic matter [30], therefore spacetime are not conditions of existence of the matter but geometric properties of it, because any real thing, in the Universe, have dynamic existence with spatial properties and as process with temporal duration.

The result is: "Spacetime is still an enigma to science and philosophy" [31] because “We really do not know what spacetime” [32].

If gravity is phenomenon of spacetime and is not known what is spacetime? Then, what can be said on gravity?

Return to the adventure of the thought that Einstein lived from his explication of gravity inside context of Special Relativity, 1907, until the formulation of General Relativity, 1915, there are three notable moments:

1. In 1907, gravity is effect of coordinates, which was abandoned owing to its application only to homogenous gravity because its generalization to extended gravity is not possible, since “Tidal gradients, i.e. spacetime curvature, can neither be created nor eliminated by a change of coordinates” [11], too Einstein wrote various times about this impossibility [9], [12], [21] etc.

2. In 1913, gravity is a phenomenon of the energy , which was abandoned because the equations of Entwurf theory are not general covariant and they do not give in the Newtonian limit the law of gravity of Newton, neither in the astronomic calculus the orbit of Mercury.

3. In 1915, gravity is effect of curvature of spacetime, geometrizing the gravity and not knowing that it is the spacetime.

Obviously, advanced readers would like disappear the double problem of the General Relativity of geometrization of gravity and improper use of spacetime for not knowing what it is, but conserving the very powerful Einstein-Grossman-Hilbert equations. The business is simple, only question of interpretation, introducing these equations in a new conceptual scenery, through transcendent EEP. Thus:

Transcendent EEP = EEP + Equivalence principle of geodesic motion between spacetime of Minkowski and Lorentz manifold.

Well known is that the geodesic motion, in a determined spacetime, is the motion free of forces that animates to particles and bodies. Thus, homogenous gravity is inertial motion in Minkowski´s spacetime, i.e. other name of gravity owing equivalence between a body in free fall and a body in inertial motion; and extended gravity is inertial motion in Lorentzian spacetime. In both cases gravity is effect of coordinates although in second case with change of geometry of spacetime respect to Minkowski´s spacetime. Therefore, observers in Minkowski´s spacetime and Lorentz′ manifold must coincide that gravity is inertial motion.

Einstein and others have declaring "extended gravity, for example, Earth´s gravity, can neither be created nor eliminated by a change of coordinates". Truly they accept a physical fact of the Universe as it is that different geometric configurations of the dynamic matter are really physics and impossible "be created nor eliminated by a change of coordinates"; thus Earth exists in an indestructible Lorentz´s manifold. However, some have identified extended gravity with the curvature of spacetime and they have understood erroneously, which gravity is not possible of vanish, giving it absolute status. No, in General Relativity gravity is inertial motion; considered as geodesic motion existent in any geometric configuration of spacetime, therefore, extended gravity like homogenous gravity would be simple effect of coordinates. During long time, this key was not understood sufficiently, i.e. that according to "the happiest thought of my life" to Einstein gravity is inertial motion, an effect of coordinates.

Of course, the $g_{\mu\nu}$ of the Einstein´s equation (12) are determinant of the curvature of Lorentz´s manifold so as the $\eta_{\alpha\beta}$ of the Minkowski´s equations (1) are determinant of the flat spacetime. Let's remember, in Relativity theory the inertial motion, accelerated motion and gravitational motion are simply relative states that arise only of transformation of reference frames, therefore impossible that gravitational motion can be considered absolute since it destroys the same foundation of relativity.

What was the Einstein´s problem to generalize gravity as effect of coordinates? The respond was: "Tidal gradients, i.e. spacetime curvature, can neither be created nor eliminated by a change of coordinates" [11]. Partially true because to observers in frames of reference animated with relative gravitational motion if among them there is change of coordinates simultaneously with change of geometry from Minkowski to Lorentz spacetimes or from Lorentz to Minkowski spacetimes then gravitational field vanishes, remaining the geodesic motion owing to the equivalence in the relative state of particles or bodies free of forces in both class of spacetimes. Of course, in frames of reference with different geometric spacetime, observers free of forces would be moving inertially and they are entirely equivalents. Thus, true important is not the curvature or rectilinearity of the geodesy but its inertial property.

17 Conclusions

The history of the development of the called General Relativity theory is of the strong personal struggled of Einstein between equations and main principle: EEP, searching produce a scientific theory on gravity based in their adequate correspondence, failing finally in front of the triumph of his very powerful equations, which working, in autonomy, give results very exacts respect to the quantities of the observables.

This sad final arose during the bad moment of the hard competency of Einstein with the best germane mathematician of his epoch, which provoked the geometrization of gravity, although no owing as Modern General Relativity have said that gravity is the curvature of the spacetime but, in general, according to the Einstein-Grossmann-Hilbert equations the gravity is operationally defined through of geometric objects void of energy-momentum.

The point of start was his famous "the happiest thought of my life" on equivalence between gravitational and inertial motions, which Einstein used as the nucleus to structure EEP, i.e. SEP, searching generalize the principle of relativity of Galilei to any arbitrary motion. However, SEP is not exactly adjusted to Special Relativity, deriving characteristic of gravity as a physical phenomenon of the energy, which under the Hamiltonian considerations of the conservation of the total energy of a particle in gravitational motion more the problem of the extended gravity are not possible vanish through of change of coordinates provoking Einstein would must adjust the tensor of energy-impulse of the material process, $T_{\mu\nu}$, more the tensor of energy-impulse, generator of the gravitational field $t_{\mu\nu}$, obligating to renounce to the general covariance. However, these equations of the Entwurf theory did not give in the Newtonian limit the law of gravity of Newton, neither the correct orbit of Mercury.

At this moment, again Einstein was in the beginning, a little as Sisyphus, being this drama frequent in the life of the scientists, in special when like Einstein his work was not protected by an institution, because he was never an institutional worker although Einstein had various generous collaborators. But, in this history, owing his hard competency with Hilbert the comedy was became tragedy. Adopting the general covariant equations, Einstein overcame the previous faults but he had pay the highest price of the geometrization of gravity, when he renounced to $t_{\mu\nu}$. Of course, one thing is to model reality with geometric objects for its methodological knowledge and other thing very different replace reality with them.

However, of have persisted, Einstein was very away of reach with the ulterior development of his Entwurf theory an alternative to the Relativistic theory of Gravitation of Logunov, Mestvirishvili and others, which was formulated six decades latter.

But, it is inexplicable that Einstein did not return to the generalization of the principle of Galilei, so easy of reach aggregating to EEP the new principle of equivalence between inertial and geodesic motions.

Gravity as effect of coordinates is the best interpretation of the immense work of Einstein embracing both punctual and extended gravity, returning to the lost theoretical scenery and overcoming his powerful equations, how your work is currently viewed.

Also, let's remember that according Modern General Relativity gravity is the curvature of the spacetime therefore in the flat spacetime the geodesic motion is the inertial motion.

Probably, Einstein was blind in front of so magnificent opportunity owing to the absence of conceptual definitions in his work on relativity more the strong seduction exerted on him of the absolute differential calculus as today both continue working in the minds of the advanced physicists.

But, the problem with the General Relativity persists owing to that EEP is inconsistent.

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