ABSTRACT

The proposal assumes that the distortion of space-time due to relative velocity (Special Relativity) and the distortion of space-time produced by gravitational fields (General Relativity), are linked to changes of state that affect to the physical properties of bodies, particularly space-time and mass-energy (The expression mass-energy refers to Einstein´s mass and energy equation $E=mc^2$).

The hypothesis proposes the existence of a process linked to gravity, this phenomenon would affect mass-energy. Requires adding an additional condition (being a more restrictive scenario). There is a relationship between Einstein´s Field Equations and the proposed process. The additional condition changes the trajectory that a body would follow in the curved space-time, with respect to the established by the Standard Model of Relativity (the curvature is modified, so the geodesic is modified as well). The effect is negligible if the distortion of space-time caused by a gravitational field does not have a significant value. The proposed hypothesis allows to mathematically calculate the discrepancy with respect to the Standard model. In case of being correct, would have important implications in various areas of science and its effect would be decisive in the study of black holes or issues related to Cosmology.

BACKGROUND, PROBLEMS JUSTIFYING NEW CONTRIBUTIONS

The mathematical model of General Relativity has made accurate predictions and calculations.

However there are certain issues about gravity that have not been satisfactorily resolved. Below are briefly described some of the problems concerning gravity:

- Theoretically the mathematical model of relativity predicts singularities at certain circumstances, an observer reaching the event horizon of a black hole, inexorably ends in a singularity.
- Paradox of information loss was a problem without a clear resolution, until the middle of the 1990s, when the Holographic Principle was proposed, which currently has the consensus and majority support of the scientific community.
- In 2012 arose a new conflict presented by Ahmed Almheiri, Donald Marolf, Joseph Polchinski and James Sully. Taking into account the officially accepted model, including the Holographic Principle, a particle would have at the same time two quantum entanglements, while being entangle with a particle that crosses the event horizon and at the same time with the duplicate information linked to the Horizon of events, contravening the quantum rules

PROCESS LINKED TO GRAVITY AFFECTING MASS-ENERGY

Features of the proposed hypothesis:

- **The hypothesis allows to use the Relativity framework to make calculations and predictions (for instance, in this paper it is calculated discrepancies with respect to the Standard Model for the Schwarzschild metric scenario).**
- **Discrepancies with respect to the Standard Model of Relativity are negligible if the gravitational field does not have a significant value, those discrepancies are smaller ones the weaker the gravitational field.**
- **The effect of the proposed process corresponds to the effect of a force opposite to the free fall, that effect will produce an additional distortion of the space-time, so that for an object in free fall, in order to follow the geodesic established by the Standard Model of Relativity, it would be neccesary to apply energy to compensate for the proposed effect. The energy required would have an infinite value at the event horizon of a black hole.**
- **Quantification. The hypothesis proposes that there is an interrelation between space-time distortion and the alteration of mass-energy, mc^2 value corresponds to the quantity of mass in (α-state). The higher the amount of mass-energy in (β-state), the higher the space-time distortion. Knowing the Einstein Field Equations, it is possible to obtain the quantity of mass-energy in (β-state). The counterpart of that value is the energy that will produce an additional space-time distortion, producing a discrepancy with respect to the Standard Model of Relativity.**
- **Probabilistic approach. The proposed process where mass-energy changes from (α-state) to (β-state) is linked to a probabilistic phenomenon, where the interaction between graviational waves with mass will alter the state of that mass. The stronger the gravitational field, the higher the amount of mass-energy in (β-state). If energy-momentum is applied, then that process will be boosted.**
- **Considering expansive scenarios, the reverse process takes place, so that instead of taking energy from the physical system, it will provide energy, this way expansive scenarios (for example the expansion of the Universe) will show velocities higher than the expected by the Standard Model of Relativity.**

PROCESS LINKED TO GRAVITY AFFECTING MASS-ENERGY

The expression: “State of a body or a particle”, alludes to the physical properties of the body or the particle.

Physical properties:

Mass-energy value **$E=mc^2$**. The interaction between spin-2 particles (“gravitons”) and mass-energy will alter the state of mass-Energy from **(α-state)** to **(β-state).** The stronger the gravitational field in a region of space-time, the higher the quantity of mass-energy in (β-state).

Space } Space-time, the proposal considers space-time as intrinsec properties of the body.

Time } Space-time distortion corresponds to alterations of the state of the body.

There is an interrelation between those physical properties. The cause or agent responsible of the alteration of state are gravitational fields, if energy-momentum is applied, then that alteration is boosted.

Mass-energy value and space-time are affected as the body changes its physical state by:

Gravitational Fields }

Energy-Momentum }

Standard Model of Relativity defines the curvature of space-time and its interrelation with the Stress-energy tensor (including the effects of Gravitational fields) applying the Einstein Field Equations. $$R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\Pi G}{c^4}T_{\mu\nu}$$

PROCESS LINKED TO GRAVITY AFFECTING MASS-ENERGY

Special Relativity scenario

Considering a hypothetical pure Special Relativity scenario, if a body has no velocity relative to the reference, we might say that the body is in "State A", if it is applied kinetic energy ($\Upsilon mc^2 - mc^2$) to the body, then the state of the body changes (physical properties mass-energy and space-time do change) the body is now in "State B" with mass-energy Υmc^2 relative to the "State A" (the previous reference) and with space-time distortion relative to the "State A".

Minkowski space $ds^2 = c^2dt^2 - dx^2 - dy^2 - dz^2$

Kinetic energy ($\Upsilon mc^2 - mc^2$)

"STATE A"

Physical properties of an object in "State A":

$E = mc^2$

Space-time: L, t

"STATE B" (velocity v relative to A)

Physical properties, relative to A, of an object in "State B":

$E' = \Upsilon mc^2$

Space-time: $L' = L/\Upsilon$, $t' = t^* \Upsilon$

Υ the Lorentz factor $\Upsilon = 1/\sqrt{(1 - v^2/c^2)}$

PROCESS LINKED TO GRAVITY AFFECTING MASS-ENERGY

Taking as reference the "State A", the process between A and B: "State A" **Energy** "State B"

Mass-Energy mc^2 **(α-state) + Energy (ϒ**mc^2-mc^2**) =** Mass-Energy (**α-state)(quantity** mc^2 **)**+Mass-Energy (**β-state) (quantity ϒ**mc^2 **-**mc^2**)** = **ϒ**mc^2

There is an interrelation between the physical properties: mass-energy and space-time $E' = \Upsilon mc^2$ ⟺ Space-time

Mass-energy is affected, being altered in accordance with what is modified the space-time.

Knowing that $L' = L/\Upsilon$ and using the defined concepts:

(L-L´)*(total mass-energy) = (L-L´)*(mass-energy(α-state)+mass-energy(β-state)) = (L-L/**ϒ**) *(**ϒ** mc^2) =L(**ϒ** mc^2-mc^2)=L*(mass-energy (β-state))

then the proportion: (L-L´)/L = (mass-energy(β-state))/(total mass-energy)

While (L´)*(total mass-energy)= L(mc^2) =L (mass-energy (α-state))

with **ϒ** = L/ L´=(total mass-energy)/(mass-energy (α-state))

That is $E' = \Upsilon mc^2$ = (L/ L´) * (mass-energy (α-state))

From a practical point of view, considering a hypothetical pure Special Relativity scenario, the result is the same, either by assuming the proposed process or the model corresponding to the Standard Model of Relativity. But when the gravitational fields effects are not negligible, then the proposed process establishes discrepancies with respect to the Standard Model of Relativity, that discrepancy is negligible if the graviational field is a weak one, but the discrepancy increases the stronger the graviational field.

PROCESS LINKED TO GRAVITY AFFECTING MASS-ENERGY

General Relativity scenario

Standard Model of Relativity , without taking into account the proposed process:

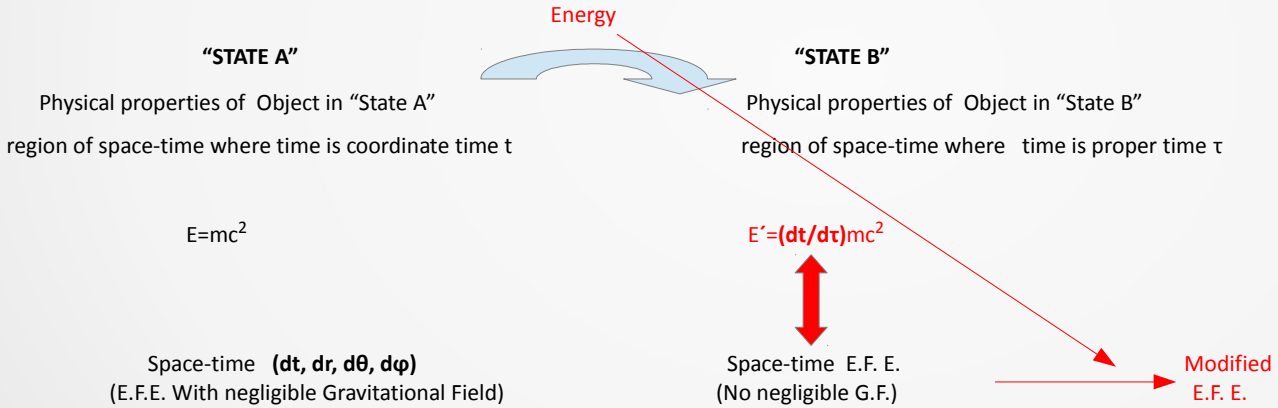
Einstein Field Equations corresponding to the Standard Model of Relativity.

$$R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\Pi G}{c^4}T_{\mu\nu}$$

Considering the Schwarzschild metric for the vacuum solution of a homogeneus sphere, uncharged, non rotating:

$$ds^2 = \mathbf{c^2 d\tau^2 = (1 - r_s/r)}\ c^2dt^2 \ \mathbf{-\ (1 - r_s/r)^{-1}}\ dr^2 \ -\ r^2\,(d\theta^2 + \sin^2\theta\, d\varphi^2)$$

τ: proper time **t: time coordinate** **r: Schwarzschild radial coordinate** **θ: colatitude** **φ: longitude** $\mathbf{r_s = 2GM/c^2}$



Note: Scheme, without including the terms in red (Energy; $E´=\mathbf{(dt/d\tau)}mc^2$; Modified E.F. E .) would correspond to the Standard Model of General Relativity.

Modified Einstein Field Equations means that the Stress-Energy Tensor of the E.F.E. should include the effect of the energy required by the process to take place

PROCESS LINKED TO GRAVITY AFFECTING MASS-ENERGY

Taking as reference "State A", the process between A and B: "State A" **Energy** "State B"

Mass-Energy mc^2 **(α-state) interaction with G.W.** + **Energy** $((dt/d\tau)mc^2 - mc^2)$ = Mass-Energy **(α-state)**(quantity mc^2) +Mass-Energy **(β-state)** (quantity $(dt/d\tau)mc^2 - mc^2$) = **total mass-energy (**quantity $(dt/d\tau)mc^2$).

The hypothesis proposes that the physical properties of an object will change according to the region of the gravitational field that it occupies, and there would be an interrelation between mass-energy and the curvature of space-time defined by the E.F.E. (that is how it is calculated the expression $(dt/d\tau)mc^2 - mc^2$))

If the proposed process has such an effect that there is conservation of energy, then: $\Upsilon_{mod}(dt/d\tau)mc^2 - (dt/d\tau)mc^2) = (\Upsilon mc^2 - mc^2)$

Result: $\Upsilon_{mod} = 1 + \Upsilon * d\tau/dt - d\tau/dt$ being $\Upsilon_{mod} = 1 / \sqrt{(1 - v^2 \text{ mod } /c^2)}$

Considering the Special Relativity scenario, there is a contribution of energy (kinetic energy) between the states, an interrelation between space-time distortion and the alteration of mass-energy, and the value of mass-energy depends on the reference taken.

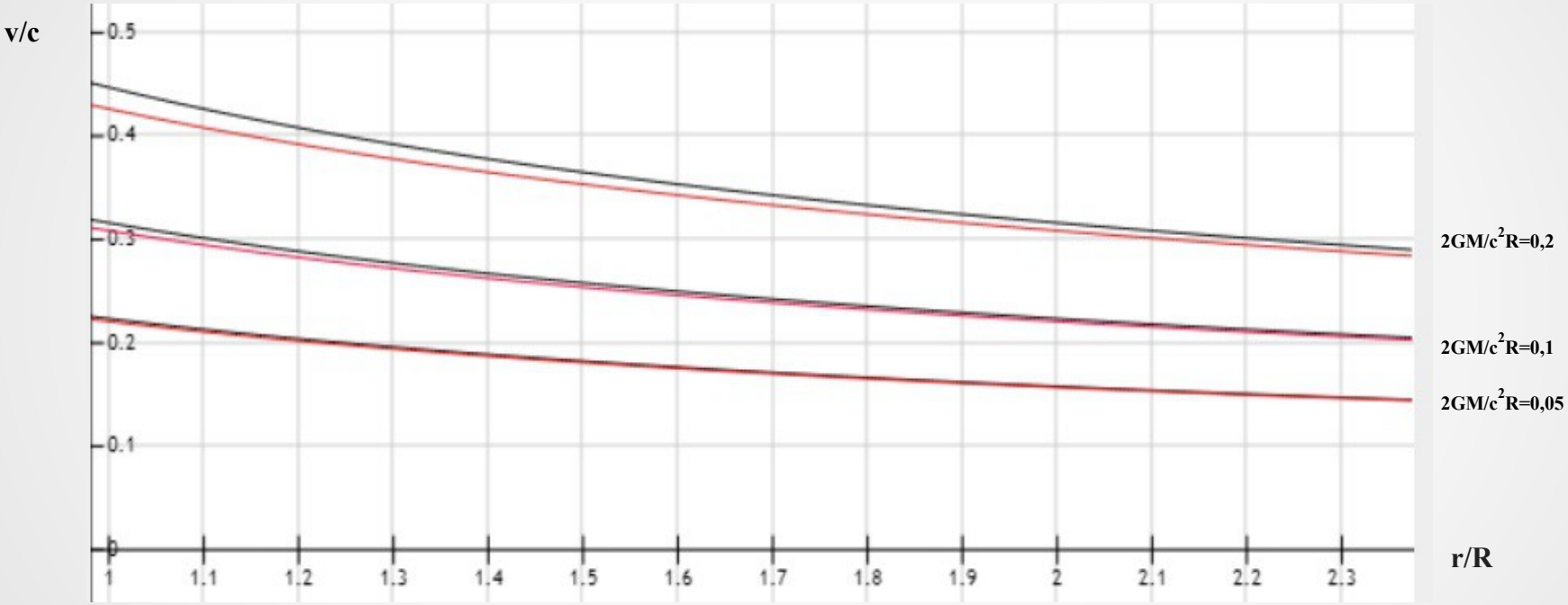
Considering the presence of gravitational fields, it is proposed a process that takes place at the expense of energy taken from the physical system, there is as well an interrelation between space-time distortion and the alteration of mass-energy, and the value of mass-energy depends on the reference taken.

$E^A_C - E^A_B = \int_{dt/d\tau_B}^{dt/d\tau_C} mc^2 d\phi$ **Energy linked to the proposed process;** $p = 1/\phi$ **Being** $\phi = dt/d\tau$ **(t coordinate time;** τ **proper time). Superscript the reference, subscripts the states**

τ_B **proper time at B;** τ_C **proper time at C. When the states B and C correspond to A and B respectively, and denoting generically** $\tau_B = \tau$, **then:** $E^A_B - E^A_A = (dt/d\tau)mc^2 - mc^2$

PROCESS LINKED TO GRAVITY AFFECTING MASS-ENERGY

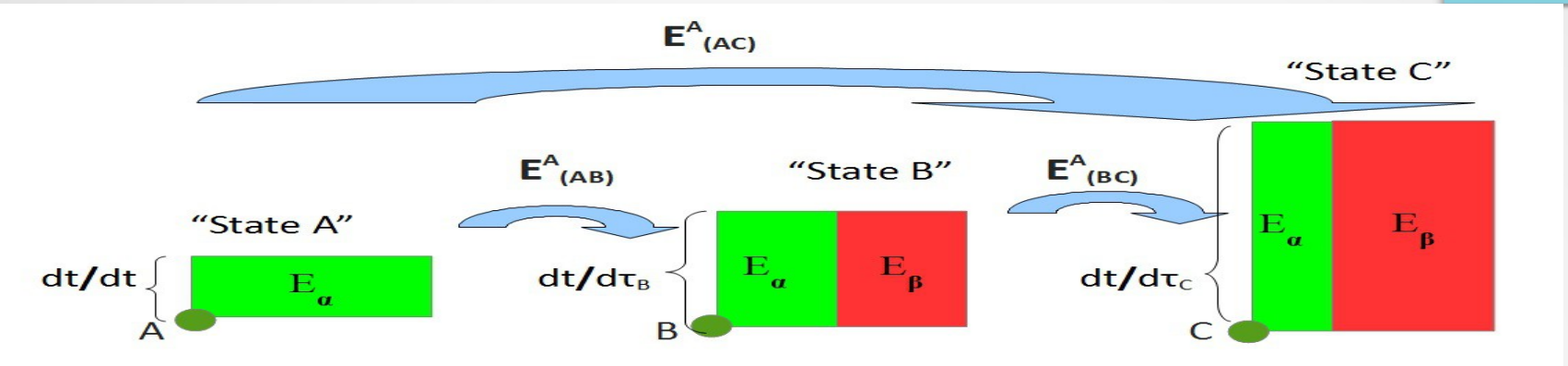
Below, it is represented the effect at the vicinity of a sphere (Schwarzschild metric outside the sphere) when $2GM/c^2R=0,2$ (a remarkable strong gravitational field), using the same graphic for $2GM/c^2R=0,1$ and $2GM/c^2R=0,05$.



Black lines represent the ratio between velocities and the speed of ligth (v/c) for a body in free fall, considering the Standard Model of Relativity, meanwhile the red ones do represent the modified value v_{mod}/c taking into account the proposed hypothesis.

PROCESS LINKED TO GRAVITY AFFECTING MASS-ENERGY

Scheme showing increasing quantity of **mass-energy (β-state),** the closer to the source of the gravitational field.



Reference: "State A"

"State A" time: t	"State B" proper time: τ_B	"State C" proper time: τ_C
mass-energy (α-state): $E_\alpha=mc^2$	**mass-energy (α-state):** $E_\alpha=mc^2$	**mass-energy (α-state):** $E_\alpha=mc^2$
mass-energy (β-state): $E_\beta= 0$	**mass-energy (β-state):** $E_\beta= (dt/d\tau_B)mc^2 - mc^2$	**mass-energy (β-state):** $E_\beta= (dt/d\tau_C)mc^2 - mc^2$
total mass-energy: $E_T=mc^2$	**total mass-energy:** $E_T=(dt/d\tau_B)mc^2$	**total mass-energy:** $E_T=(dt/d\tau_C)mc^2$

Energy between states B and C with reference the "State A" $E^A_{(BC)} = E^A_C - E^A_B = \int_{dt/d\tau_B}^{dt/d\tau_C} mc^2 d\phi = (dt/d\tau_C)mc^2-(dt/d\tau_B)mc^2$

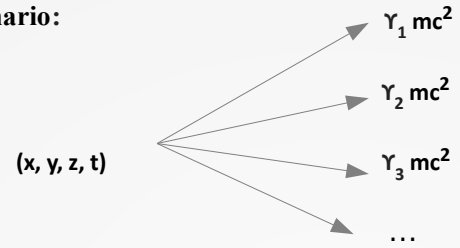
Energy between states A and B with reference the "State A" $E^A_{(AB)} = E^A_B - E^A_A = (dt/d\tau_B)mc^2-mc^2$

Energy between states A and C with reference the "State A" $E^A_{(AC)} = E^A_C - E^A_A = (dt/d\tau_C)mc^2-mc^2$

PROCESS LINKED TO GRAVITY AFFECTING MASS-ENERGY

Concerning Relativity, it is not enough the assignation of four space-time coordinates to define the properties of the physical system.

For instance, considering the Special Relativity scenario:



Mass-energy of a body located in (x, y, z, t) depends on the reference taken. ϒ relates the "State B" (referenced state) of the body situated at (x, y, z, t) with the "State A" (the reference). In order to establish the physical properties of a body, it is required to define x, y, z, t and ϒ.

The present paper suggests that there is not just three space-like dimensions and one time-like dimension, but four spatial dimensions and one time dimension x, y, z, w, t where the space-time framework fulfills:

$$ds^2 = c^2d\tau^2 = c^2dt^2-dx^2-dy^2-dz^2 = dw^2-dx^2-dy^2-dz^2$$

- There is a dependent relation between them as established by the expression $c^2d\tau^2 = dw^2-dx^2-dy^2-dz^2$ linking the time-like coordinate to the space-like coordinates.

- The distortion of the space-like coordinate w is the same than the distortion of the time-like coordinate t. That is what is representing $c^2dt^2-dx^2-dy^2-dz^2 = dw^2-dx^2-dy^2-dz^2$

- There is an interrelation between mass-energy and space-time.

PROCESS LINKED TO GRAVITY AFFECTING MASS-ENERGY

Minkowski space-time for the Special Relativity scenario and the Riemannian geometry corresponding to a curved space-time framework due to the presence of mass-energy, for instance the Schwarzschild metric for the vacuum solution of a homogeneus sphere, uncharged, non rotating.

The proposal implies that there is an interrelation between the quantity of mass-energy that changes to mass-energy (β-state) and the distortion of space-time. Time has to be taken into account, with distortion of time coordinate the same than distortion of w.

Taking into account now the effect due to the distortion of the time coordinate, the amount of mass-energy will be:

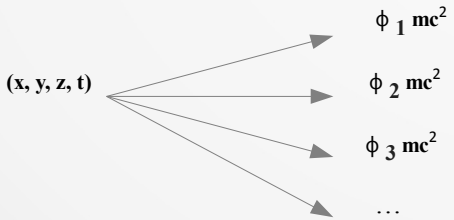
mc^2 value of mass-energy corresponding to "State A"

Υmc^2 value of mass-energy corresponding to "State B" relative to "State A"

Similarly to the Special Relativity Scenario, will be the General Relativity Scenario with the presence of gravitational fields.

mc^2 value of mass-energy corresponding to "State A"

$(dt/d\tau)mc^2$ value of mass-energy corresponding to "State B" being τ proper time in "State B"



Denoting $\phi=(dt/d\tau)$

That is the reason for the notation of the type E^A_B **where it is defined the referenced and reference taken.**

PROCESS LINKED TO GRAVITY AFFECTING MASS-ENERGY

Probabilistic approach

It is defined the following Physical System: Special Relativity Scenario.

A radioactive element that has a hypothetical uniform distribution of mass, dm/(dxdydz) homogeneous density throught a region of space-time between (0, 0, 0) and (x, y, z).

The decay of that radioactive element over a period of time t (0 starting point of the expeeriment and t moment of the measurement, with dt time element for the time coordinate), follows the Poisson´s distribution: $\mathcal{P}(\lambda,x)$ where λ represents the frequency of occurrence of a given event (this case, the decay of the radioactive element) and x would represent the amount or number of events in an interval.

The Poisson distribution is related to another discrete probability distribution, the binomial distribution. Considering n Bernoulli statistical trials, each of them with probability $p \cdot P$ that a certain event takes place, fulfilling the following conditions:

$0<p\cdot P<<1$ very small probability of success.

$n\uparrow\uparrow$ very high number of statistical trials.

$n\cdot p\cdot P=\lambda$ The product of the number of statistical events multiplied by the probability associated with each of the trials is equal to the frequency of occurrence λ

If these three conditions are met, both distributions give very similar values, at the limit when $n\rightarrow\infty$ are equivalent ones.

PROCESS LINKED TO GRAVITY AFFECTING MASS-ENERGY

This leads to the proposal that at the Physical System is taking place the occurrence of statistical events each one with probability $p \cdot P$ of being successful.

That is to say, during the period of time dt, it takes place n statistical events, P representing the probability of an event taking place at a particular trial (the example corresponds to the decay of the radioactive element), meanwhile p is a factor (which depends on distortion of space-time) that modifies the value of P.

The value of p will be linked to the alteration of mass-energy, if all the mass-energy corresponds to mass-energy **(α-state)** then the value of p is 1 (that is the case for a reference frame with no velocity), when there is velocity, the kinetic energy do alter the state of mass-energy. The higher the quantity of mass-energy that is affected changing to **(β-state),** the lower the value of p.

The value of mass-energy corresponding to mass-energy **(α-state)** is $p \cdot P$, while the corresponding to mass-energy **(β-state)** is $q \cdot P = (1-p) \cdot P$.

Each of the n statistical events will have associated a value for mass-energy **(α-state)** and mass-energy **(β-state),** the quantity of mass-energy **(β-state)** is linked to the dilation of the w coordinate and the contraction of the coordinate corresponding to the direction of velocity (considering the Special Relativity scenario).

The value of p for the "State A" (no velocity) is 1, the value of p for the "State B" is linked to the quantity of mass-energy **(α-state)**, but increasing the number of statistical events to n´ instead of n, the physical system reaches the same total amount of mass-energy **(α-state)** where $n \cdot 1 \cdot P = \lambda = n' \cdot p \cdot P$

"State A" "State B"

PROCESS LINKED TO GRAVITY AFFECTING MASS-ENERGY

The kinetic energy alters the amount of mass-energy (α-state), and that value is linked to the distortion of space-time. Considering scenarios with presence of gravitational fields, it is proposed that the curvature of space-time is linked to the alteration of mass-energy, so knowing the E.F.E. might be calculated the alteration of mass-energy and in turn the energy required for that alteration to take place, which is responsible of an additional distortion of space-time.

This way it is linked the curvature of space-time with the probability of events taking place.

Summarizing:

Mass-energy is altered by the gravitational fields, that process is boosted by energy-momentum, that is what happens for example considering Special Relativity scenarios.

Gravitational waves do change the State of mass-energy from **(α-state)** to **(β-state).**

(α-state) is linked to x, y, z meanwhile **(β-state)** is linked to w, which dilates at the expense of the contraction of x, y, z

Gravitational waves increase the probability of mass-energy in **(β-state)** at the expense of reducing the probability in **(α-state).** That probability is recovered increasing the number of statistical trials.

The increase of sttatistical trials is the effect corresponding to time dilation and that dilation is the same than the corresponding to the coordinate w.

This process requires energy, which is taken from the physical system, producing an additional distortion of space-time.

CONCLUSIONS

Quantum mechanics is characterized by processes where particles interact, passing from an “α state” to a “β state”.

Considering the phenomenon corresponding to the photoelectric effect :

Photons interact with electrons, part of the energy is absorbed by the process and the rest goes to kinetic energy.

The hypothesis proposes that the interaction between Gravitational waves and mass-energy requires a contribution of energy,

It is defined a process linked to gravity where mass-energy would be affected changing its physical state. Gravitational waves would interact with mass-energy, part of the energy is absorbed by the process and the rest goes to the velocity term of the kinetic energy.

It is added a new condition to the Einstein Field Equations (being a more restrictive scenario). Using this approach might be possible to quantize gravity.

The proposed hypothesis allows to do mathematical calculations and predictions.

REFERENCES:

Larmor, J.

"A Dynamical Theory of the Electric and Luminiferous Medium. Part III. Relations with Material Media".Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences 190: 205. (1897).

Poincaré, H.

"The Principles of Mathematical Physics". The Monist, Vol. XV. (1905).

Einstein, A.

"Zur Elektrodynamik bewegter Körper". ("On the Electrodynamics of Moving Bodies"). Annalen der Physik Vol. 322 Issue 10 pages 891-921 (1905).

"Concerning an Heuristic Point of View Toward the Emission and Transformation of Light" (1905) Translation into English American Journal of Physics, v. 33, n. 5, May 1965

"On a Heuristic Viewpoint Concerning the Production and Transformation of Light". (1905).

"Die Feldgleichungen der Gravitation" Sitzungsberichte der Preussischen Akademie der Wissenschaften zu Berlin: 844–847. Retrieved 2006-09-12. (1915).

"The Foundation of the General Theory of Relativity". Annalen der Physik 354 (7): 769. (1916).

"Does the Inertia of a Body Depend Upon Its Energy Content?" Translation by George Barker Jeffery and Wilfrid Perrett in The Principle of Relativity. London: Methuen and Company, Ltd., 35- 65. (1923).

"Quantentheorie des einatomigen idealen Gases. 2. Abhandlung." Sitzber. Ber. Preuss. Ak. Wiss. : 3–14. (1925).

Planck, M.

"Eight Lectures on Theoretical Physics.Wills, A. P. (transl.). Dover Publications. ISBN 0-486-69730-4.(1915).

Noether, E.

"Invariante Variationsprobleme". *Nachr. D. König. Gesellsch. D. Wiss. Zu Göttingen, Math-phys. Klasse 1918*: 235–257. (1918).

Heisenberg, w.

"Über den anschaulichen Inhalt der quantentheoretischen Kinematik und Mechanik". *Z. Phys.* 43 (3–4): 172–198. (1927).

REFERENCES:

Kennard, E.

"Zur Quantenmechanik einfacher Bewegungstypen". *Zeitschrift für Physik* 44 (4–5): 326. (1927).

Bohr, N.

"Discussions with Einstein on Epistemological Problems in Atomic Physics". In P. Schilpp. Albert Einstein: Philosopher-Scientist. Open Court. (1949).

Macfarlane, A.

"On the Restricted Lorentz Group and Groups Homomorphically Related to It". Journal of Mathematical Physics 3 (6): 1116–1129. (1962).

Hawking, S.

"Particle Creation by Black Holes Commun. Math Phys. 43(3): 199–220. (1975)

Hooft, G.

"Dimensional Reduction in Quantum Gravity". ArXiv:gr-qc/9310026 (1993).

Susskind L.

"The World as a Hologram".*Journal of Mathematical Physics 36* (11): 6377–6396.(1995).

Hamza, K.

"The smallest uniform upper bound on the distance between the mean and the median of the binomial and Poisson distributions Statist. Probab. Lett. 23 21–25. (1995).

Saunders, S.

"Complementarity and Scientific Rationality".*Foundations of Physics* 35 (3): 417–447. doi:10.1007/s10701-004-1982-x. (2005).

Ahmed Almheiri, Donald Marolf, Joseph Polchinski, and James Sully

"Black Holes:Complementarity or Firewalls? doi: 10.1007/JHP02(2013)062