HYPOTHESIS

PROCESS LINKED TO GRAVITY AFFECTING MASS-ENERGY

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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 mass-energy.

- The hypothesis proposes the existence of a process linked to gravity
  - This phenomenon would affect mass-energy
  - Requires an additional condition (being a more restrictive scenario) to the field equations that define space-time curvature,
  - Adding the condition linked to the proposed phenomenon, the trajectory that follows mass-energy in that curved space-time, changes with respect to the established by the officially accepted model.
  - The effect is negligible if the distortion of space-time caused by a gravitational field does not have a significant value.

- The hypothesis proposed allows to mathematically calculate that discrepancy,

- The proposal would have important implications in diverse areas of science and its effect would be determinant in the study of black holes or questions related to Cosmology.
The mathematical model of General Relativity has allowed to carry out 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.

- At 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
The proposal assumes that the distortion of space-time due to relative velocity (Special Relativity), and the distortion of space-time that is produced by gravitational fields (General Relativity) are linked to changes of state that affect the mass-energy, generically denoted "State A" and "State B".

The hypothesis proposed consists on assuming that there is a contribution of energy between both states. That would be already taken into account for Special Relativity \( (E_T = E_K) \) but not with General Relativity.

\[
\begin{align*}
E_A &= mc^2 \\
E_T &= \frac{1}{\gamma}mc^2 - mc^2 \\
E_B &= \frac{1}{\phi}mc^2
\end{align*}
\]

- Concerning Special Relativity: \( p = 1/\gamma \) \quad Being \( \gamma \) The Lorentz factor
  \( E_T = \gamma mc^2 - mc^2 \) corresponding to the kinetic energy; "State B" velocity \( v \) relative to "State A"

- Concerning General Relativity: "State A" is linked to \( dt \) and "State B" linked to \( d\tau \), hypothetically with no relative velocity between both states: \( p = 1/\phi \) \quad Being \( \phi = dt/d\tau \) \quad (t coordinate time; \( \tau \) proper time)
  \( E_T = (dt/d\tau)mc^2 - mc^2 \)
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Considering an observer at “State A”, and an object at State A as well, with associated energy $E_A = mc^2$. If that object passes to “State B”, while the observer is sit at “State A”, the value of the energy associated to that object relative to the observer fixed at “State A”, changes to $E_B = (dt/d\tau)mc^2$, and the value of the energy required for that process to take place is $E_T = (dt/d\tau)mc^2 - mc^2$.

The value of the energy $E_B$ is the value at B with reference the “State A”, indicating that energy at B is with respect to A, already implies that relation, although for this concept to be explicitly represented would be required a notation of the type:

$$E_A^A = mc^2$$  $$E_B^A = (dt/d\tau)mc^2$$

Upper index A indicates that the reference is "State A", so the value of the energy at A with reference A has value $mc^2$ while the value at B with reference A would have value: $(dt/d\tau)mc^2$. If we consider the value at B with reference B then $E_B^B = mc^2$ and the value at A with reference B would be $E_A^B = (dt/dt)mc^2$.

The energy between two states B and C taking as reference A (with associated time $t$, at A):

$$E_C^A - E_B^A = \int_{\tau_B}^{\tau_C} mc^2 d\phi$$

Energy linked to the proposed process

$\tau_B$ proper time at B; $\tau_C$ proper time at C

When the states B and C correspond to A and B respectively, and denoting generically $\tau_B = \tau$, then: $E_B^A - E_A^A = (dt/d\tau)mc^2 - mc^2$.
The value at B for an observer at State A

\[ E^A_B = (mc^2)(dt/d\tau)mc^2 - mc^2 = dt/d\tau mc^2 \]

The value at A for an observer at State B

\[ E^B_A = (mc^2) + ((d\tau/dt)mc^2 - mc^2) = d\tau/dt mc^2 \]

Because concerning General Relativity, both observers do agree on the values of \( dt \) and \( d\tau \), so that the parameters \( dt \) and \( d\tau \) have inverse position for an observer at B. (Note: concerning Special Relativity, the energy at “State B” (with relative velocity \( v \) respect of “State A”) for the observer at “State A” is \( \Upsilon mc^2 \), while for an observer at “State B” is \( mc^2 \). But both observers would take as value \( p \) for the other state as \( p = 1/\Upsilon \).

So Concerning General Relativity, considering the reverse process (from “State B” to “State A”), if the object with associated energy \( E^B_B = mc^2 \) changes to “State A” ( \( E^B_A = (dt/d\tau)mc^2 \) ), then instead of requiring energy, would be an exothermic process, having \( (dt/d\tau)mc^2 - mc^2 \) a negative value.
The proposed process, as defined, implies an additional effect to the currently accepted model, caused by the gravitational waves. The endothermic process from A to B would be at the expense of velocity corresponding to the Kinetic Energy, while the exothermic process from B to A would increase velocities of bodies at an expansive scenario.

Elements involved in the proposed process:
- Gravitational waves, which will interact with mass-energy.
- Mass-energy with a starting reference value \( mc^2 \). (Value of mass-energy at “State A” with reference the state A, linked to \( dt \), \( E_A^{A} = mc^2 \)).
- Potential Energy, part of it will be absorbed by the process and the rest would be transformed into the velocity term of the kinetic energy.

Result (“State B”):
- Space-time distortion at the space-time position linked to the “State B” (as defined by Einstein field equations).
- Mass-energy with value \( E_B^{B} = (dt/d\tau)mc^2 \)
- Kinetic energy that will have the altered mass-energy in the new state. The total value of the kinetic energy does not change, what is modified is the velocity term of that kinetic energy, because the process will take place at the expense of the velocity (That value is linked to \( \Upsilon_{mod} \) \( \Upsilon_{mod} = 1/\sqrt{1-v^2/c^2} \)), while \( \Upsilon = 1/\sqrt{1-v^2/c^2} \) is the value corresponding to the theoretical Kinetic energy without taking into account the proposed process.

In order to calculate \( \Upsilon_{mod} \) it is necessary to take into account the combination of both phenomena: relative velocity and the gravitational field.

It is worthwhile noticing that the process as described is similar to the phenomenon corresponding to the photoelectric effect (each with its own characteristics):

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

Hypothesis: Gravitational waves would interact with mass-energy, part of the energy is absorbed by the process, the rest goes to the velocity term of the kinetic energy.
The weak equivalence principle:

The trajectory of a point mass in a gravitational field depends only on its initial position and velocity, and is independent of its composition and structure.

<table>
<thead>
<tr>
<th>Space-time position A</th>
<th>Space-time position B</th>
</tr>
</thead>
<tbody>
<tr>
<td>body with mass-energy m1</td>
<td>body with mass-energy m1 and velocity v</td>
</tr>
<tr>
<td>body with mass-energy m2</td>
<td>body with mass-energy m2 and velocity v</td>
</tr>
</tbody>
</table>

Considering the proposed process:

“State A”

body with mass-energy m

“State B”

body with mass-energy \((\frac{dt}{d\tau})m\) and velocity \(v_{\text{mod}}\) relative to “State A”

The kinetic Energy of the body, now with energy \(E_A^B = (\frac{dt}{d\tau})mc^2\) when it reaches the “State B” has to be the same than the kinetic energy of the body if all the Potential Energy would transform into Kinetic Energy corresponding to velocity \(v\)

\[
\gamma_{\text{mod}}(\frac{dt}{d\tau})mc^2 - (\frac{dt}{d\tau})mc^2 = \gamma mc^2 - mc^2
\]

\[
(\gamma_{\text{mod}} - 1)(\frac{dt}{d\tau})mc^2 = (\gamma - 1)mc^2
\]

\[
\gamma_{\text{mod}} = 1 + \gamma \frac{d\tau}{dt} - \frac{d\tau}{dt}
\]

This expression does not depend on mass, so bodies with different mass will still have the same velocity, but \(v_{\text{mod}}\) instead of \(v\)
If we consider the following scenario:

“State A” reference time $t$

“State B1” with proper time $\tau$ due to G.R. and velocity $v_1$ relative to State A

We would have distortion of time between both states due to GR and SR with velocity $v_1$

If we now consider:

“State A” reference time $t$

“State B2” with proper time $\tau$ due to G.R. and velocity $v_2$ ($<v_1$) relative to State A

We would have distortion of time between both states due to GR and SR with velocity $v_2$

The distinction between both B1 and B2 is the energy required to decelerate the object from $v_1$ to $v_2$

The proposed process has a similar effect so that due to the requirement of energy $(\frac{dt}{d\tau})mc^2-mc^2$ on the trajectory from A to B, instead of velocity $v_1$ results $v_2$

Taking this approach is useful to obtain certain data, for example to calculate the velocity at State B or time distortions.
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EXAMPLE

Discrepancy (increment per unit) between $\gamma$ ($\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$) and $\gamma_{\text{mod}}$ ($\gamma_{\text{mod}} = \frac{1}{\sqrt{1 - \frac{v^2_{\text{mod}}}{c^2}}}$)

Considering the GF corresponding to the Sun, the Schwarzschild metric outside the sphere

Taking as value $2GM/c^2R = 0,00000424607412878786$

corresponding to a trajectory between State A (far away from the gravitational source so that its effect is negligible) State B (the surface of the sun)

That discrepancy has a value of $0,0000000000045072738$

That would be the discrepancy for a body in free fall for the whole trajectory between State A and State B. If “State B” corresponds to a distance $r$ to the surface of the sun, the discrepancy is substantially lower, because most of the discrepancy is produced at the vicinity of the sphere.

If the body evolves in space-time without increasing time distortion, then the discrepancy is null, evolution at the surface of a planet or in an orbit around a planet or a star with little change of time distortion, the effect of the proposed process is negligible. That might be the reason for this effect to go unnoticed.
The equations proposed represent an additional condition.

The equation of motion (if there is no external force):

$$m \left( \frac{d^2x^\mu}{d\tau^2} \right) = f^\mu - m \Gamma^\mu_{\nu\lambda} \left( \frac{dx^\nu}{d\tau} \right) \left( \frac{dx^\lambda}{d\tau} \right)$$

That is the equation for the geodesic in the curved space-time. If we add the additional condition proposed, then the system would not correspond to the equation of motion with no external force.

We know the geodesic that the particle or the body would follow if there is no external force, to know the trajectory of the particle adding the additional condition, we have to add the force corresponding to each space-time position of the trajectory (the equations proposed allow us to know that force corresponding to each space-time position).

So it has to be applied the Energy term (opposed to the free fall) that takes place between the initial State A and all the space-time positions in its trajectory until reaching the final State B. Knowing the energy required by the proposed process.
Special Relativity

\[ v = \frac{x}{\left(\frac{l_p}{t_p}\right)} \]

\[ x < 1 \]

\( x = 1 \) that state corresponds to a “saturated Physical System” requires an infinite amount of energy.

General Relativity

Considering the Schwarzschild metric for the vacuum solution of the field outside the homogeneous sphere, uncharged, non rotating.

\[ \frac{2GM}{c^2R} = \left(\frac{2M}{m_p}\right) / \left(\frac{R}{l_p}\right) \]

With \( m_p = \sqrt{\frac{h}{2\pi G}} \)

\[ l_p = \sqrt{\frac{hG}{2\pi c^3}} \]

\[ \frac{l_p}{m_p} = \frac{G}{c^2} \]

\( (2M/m_p) < (R/l_p) \) or \( (2M/R) < (m_p/l_p) \)

\( (2M/R) = (m_p/l_p) \) state corresponds to “saturated Physical System” requires infinite amount of energy for a body to reach the event horizon of a black hole, because the value of the energy required by the proposed process ((\( dt/d\tau \)) \( mc^2 \)) to reach that state (corresponding to the event horizon) has an infinite value.
The proposed process Schematically:

- General Relativity (not including the proposed process)

\[ \text{State A} \quad \text{State B} \]
\[ (1) \quad \mathbf{p} \cdot \mathbf{E} \quad \mathbf{p}' \cdot \mathbf{E}' \]

Gravitational waves

- General Relativity (including the proposed process)

\[ \text{State A} \quad \text{State B} \]
\[ (2) \quad \mathbf{p} \cdot \mathbf{E} \quad \mathbf{p}' \cdot \mathbf{E}' + \mathbf{q}' \cdot \mathbf{E}' \]

Gravitational waves + \( E_T \)

- Special Relativity (energy corresponds to the Kinetic energy and is already taken into account in the Relativity model)

\[ \text{State A} \quad \text{State B} \]
\[ (3) \quad \mathbf{p} \cdot \mathbf{E} \quad \mathbf{p}' \cdot \mathbf{E}' + \mathbf{q}' \cdot \mathbf{E}' \]

\( E_T = E_K \)
If $E$ represents mass-energy, now $P$ represents the probability that a given event will take place.

As example, a particular phenomenon, the decay of a radioactive material, is analyzed. This phenomenon is probabilistically characterized by the Poisson distribution. $P(\lambda, x)$ where $\lambda$ represents the frequency of occurrence of a given radioactive material decaying and $x$ would represent the amount of radioactive material that decays.

$P(\lambda, x_1)$ Would give us the probability that a given amount of material $x_1$ will decay after a stipulated period of time.

The Poisson distribution is related to another discrete probability distribution, the binomial distribution. So if we have $n$ statistical tests, each of them with a linked probability $p \cdot P$ that a certain event takes place (taking into account the example, the event would correspond to the decay of the radioactive material), fulfilling the following conditions:

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

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

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

If these three conditions are met, both distributions give very similar values, in fact at the limit when $n \to \infty$ are equivalent ones.
This leads to the proposal that this phenomenon might be linked to the occurrence of statistical tests each of them with probability \( p \cdot P \) to be successful.

Analyzing the components of the expression \( n \cdot p \cdot P = \lambda \) (at the end we would have a value or final result set, but would be the result of conjugating various effects).

\( P \) would be linked to the probability of this event taking place, if we were able to vary the value of \( P \) to \( P' \) but keeping \( n \cdot p \) as a constant value, then \( \lambda \) value would change to \( \lambda' = n \cdot p \cdot P' \).

On the other hand, \( p \) and \( n \) would be interrelated, where \( p \) would act as a distribution factor of the probability \( P \) at each trial. Thus if we keep \( P \) constant and what varies is \( p \) to \( p' \) (this value being less than \( p \)), then the value of \( p' \cdot P \) at each of the trials is smaller, than that we had with \( p \cdot P \) but If we increase the number of trials so that \( n' \cdot p' \cdot P = n \cdot p \cdot P \) then \( \lambda \) would remain a constant value.

The third possible scenario is to change \( P \) and change \( p \) and \( n \) as well (the variation of \( p \) and \( n \) would always go together, what decreases one, increases the other).

All this leads to the proposal that gravitational waves interact with mass-energy by altering the value of the factor \( p \) and consequently the value of \( n \).

The factor \( p \), called here a distribution factor, is the one that would affect the energies, in the section related to energies, it is the factor that relates the reference state (State A) to the referenced state (State B)

The hypothesis proposed raises a scenario where gravitational waves interact with mass-energy and energy \( q' \cdot P' \) is required, as a result instead of having \( p'P' \) we would have \( p' \cdot P' + q' \cdot P' \)
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Absence of GF and no relative velocity between A and B:

Observer at reference A.

GF and no relative velocity between A and B:

Just taking into account space-time distortion effect and not the effect on values of the wave function.

Q = (t'_a / t_a)P \cdot P in order to keep the same value of probability per number of trials n.

After n' Clock has run t'_a at A but t_a at B.

After n Clock has run t_a at A but t_a (t_a/t'_a) at B.
The effect produced by the gravitational field affects space-time position B and locally to its space-time surroundings, as defined by the Einstein Field Equations.

Considering the Schwartzschild metric

\[ r \] representing now the radial coordinate, distortion of time coordinate corresponding to clock running more slowly at B and space contraction on radial direction.

Scheme represents the proportion between \( \alpha \)-state and \( \beta \)-state, meaning that interaction of gravitational waves and mass-energy on the radial space direction produces the result \( \beta \)-state of mass-energy on that proportion, which corresponds to the distortion of space on that direction. Inversely to the distortion of space, is the distortion of time. So knowing the value of the distortion of time is possible to know the value of mass-energy at \( \beta \)-state linked to the space-time position B (or “State B”).

Locally, for the radial coordinate on the surroundings of B, the chances of a quantum of energy to transform into \( \beta \)-state will increase, the higher the value of \( \frac{2GM}{c^2 R} \). On the other hand, time-like coordinate is distortioned as previously defined. Similarly, this process will take place on a general expression of space-time curvature considering gravitational fields and energies corresponding to General Relativity. The Schwartzschild metric does not include space-time like coordinates, metrics with space-time distortion including them, have to be taken into account to obtain the value of the energy linked to the process, which ultimately will depend on the corresponding distortion of space.

The process, in order to take place as defined, requires energy, and it has to be taken into account the conundrum of General Relativity and Special Relativity.
Special Relativity

Considering the same interval of time, and the same space-time position B (same “State B” of the Gravitational Field), bodies with different relative velocities would suffer a different interaction process between gravitational waves and mass-energy, corresponding to different states. Note: the pure idealistic “Special Relativity” scenario in absence of gravitational fields is not a realistic scenario, bodies are immersed in gravitational fields, even in an area of extremely low effect produced by gravitational fields, the proposed process would take place, bodies with different relative velocities would affect the interactions and correspond to different states.

Considering the same interval of time, or a particular instant of time, interactions will differ depending on the velocity of the body.

Velocity on x direction.

A case of negligible distortion of space-time corresponding to General Relativity, the energy linked to the proposed process is the Kinetic Energy, so that energy is already taken into account as a body passes from “State A” to “State B”.

\[ Q = E_K = \gamma mc^2 - mc^2 \]

Q energy linked to the proposed process concerning Special Relativity

When General Relativity has a significant effect and it is needed to take into account both effects, for example a free fall body at space-time position B relative to another position A, between them there is different space-time curvature due to General Relativity and Special Relativity in this case the energy required for the process corresponding to General Relativity will be at the expense of the velocity, so that the energy available will satisfy the process corresponding to General and Special Relativity.
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 at this paper proposes that the interaction between Gravitational waves and mass-energy requires a contribution of energy, defining a process linked to gravity where mass-energy is affected changing its state from A to B. Gravitational waves would interact with mass-energy, part of the energy is absorbed by the process and the rest goes to kinetic energy.

The process linked to gravitational fields is endothermic from A to B and exothermic from B to A. the endothermic process would be at the expense of reducing velocity of the kinetic energy, meanwhile the reverse process would be an exothermic one, increasing the velocity of the body that passes from “State B” to “State A”. Expansive scenarios would show velocities higher than expected.

A free fall body follows a trajectory in a curved space-time framework towards the source of the gravitational field. The trajectory is defined by applying the Euler-Lagrange equations to Einstein field equations. The effect proposed implies that the body would not follow the geodesic of a “free fall body” what we consider as a “free fall body” in fact would be forced by the effect proposed. The effect is negligible insofar the distortion of time does not reach a significant value. Considering the officially accepted model, nothing prevents from a free fall body reaching the horizon event and inevitably ending in a Singularity. The proposal forces the body out of that geodesic, the energy required to follow that geodesic at the event horizon would be infinite.

The proposal allows to mathematically calculate the discrepancy between both scenarios.
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