Does the value of Planck time vary in a Black Hole Event Horizon?
A new way to unify General Relativity and Quantum Mechanics

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Abstract

This paper considers the assumption that Planck time and length values increase in gravitational wells, an effect that becomes more extreme in a black hole event horizon. Obviously, this assumption considers the point of view of an observer who is far from the gravity well, as opposed to an observer in the well, will not feel the effects predicted by the Schwarzschild equation. Whereas the values of these Planck constants remain unchanged for the observer in the well.

If physicists can accept that the Schwarzschild equation describes effects that are applicable to Planck time and Planck length, they will see that in a black hole´s event horizon the value of Planck length grows to the size of the event horizon. Thus, in terms of Planck length, every black hole (no matter its mass) has an event horizon radius that is always the same size, which is equal to one Planck length.

These authors believes that these considerations are fundamental in the development of a new theory that can effectively unite quantum mechanics with general relativity. The first step in this direction is to break the basic paradigm that considers that Planck constant values (Planck time and Planck length) are always constant, regardless of the location of the observer, which comes into direct confrontation with the Schwarzschild equation. Keeping in mind that the time dilatation and space shrink effects, given by the Schwarzschild equation, depend on the observer´s position.

Indexing terms/Keywords

Quantum Mechanics, General Relativity, Planck Time, Planck Length, Schwarzschild Equations, Black Hole

Academic Discipline and Sub-Disciplines

Relativity and Quantum Mechanics

SUBJECT CLASSIFICATION

Physics Classification

TYPE (METHOD/APPROACH)

Theoretical analysis considering a mental experiment, based on a Planck clock (a counter that increases its value with every new Planck time) that is put into orbit around a black hole, being subject to the effects of time dilation predicted in Schwarzschild equation.

Mathematical analysis that calculates Planck length and Planck time (considering Einstein´s mass energy conversion equation and Planck's energy equation) in a black hole´s horizon event, with a black hole´s wave length equal to its Schwarzschild radius.

INTRODUCTION

In 2015, physicists celebrated the centenary of the General Relativity Theory, published by Albert Einstein [1] on December 2nd, 1915.

2015 also marked 115 years since Max Planck [3] discovered the law of thermal radiation, which was the basis of Quantum Theory, leading to the beginning of Quantum Mechanics in 1910, with the collaboration between Planck, Einstein and Niels Bohr.

Currently, General Relativity (GR) and Quantum Mechanics (QM) are two pillars of modern physics. However, even after a century of research, physicists have failed to unite the two theories.

As GR describes our universe as very large distances, and QM describes our universe as very small distances, the incompatibility between them, prevents these two aspects of our universe (big and small) to be considered simultaneously. Thus, blocking the process of creating a unified physics theory that can describe our universe more thoroughly.

This article presents two fundamental hypotheses that can link GR and QM:

a) Planck time value increases in the vicinity of a black hole;

b) Planck length value increases in the vicinity of a black hole.

Even though these two hypotheses are very simple, until today, they haven´t been considered in any publication in Physics. These authors believes that they are "hidden" behind a paradigm associated with Planck constants:

"Planck constants must not change their values because they are constant"

This statement is correct if we consider the point of view of a single observer. But, Similarly, the Schwarzschild equation also becomes useless because the phenomena that it describes (time dilatation and space contraction isn´t applied to an observer in the vicinity of a black hole. In fact, the Schwarzschild equation describes the point of view of an observer far away from a black hole. For this same observer, the paradigm above is wrong and the two fundamental hypotheses become true.

These assumptions are fairly easy to observe through mental experiments, using "Planck clocks", based on counters that increase their values with every new Planck time.

If we break the Planck constant paradigm, we can see that the time dilatation and space shrinkage phenomena provided by the GR are actually affect Planck time and Planck length values, which obviously must be taken into account if we are to unite general relativity with quantum mechanics.

PLANCK'S CONSTANT AND BLACK HOLES

In the context of quantum mechanics, the smallest time that can be measured is Planck time (T_P), which has a constant value of 5.3912×10^{-44} seconds.

In space, in the vicinity of a black hole, general relativity (specifically the Schwarzschild equation) predicts a time-dilatation phenomenon. This means that time "goes slowly" when an object approaches a black hole, from the point of view of an observer who is far away from it. Near a black hole time "freezes" when the object reaches the event horizon.

But what about Planck time value in regions close to a black hole?

The most obvious answer is that Planck time is a constant and its value never changes.

However, we can also say that for the observer who "falls" into a black hole, the Schwarzschild equations mean nothing because he does not directly observe any of its effects. In fact, for this observer, the Planck time value doesn´t change. But what happens to an observer far away from the black hole?

The time dilatation phenomenon, as predicted by the Schwarzschild equation, only makes sense for the distant observer, and for this observer it is easy to show that the Planck time value increases. Thus, at the black hole event horizon, Planck time assumes a value that is proportional to the Schwarzschild radius divided by the speed of light.

Considering, for example, a black hole with a mass equal to that of the Sun, in the GR context, we can calculate that the event horizon radius (Schwarzschild radius) is about 3000 meters. This means Planck time near its event horizon is equal to 1.97×10^{-5}s. Thus, for an observer near to the event horizon of the "solar mass" black hole, even a very short time (e.g. 10^{-12} seconds), represents a very long time for observers elsewhere in the universe (in this example, 3.65×10^{26} seconds, which is equivalent to 843 million times our universe´s age), which explains why time seems to be frozen at a black hole´s event horizon.

Also, in the context of quantum mechanics, the shortest distance that can be measured is Planck length (L_P), which has a value equal to 1.616×10^{-35} meters.

The L_P value can be easily obtained by multiplying the T_P by the light speed. Thus, if an observer orbiting a black hole undergoes a time dilatation of a 100, this means that for every second this observer can measure, a far away observer can measure a hundred seconds more. For this time dilatation, the T_P value becomes 5.3912×10^{-42}s, which multiplied by light speed, generates an L_P value equal to 1.616×10^{-33}m that is 100 times larger than the default L_P value.

We can consider that all distances between two points are measured in terms of number of L_P "jumps" between these points. This becomes more obvious, using light beams to measure distance, as photons "jump" one L_P for each new T_P. Meaning that increasing Planck length (from the point of view of an observer far away to the black hole) causes space (and objects inside it) to appear to "shrunk". But in fact, when we consider distances closer to the black hole, the space-time fabric itself (in terms of a Planck length grid) becomes larger.

In this "solar mass" black hole example, Planck length at the event horizon becomes equal to 2,1 Km. The calculation of this value is based on equation 14, presented at the end of this paper and means that the event horizon radius of any black hole, regardless of its mass, is always equal to Planck distance divided by $\sqrt{2}$.

A mental experiment using a "Planck clock"

Supposing it is possible to create a "Planck clock", based on a digital counter, whose value increments at each new Planck time, we can make this mental experiment:

Two astronauts, Alice and Bob, each in their own spaceship. Bob's spaceship orbits a black hole and Alice´s is stop in space at far away distance where the effects of the black hole are virtually null.

Each ship has a "Planck clock". In Bob's spaceship the clock value is presented in a big display window on the outside of the vessel. Each time Bob´s spacecraft intersects Alice´s point, she can see the value of both clocks. Observing that Bob's time value image travels to Alice at light speed and can take a few seconds to get to her position. However, this delay is irrelevant, because with the two spaceships in the same position, it is constant.

Using a radio link, Alice tells Bob to approach or move far away from the black hole, until she observes a time dilatation on Bob´s clock that is equal to 100. So, if for Bob each orbit duration, for example, takes 2 hours (on Bob's clock), Alice will see that Bob takes a total of 200 hours (on Alice´s clock) to make a new orbit.

But, in fact, what is actually happening with Bob´s Planck clock when it orbits close to the black hole?

If we consider, for example, a short time interval, where Alice´s Planck clock counts only 1000 pulses (1000 Planck times), where Bob´s Planck clock will count only 10 pulses (10 Planck times).

If it were possible to observe the two clocks side by side, we would see Alice´s clock incrementing 99 times while Bob´s clock is "frozen" in the same value. So, just as Alice´s clock counts to 100 new pulses, Bob's clock increases to a new value.

Although this is just a mental experiment, it seems quite obvious that Bob´s "Planck clock" counts "more slowly" because the Planck time itself was 100 times bigger than usual due to the proximity to the Black Hole.

As the Planck distance is equal to the Planck time multiplied by light speed we can see that the L_P value is also 100 times greater. This means, for example, that if Alice´s spaceship is the same size as Bob´s spaceship, Alice will see Bob´s spaceship will appear 100 times smaller.

To better illustrate this using small numbers, for example, considering the length of Alice´s spacecraft is only 100,000 L_P, at Bob´s position (where L_P is 100 times greater) she will see the length of his spaceship as only 1,000 L_P.

The presence of matter expands space fabric

Although Einstein affirms in the RG context that matter concentration shrinks space, considering the mental experiment above is true, we can conclude that, in fact, the presence of matter expands space fabric, causing Plank length to become larger.

Figure 1 helps to explain this point:

a) A two-dimensional space containing a Planck length grid with all the black circles having Plank length diameters. The red circle represents an area of space that will be shrunk by a mass;

b) The appearance of a mass (the red dot) seems to shrink the grid, but in fact the Planck length becomes larger near the mass. Therefore, near the mass the black circle are bigger.

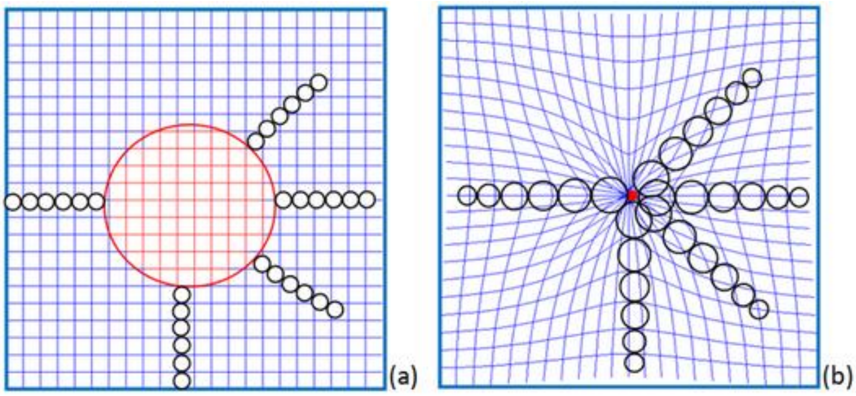

Fig 1: Space containing a Planck length grid. (a) Uniform grid in which a mass will collapse a space region (red circle). (b) Planck length becomes larger near the mass point (red dot).

This point can also be better understood with the analogy presented in Figure 2, where a river with parallel margins is bridged by rows of stones. The river will be crossed by a frog that jumps stone by stone:

a) For a human observer the river width is constant;

b) For the frog the river width appears to shrink in the center.

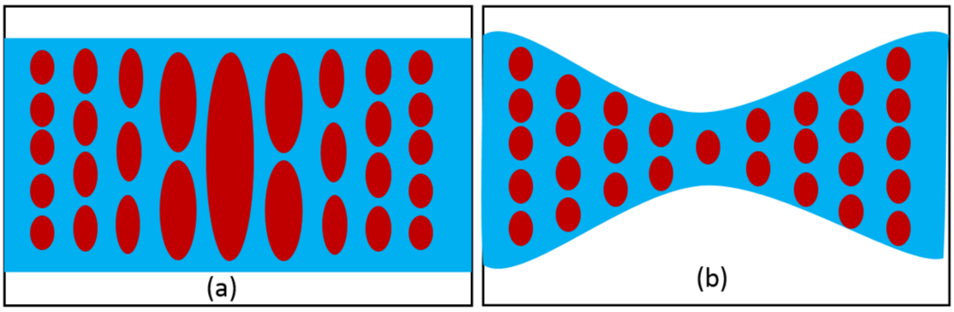

Fig 2: Analogy of a river bridged by rows of stones. (a) Real width. (b) Width expressed by number of stones.

Figure 3 shows a typical representation used in GR books, where a two-dimensional space containing a grid (defined by parallel lines) is "curved" by the presence of a mass located at the grid´s center. The lines are closer together the nearer the center, which explains the concept defined by Einstein that “mass shrinks space”.

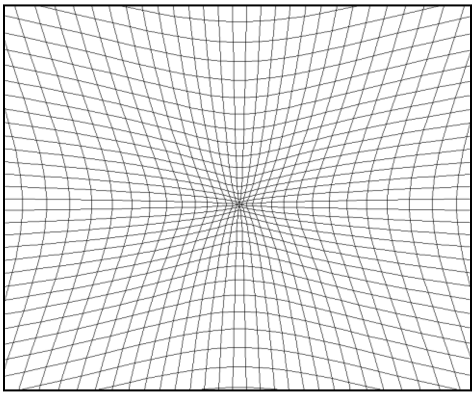

Fig 3: Common general relativity example, where a mass is placed at the center of a two-dimensional grid.

Figure 4 presents the same diagram as Figure 3, but now showing the value of Planck length, extremely magnified to allow visualization. Where Planck length is increased, we see that the grid´s parallel lines are, in fact, at the same distance from each other, but the distance "counted" in terms of the number of Planck lengths will be much smaller.

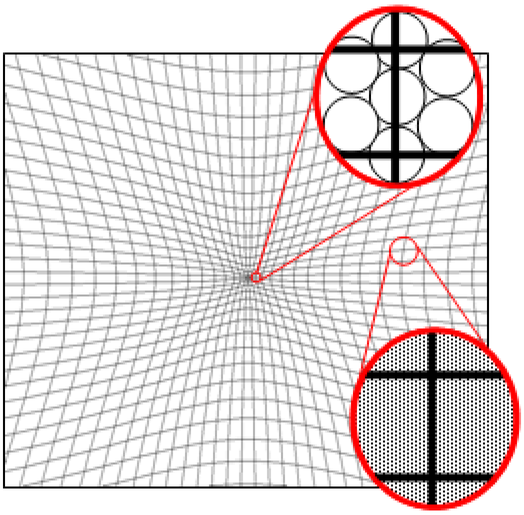

Fig 4: The same as Figure 3 with red circles magnifying Planck lengths in two grid areas.

CALCULATING PLANCK LENGTH IN THE EVENT HORIZON

Assuming Planck length increases at a black hole´s event horizon, this new L_P value can be calculated based on some equations (Schwarzschild equation, Einstein´s mass energy conversion equation and Planck's energy equation) applied to a black hole. However, we must also consider the quantum mechanics assumption that all massive bodies also have wave behavior. For black holes this wave behavior can be associated with a wave length that is defined by their Schwarzschild radius.

Equations from General Relativity

The main equation of GR is based on two tensors: The Einstein Tensor ($\mathbf{G}_{\mu\nu}$) related to the curvature of space-time and the Energy-momentum Tensor ($\mathbf{T}_{\mu\nu}$) that depends on the distribution of matter and energy. This equation is defined as:

$$\mathbf{G}_{\mu\nu} = -\frac{8\pi G}{c^2}\mathbf{T}_{\mu\nu} \qquad (1)$$

Where G is a gravitational constant and c is the speed of the light.

In a space without matter-energy, the space time coordinates (ct, x, y, z) are related to a flat space where the Einstein Tensor is:

$$g_{\mu\nu} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{bmatrix} \qquad (2)$$

In this case, a metric of a flat Minkowski space can be defined by:

$$ds^2 = c^2dt^2 - dx^2 - dy^2 - dz^2 \qquad (3)$$

In the presence of matter-energy, the Einstein Tensor can be defined as:

$$\mathbf{G}_{\mu\nu} = \mathbf{R}_{\mu\nu} - \frac{1}{2}R\,g_{\mu\nu} = -\frac{8\pi G}{c^2}\mathbf{T}_{\mu\nu} \qquad (4)$$

Where $\mathbf{R}_{\mu\nu}$ is the Ricci tensor and R is a scalar of curvature.

From equation (4) the GR field equations can be assembled, resulting in a series of partial differential nonlinear equations of second order and with hyperbolic elliptical coupling.
These equations aren´t usually very easily solved, even for the simplest of cases, and for more complex cases the solution involves the use of numerical simulations.
In a basic case, where there is a single spherical body of mass M in an empty space, the resolution of equation (4) generates a solution called the Schwarzschild metric [1].

This metric can be defined in spherical coordinates by the following equation:

$$ds^2 = c^2(1-\frac{2GM}{c^2 r})dt^2 - \frac{dr^2}{1-\frac{2GM}{c^2 r}} - r^2 d\Omega^2 \tag{5}$$

Where $d\Omega^2$ is defined by:

$$d\Omega^2 = d\theta^2 + \sin^2(\theta)\, d\phi^2 \tag{6}$$

Where (r, θ, ϕ) indicates the considered point from a spherical coordinate system, whose center is positioned at the gravity center of the considered spherical body.

If M is equal to zero, equation (5) becomes the Minkowskian metric for a flat space generating equation (3), which can also be written in spherical coordinates, as follows:

$$ds^2 = c^2 dt^2 - dr^2 - r^2 d\Omega^2 \tag{7}$$

For M values greater than zero, there will be an r value (the Schwarzschild radius) for which the value that multiplies dr^2 tends to the infinite, while the value that multiplies dt^2 tends to zero:

$$r_s = \frac{2GM}{c^2} \tag{8}$$

Equation (5) is only valid for the space outside the considered spherical body. If the radius of the body is greater than the Schwarzschild radius a division of zero in equation (5) will be avoided. In cases where the body radius is less than the Schwarzschild radius, there will be a situation in which the space curvature is so pronounced that not even light can overcome it, thus creating a black hole.

Planck equations

The value of Planck length is given by the following equation [3]:

$$L_{\mathrm{p}} = \sqrt{\frac{\hbar G}{c^3}} \tag{9}$$

Therefore, Planck time can be obtained by dividing Planck length by the speed of light:

$$T_{\mathrm{p}} = \frac{L_{\mathrm{p}}}{c} = \sqrt{\frac{\hbar G}{c^5}} \tag{10}$$

From equation (8) we can express the gravitational constant as a function of the Schwarzschild radius:

$$G = \frac{c^2 r_s}{2M} \tag{11}$$

Applying equation (11) into (9) we obtain:

$$L_{\mathrm{p}} = \sqrt{\frac{c^2 r_s}{2M} \frac{\hbar}{c^3}} = \sqrt{\frac{r_s}{2M} \frac{\hbar}{c}} \tag{12}$$

Considering the energy of a black hole can be related to its mass through Einstein´s energy equation ($E = m\ c^2$) and considering the wave behavior of matter, where the energy associated with a wave is given by the Planck energy equation ($E = h\ c / \lambda$).

If a black hole´s wave length is made equal to the Schwarzschild radius multiplied by 2 π , the following relationship can be established:

$$E = Mc^2 = \frac{hc}{\lambda} = \frac{hc}{2\pi\, r_s} = \frac{\hbar c}{r_s}$$

$$M = \frac{\hbar}{c\, r_s} \tag{13}$$

Applying equation (13) in (12) we get:

$$L_{\mathrm{p}} = \sqrt{\frac{c\, r_s}{\hbar} \frac{r_s}{2} \frac{\hbar}{c}}$$

$$L_{\mathrm{p}} = \frac{r_s}{\sqrt{2}} \tag{14}$$

$$L_{\mathrm{p}} \cong r_s$$

Further applying equation (14) in (10) we can obtain:

$$T_{\mathrm{p}} = \frac{r_s}{\sqrt{2}\, c}$$

$$T_{\mathrm{p}} \cong \frac{r_s}{c} \tag{15}$$

CONCLUSION

The mental experiments using “Planck clocks” point to the undisputed fact that Planck time increases in gravitational wells. Meaning that Planck time becomes extremely much larger in a black hole´s event horizon, therefore, time in this region appears to freeze. At the same points of space Planck length increases proportionally with Planck time, making objects appear shorter, which also explains why the speed of light is constant as it passes through regions of space-time distorted by black holes.

In addition, the mathematics presented above points to the fact that if the mass of a black hole is associated with wave behavior, Planck length at the event horizon tends to the Schwarzschild radius.

In one simple analogy, we can imagine that “space fabric” is connected to a net full of holes, where each hole´s diameter is connected to Planck length, which means that no distance can be measured inside of one hole (because Planck length is the smallest distance that can be measured), implying the “hole inside” cannot be observed.

It seems like "space fabric" is formed by a union of "micro black holes", each having a diameter (event horizon) equal to Planck length. In this analogy the presence of mass sucks in some of the "micro black holes" and so the neighbouring ones grow to occupy the available volume. This means that a black hole is only a big "micro black hole" formed by the stacking of many "micro black holes".

So, the question: Where does mass that falls into a black hole go?

It does not make sense…

The new mass just adds more micro black holes to the stack and causes Planck length in the vicinity of the black hole to become greater, implying that the event horizon´s radius (which is proportional to Planck length size) also becomes greater.

Beyond this, equation (14) shows us that black hole´s event horizon always have the same radius (equal to Planck length divided by $\sqrt{2}$), regardless of their mass. This means that each black hole is only one "space fabric" hole that has grown so much. Meaning that trying to look inside of a black hole is the same as trying to look inside of a sphere´s Planck length diameter.

The hypothesis that Planck time values change near to a black hole can easily be derived from the time dilatation phenomenon, as defined in the Schwarzschild equation, considering some kind of “Planck clock”. The fact that no one has observed this in a hundred years can only be explained by the Planck constants paradigm (Planck length and Planck time are always constant values) that has blinded physicists all over the world for all this time.

These authors believes that if this paradigm can be broken, with the hypotheses that gravitational wells can change Planck length and Planck time, becomes accepted by modern physicists, it will be the first step to a unified theory that can effectively meet general relativity with quantum mechanics.

REFERENCES

[1] Einstein, A. Relativity: The Special and General Theory, H. Holt and Company, 1920.

[2] Adler, R., Bazin, M. & Schiffer, M. Introduction to General Relativity, McGraw-Hill New York, 1975.

[3] Klein, M. J. Max Planck and the Beginnings of Quantum Theory, Archive for History of Exact Sciences, 1962, 459-479.

[4] Ulianov, P. Y. (2012). "Small Bang Creating a Universe from Nothing." https://vixra.org/abs/1201.0109

[5] Ulianov, P. Y., Freeman, A. G. (2015). “Small Bang Model. A New Model to Explain the Origin of Our Universe." Global Journal of Physics, 3(1). https://vixra.org/abs/1211.0157

[6] Freeman A. G., Ulianov P. Y. (2011) "The Small Bang Model - A New Explanation for Dark Matter Based on Antimatter Super Massive Black Holes." http://vixra.org/abs/1211.0157

[7] Ulianov, P. Y. (2010). "Ulianov String Theory A new representation for fundamental particles." Space, 1, 1. https://www.academia.edu/download/89325911/1201.0101v1.pdf

[8] Ulianov, P. Y. (2013). "One Clue to the Proton Size Puzzle: The Emergence of the Electron Membrane Paradigm." https://vixra.org/abs/1302.0026

[9] Ulianov, P. Y. (2012) "Explaining the Variation of the Proton Radius in Experiments with Muonic Hydrogen." https://vixra.org/abs/1201.0099

[10] Ulianov, P. Y. (2013) "Rotating the Einstein’s light clock, to explain the Witte Effect. A basis to make the LIGO experiment work." https://vixra.org/abs/1302.0134

[11] Ulianov, P. Y. (2010) "Ulianov Sphere Network-A Digital Model for Representation of Non-Euclidean Spaces." https://vixra.org/abs/1201.0100

[12] Ulianov, P. Y. (2012) "Explaining the Variation of the Proton Radius in Experiments with Muonic Hydrogen." https://vixra.org/abs/1201.0099

[13] Ulianov, P. Y. (2012) "A New Digital Complex Model of Time." https://vixra.org/abs/1201.0102

[14] Ulianov, P. Y. (2013) "Spacetime Dipole Waves Pressure and Elemental Particles." https://vixra.org/abs/1306.0222

[15] Ulianov P. Y. (2013) "Spacetime Dipole Wave Pressure And Black Holes A New Way To Obtain The Schwarzschild Metric, Without Using General Relativity Field Equations." Asian Journal Of Mathematics And Physics, Volume 2013, Article ID amp0107, 15 pages. ISSN 2308-3131. 2309.0090v1.pdf (vixra.org)

[16] Ulianov P. Y. (2013) "An Alternative to the Higgs field Mass Generation Mechanism based on a Dipole Wave Pressure Model." Asian Journal Of Mathematics And Physics. Volume 2013, Article ID amp0084, ISSN 2308-3131. https://vixra.org/abs/2308.0200

[17] Ulianov, P. Y. (2016). "Breaking the Paradigm of Negative Mass: Why Newton’s Second Law Needs to Be Modified to Enable Newton’s Gravitational Law to Deal with Antimatter." Global Journal of Physics Vol, 4(1).

[18] Ulianov, P. Y. (2013). "An alternative to the Higgs field mass generation mechanism based on a dipole wave pressure model." Asian Journal of Mathematics and Physics, 2013. https://vixra.org/pdf/2308.0200v1.pdf

[19] Ulianov, P. Y. (2023). "Ulianov Perfect Liquid Model Explaining why Matter Repels Antimatter." https://vixra.org/pdf/2308.0199v1.pdf

[20] Ulianov, P. Y., Mei, X., & Yu, P. (2016). "Was LIGO's Gravitational Wave Detection a False Alarm?". Journal of Modern Physics, 7(14), 1845. https://www.scirp.org/html/1-7502879_71246.htm

[21] Mei, X., Huang, Z., Ulianov, P. Y., & Yu, P. (2016). "LIGO Experiments Cannot Detect Gravitational Waves by Using Laser Michelson Interferometers—Light's Wavelength and Speed Change Simultaneously When Gravitational Waves Exist Which Make the Detections of Gravitational Waves Impossible for LIGO Experiments". *Journal of Modern Physics*, *7*(13), 1749-1761, https://www.scirp.org/journal/paperinformation.aspx?paperid=70953

[22] Ulianov, P. Y. (2016). "How Can We Observe Waves Without Seeing The Ocean?", https://vixra.org/abs/2308.0042