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Does gravitational time dilation influence the propagation of the change of gravitational field?

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Abstract. This article uses thought experiments and strict logical deductions to discuss the propagation the change of gravity field and find that all "current" gravity fields are generated some time before and they are not static but are constantly propagating. If there is a change of the gravity field of a celestial body, it takes time for this change to propagate before interacting with this another celestial body. However, for a binary black hole system, the positions of the two black holes constantly changes relative to each other, resulting in changes of the gravity fields of both black holes, and, it also takes time for the change of gravity field of one black hole to reach the other black hole. If gravitational time dilation governs, it takes forever for the change of the gravity field of one black hole to propagate across the event horizon of the other black hole and interact gravitationally with it. If so, one black hole will never be able to respond to the change of the location of the other black hole. This is impossible. Thus, gravitational time dilation should not have the same influence upon the propagation of the change of gravity field as it has on light.

Keywords: gravitational time dilation, light speed, gravity speed, gravitational wave.

1. Introduction

It is accepted by current mainstream science that the propagation speed of gravity (c_g) field is the same as the speed of light(c) according to the recent gravitational wave detection results. Initially, in 2016, scientists concluded the upper bound $c_g < 1.7c$[1]. If $c_g < c$, then, $c_g \div c - 1 \geq -10^{-15}$[1-2]. Then, in 2021, scientists concluded that gravity speed is identical to light speed [3-4].

And it is commonly accepted that gravitational time dilation has influence upon the moving of object/celestial body, as well as the propagation of light/electric field/magnetic field [5], according to the following equation.

$$T_{dilated} = \sqrt{1 - \frac{2Gm}{Rc^2}} \cdot T_{withoutgravity}$$

where

- $T_{dilated}$ is the proper time between two events for an observer deep within the gravitational field,

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- $T_{withoutgravity}$ is the coordinate time between the events for an observer located at a faraway place where gravity field intensity is zero,
- G is the gravitational constant,
- m is the mass of the object creating the gravitational field,
- R is the radial coordinate of the observer within the gravitational field
- c is the speed of light.

This indicates, according to observers on the earth, light speeds near a black hole is less than c (299792458m/s). And, according to observers on the earth, when a beam of light arrives to be very near to a black hole, the speed of light is almost zero due to extremely dilated time near the black hole.

Now a question can be asked, does gravitational time dilation has the same influence upon the propagation of the change of gravity field as it has on the propagation of light/electric field/magnetic field?

2. Methods

2.1. The design of a thought experiment

In finding about the conclusion of whether gravitational time dilation has influence upon the propagation of the change of gravity field, a thought experiment is designed as shown by Figure 1.

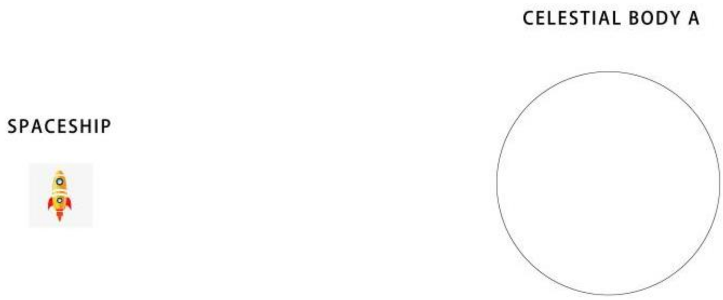

Figure 1. The CELESTIAL BODY A and a SPACESHIP.

Inside Figure 1, the mass of the CELESTIAL BODY A is m, and the SPACESHIP is 1 billion light years away from the CELESTIAL BODY A.

So, the gravitational field of CELESTIAL BODY A will propagate to the space where the SPACESHIP is located. At the place of the SPACESHIP, the intensity of gravitational field generated by CELESTIAL BODY A is g. This is the original situation. At all places in the direction of SPACESHIP, the gravitational field intensities of the CELESTIAL BODY A are “original intensities” of the CELESTIAL BODY A at each respective place. So, at the place of the SPACESHIP, the “original intensity” of gravitational field of CELESTIAL BODY A is g.

2.2. The process of the thought experiment

Then the experiment process starts.

Step 1: Today, the original situation changes. We transfer part of the mass of the CELESTIAL BODY A to a place in the direction away from the SPACESHIP. Then, the gravitational field intensity of the CELESTIAL BODY A at the place of the SPACESHIP will change to be smaller than g, and we can identify it “smaller intensity” of the CELESTIAL BODY A at the place of the SPACESHIP. And, the gravitational field intensities of the CELESTIAL BODY A at all places in the direction of the SPACESHIP will change to be smaller than the “original intensities” of gravitational field of CELESTIAL BODY A, and we can identify them as “smaller intensities” at each respective place. This change is not instantaneous but will propagate at light speed into the space (according to the mainstream view that gravity travels at light speed). So, this change of the gravitational field of the CELESTIAL BODY A will arrive at the place of the SPACESHIP one billion years after today.

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Step 2: Then, one day later, the situation changes back to the original situation. We transfer the same mass back to the CELESTIAL BODY A. Then, the gravitational field intensity of the CELESTIAL BODY A at the place of the SPACESHIP will change back to be g, the "original intensity" of gravitational field of CELESTIAL BODY A. And, the gravitational field intensity of the CELESTIAL BODY A at all places in the direction of the SPACESHIP will change back to be the "original intensities" of gravitational field of CELESTIAL BODY A at each respective place. This new change is also not instantaneous but will propagate at light speed into the space. Again, this change of the gravitational field of the CELESTIAL BODY A will arrive at the place of the SPACESHIP after one billion years.

Step 3: Then, one day later, the situation changes again. We again transfer part of the same mass of the CELESTIAL BODY A to the same place in the direction away from the SPACESHIP as in Step 1. Then, the gravitational field intensity of the CELESTIAL BODY A at the place of the SPACESHIP will change to be smaller than g, and we can identify it "smaller intensity" of the CELESTIAL BODY A at the place of the SPACESHIP. And, the gravitational field intensities of the CELESTIAL BODY A at all places in the direction of the SPACESHIP will change to be smaller than the "original intensities" of gravitational field of CELESTIAL BODY A, and we can identify them as "smaller intensities" at each respective place. This change is also not instantaneous but will propagate at light speed into the space. Again, this change of the gravitational field of the CELESTIAL BODY A will arrive at the place of the SPACESHIP after one billion years.

Then we continuously repeat Step 2 and Step 3. Thus, the gravitational field intensity of CELESTIAL BODY A will change once a day in all places in the direction of the SPACESHIP. These changes are not instantaneous but will propagate at light speed into the space.

3. Results

Then, the results of this experiment process will be: one billion years after today, at the place of the SPACESHIP, the gravitational field intensity of CELESTIAL BODY A will start to change, specifically:

At the day one billion years after today, at the place of SPACESHIP, the gravitational field intensity generated by CELESTIAL BODY A changes to be smaller than g, as shown by Figure 2.

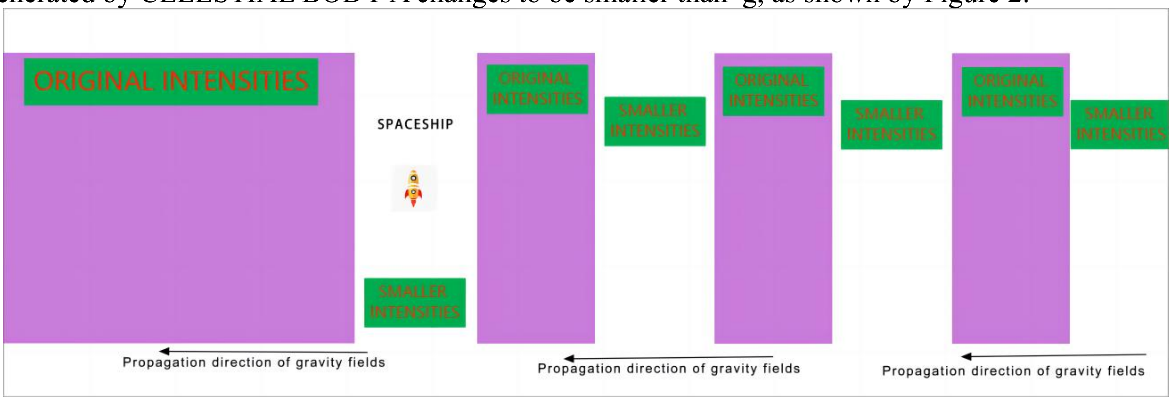

Figure 2. The gravity fields near the SPACESHIP 1 billion years after today.

Inside Figure 2 and all following figures, along the direction of the SPACESHIP, the gravity fields with "original intensities" are represented by purple color, the gravity fields with "smaller intensities" are represented by white color.

Then, at the day one billion years plus one day after today, at the place of SPACESHIP, the gravity field intensity generated by CELESTIAL BODY A changes again to be g, as shown by Figure 3.

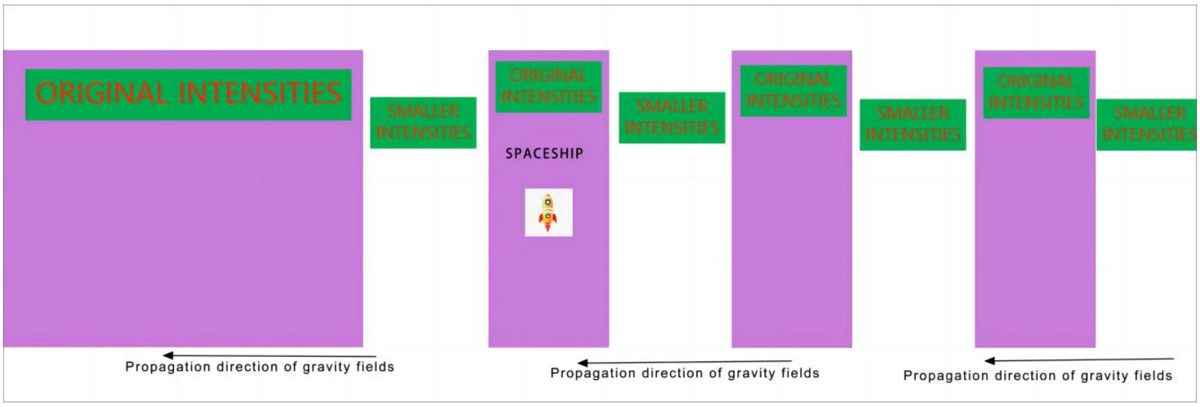

Figure 3. The gravity fields near the SPACESHIP 1 billion years plus one day after today.

Then, at the day one billion years plus two days after today, at the place of SPACESHIP, the gravity field intensity generated by CELESTIAL BODY A changes again to be smaller than g, as shown by Figure 4.

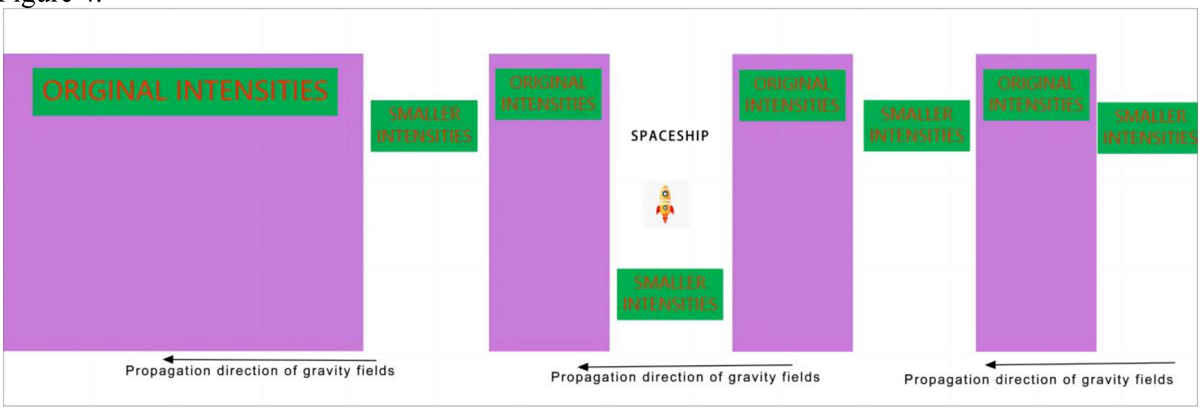

Figure 4. The gravity fields near the SPACESHIP 1 billion years plus two days after today.

Then, at the day one billion years plus three days after today, at the place of SPACESHIP, the gravity field intensity generated by CELESTIAL BODY A changes again to be g, as shown by Figure 5.

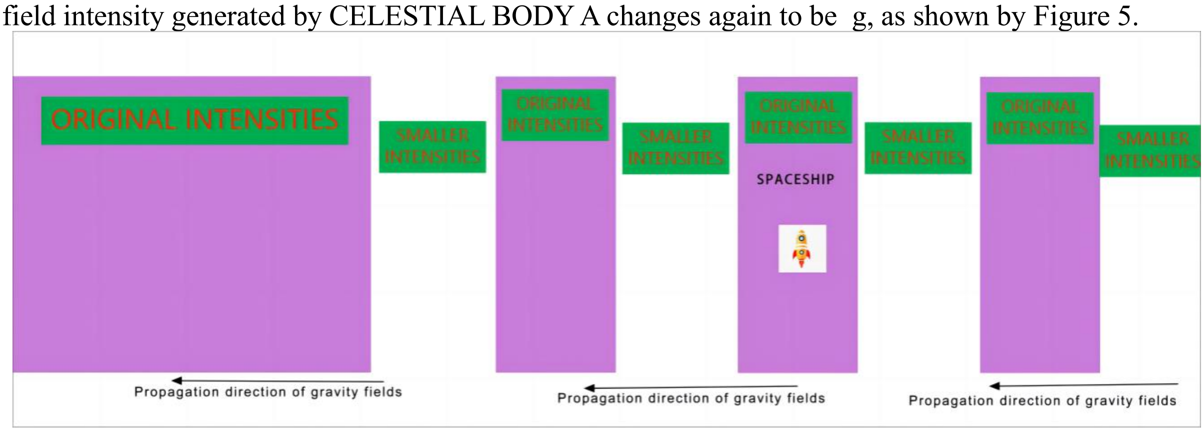

Figure 5. The gravity fields near the SPACESHIP 1 billion years plus three days after today.

In sum, at the place of the SPACESHIP, the gravitational field intensity of CELESTIAL BODY A will change each day repeatedly: at one day it is g, then, at the next day it is smaller than g, then, at the next day it is g again, then, at the next day it is smaller than g again, ...etc.

4. Discussion

This indicates, at the place of the SPACESHIP, at each day (and, for the same reason, at every moment), the gravity field of CELESTIAL BODY A was already generated by CELESTIAL BODY A 1 billion years before and just propagated to the place of the SPACESHIP. And it should be mentioned that, inside this thought experiment, we use the time interval by "one day", but if we use smaller time interval, such as by "one microsecond", or by "one Planck time", we will very easily find that the gravity fields are never static, they are always propagating(moving). Although we are influenced by gravity fields at any "current" time, there is no static gravity field at any place in the universe, all "current" gravity fields are constantly propagating/moving, all "current" gravity fields are generated some time before but not generated at the very moment we feel/detect the gravity fields.

Inside the above thought experiment, it always takes 1 billion years for the gravity field of CELESTIAL BODY A to reach the place of the SPACESHIP. So, if the mass of CELESTIAL BODY A changes, the gravity field of CELESTIAL BODY A will change, and this change will take 1 billion years to reach the place of the SPACESHIP.

Similarly, it can be easily deducted that, if the location of CELESTIAL BODY A changes, the gravity field of CELESTIAL BODY A will also change, and this change will also take 1 billion years to reach the place of the SPACESHIP(to be more accurate, if CELESTIAL BODY A moves to be nearer to the place of the SPACESHIP, this change will also take a little bit less than 1 billion years to reach the place of the SPACESHIP, if CELESTIAL BODY A moves to be farther to the place of the SPACESHIP, this change will also take a little bit more than 1 billion years to reach the place of the SPACESHIP, but generally the change will also take approximately 1 billion years to reach the place of the SPACESHIP. This minor difference will not influence the discussion of this article, so we can say "this change will also take 1 billion years to reach the place of the SPACESHIP").

Now, we add one condition in this thought experiment: there is a black hole located very near to the SPACESHIP and, to the SPACESHIP, the black hole is located in the opposite side of CELESTIAL BODY A, and the SPACESHIP is extremely near to the event horizon of the black hole.

Under such condition, according to the equation:

$$T_{dilated} = \sqrt{1 - \frac{2Gm}{Rc^2}} \cdot T_{withoutgravity}$$

The time on the SPACESHIP is extremely dilated.

Then, if gravitational time dilation has no influence on the propagation of the change of gravity field, everything will be the same:

One billion years after today, at the place of SPACESHIP, there will be change of the gravitational field of CELESTIAL BODY A (due to mass change of CELESTIAL BODY A or due to location change of CELESTIAL BODY A), because the change of the gravity field of CELESTIAL BODY A will propagate to the place of the SPACESHIP after one billion years.

But, if gravitational time dilation has influence on the propagation of the change of gravity field as it has on the propagation of light in that gravitational time dilation will cause the propagation of the change of gravity field to be extremely slow near black hole's event horizon according to distant observers, everything will be different:

One billion years after today, at the place of the SPACESHIP, the gravitational field of CELESTIAL BODY A will not change once a day, according to distant observers, because the change of the gravity field of CELESTIAL BODY A will not be able to propagate to the place of the SPACESHIP after one billion years due to gravitational time dilation near the black hole. Actually, at the place of the SPACESHIP, the gravitational field of CELESTIAL BODY A will never change according to distant observers, because the change of the gravity field of CELESTIAL BODY A will never be able to propagate to the place of the SPACESHIP according to distant observers, considering the fact that the SPACESHIP is located extremely close to the event horizon of the black hole where time is extremely dilated.

If so, then, certainly, the change of the gravity field of CELESTIAL BODY A will never be able to propagate across the event horizon of the black hole to enter into the black hole to interact with the matter and energy inside the black hole.

Then, it can be logically deduced that if CELESTIAL BODY A is not located one billion light years away from the black hole, but located very near to the black hole, any change of the gravity field of CELESTIAL BODY A will still never be able to propagate across the event horizon of the black hole to enter into the black hole to interact with the matter and energy inside the black hole.

This indicates that, if CELESTIAL BODY A is also a black hole, and CELESTIAL BODY A is very near to the previously-mentioned black hole, when the location of CELESTIAL BODY A changes, the previously-mentioned black hole cannot respond to the location change of CELESTIAL BODY A, and for the same reason, CELESTIAL BODY A also cannot respond to the location change of the previously-mentioned black hole. This indicates that two black holes cannot orbit around each other, thus it is not possible for the existent of binary black hole system.

However, the existence of binary black holes was already confirmed when LIGO detected GW150914 (detected September 2015, announced February 2016). [6][7][8].

Thus, it is impossible that gravitational time dilation has the same influence on the propagation of the change of gravity field as it has on the propagation of light/electric field/magnetic field. Because gravitational waves are disturbance of gravity field, which is also a change of gravity field, gravitational time dilation cannot have the same influence on the propagation of gravitational waves as it has on the propagation of light/electric field/magnetic field.

Here, it is worth mentioning, when examining the topic of this article, it is also possible to use different perspectives and arrive at the same conclusion.

For example, for a binary black hole system which includes black hole A and black hole B, if this binary system meets a neutron star or a third black hole and black hole A merges with this neutron star or this third black hole, the mass of black hole A will change and its gravity field intensity will change. But black hole B will not be able to immediately respond to this change of the gravity field intensity of black hole A, because it takes time for this change of the gravity field intensity of black hole A to propagate towards black hole B and come across the event horizon of black hole B and reach the matter and energy of black hole B inside its horizon before interacting with black hole B. If gravitational time dilation has the same influence upon propagation of the change of gravity field as it has on light, it takes forever for the change of the gravity field intensity (change of gravity field caused by mass change) of black hole A to propagate across the event horizon of black hole B and interact gravitationally with black hole B. This indicates, if the mass of one member of a black hole binary system changes, this change will have not result in any change upon the mutual orbiting movements of the binary system. This is apparently not possible according to current scientific views.

Another perspective to examine this topic is, if a celestial body changes its location, its gravity field will also change, as previously mentioned. Then, for a celestial body system consisting of black hole C and black hole D which already have stable orbits, if there is another black hole E passing by and pulling black hole C away from the black hole D, this will cause the change of the gravity field of black hole C towards black hole D, and it takes time for this change of gravity field of black hole C to propagate towards black hole D and come across the event horizon of black hole D and reach the matter and energy of black hole D. If gravitational time dilation has influence upon propagation of the change of gravity field, it takes forever for the change of the gravity field (change of gravity field caused by position change) of black hole C to propagate across the event horizon of black hole D and interact gravitationally with black hole D. This indicates, if the position of one member of a black hole binary system changes, this change will never alter the previous stable orbit of the other member, according to distant observers. This is apparently not possible according to current scientific views.

According to the same line of reasoning, we come to a discussion very similar to the previous discussion: for a binary black hole system, the positions of the two black holes constantly changes relative to each other. This will result in changes of the gravity fields of both black holes. And, it also takes time for the change of gravity field of one black hole to reach the other black hole. If gravitational time dilation has influence upon propagation of the change of gravity field as it has for light propagation, it takes forever for the change of the gravity field (change of gravity field caused by position change) of one black hole to propagate across the event horizon of the other black hole and interact gravitationally with the other black hole. If so, inside a binary black hole system, one black hole will never be able to respond to the change of the location of the other black hole. This will rule out the possibility of existence of binary black hole system. But this is not possible because the existence of binary black hole system has already been confirmed.

Therefore, either gravitational time dilation theory is incorrect, or gravitational time dilation is correct but it doesn't have the same influence upon the propagation of any change of gravity field as it has for light propagation.

5. Conclusion

- The gravity fields are never static, they are always propagating(moving).
- Although we are influenced by gravity fields at any "current" time, all "current" gravity fields are generated some time before but not generated at the very moment we feel/detect the gravity fields.
- If the mass of a celestial body changes, the gravity field of the celestial body will change, and this change will propagate into the space at light speed.
- If the location of a celestial body changes, the gravity field of the celestial body will change, and this change will propagate into the space at light speed.
- Either gravitational time dilation theory is incorrect, or, gravitational time dilation doesn't have the same effects upon the propagation of the change of gravity field as it has on the propagation of light/electric field/magnetic field.

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