Discussion on the characteristics of virtual spacetime from Schwarzschild's internal solution

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Abstract. This article analyzes Schwarzschild's internal solution and provides a relativity theoretic basis for the existence of virtual spacetime. Based on this, the corresponding relationship between virtual spacetime and real spacetime is analyzed, and Maxwell's equations of virtual spacetime are constructed, and the conversion relationship between the two spacetimes, including speed, length, and time, is obtained. It is pointed out that the existence of virtual spacetime is a corollary of general relativity theory. It also pointed out that the concept of virtual spacetime can better explain some unusual properties on the surface and interior of black holes.

1 Introduction

In the process of constructing virtual spacetime physics, the enlightenment I got mainly came from Feynman's virtual photon hypothesis [1]. The logic lies in the fact that since the virtual photon has such a big effect and it does transfer energy, then this "virtual" should exist objectively, and it should be able to be reflected in the calculation process of the physical formula. Thus, the symmetric Maxwell equations based on virtual spacetime [2,3] are constructed. However, in the process of construction, the virtual spacetime "three-dimensional time plus one-dimensional space" corresponding to the "three-dimensional space plus one-dimensional time" in the real spacetime, which I envision, has a certain degree of subjectivity. The wave equation of virtual photons does not seem to be universally recognized by other physists.

I am currently rethinking the general theory of relativity. In the process of studying Schwarzschild spacetime, I discovered that Schwarzschild’s internal solution supports the existence of virtual spacetime, and the results obtained are basically consistent with my original assumptions. Considering that General Relativity has received a lot of experimental support, Penrose also won the Nobel Prize in Physics last year, proving that this theory has at least been recognized by many physicists. Therefore, the Schwarzschild solution based on the general theory of relativity should be closer to the law of motion in the objective physical world. The results derived from virtual spacetime physics theory are believed to be more convincing.

2 Schwarzschild's internal solution

The Schwarzschild solution is a description of the gravitational field in a vacuum without mass. It is the exact solution of Einstein's field equation.

The Schwarzschild solution includes the external solution and the internal solution. The external solution describes the spacetime characteristics outside the black hole, while the internal solution describes the spacetime characteristics inside the black hole.

Both external and internal solutions can be described by Schwarzschild metric:

$$g_{\mu\nu} = \begin{pmatrix} -1 + \frac{2GM}{rc^2} & 0 & 0 & 0 \\ 0 & \left(1 - \frac{2GM}{rc^2}\right)^{-1} & 0 & 0 \\ 0 & 0 & r^2 & 0 \\ 0 & 0 & 0 & r^2 sin^2\theta \end{pmatrix} \tag{1}$$

The corresponding distance square formula is

$$\mathrm{d}s^2 = -\left(1 - \frac{2GM}{rc^2}\right) dt^2c^2 + \left(1 - \frac{2GM}{rc^2}\right)^{-1} dr^2 + r^2 d\theta^2 + r^2 sin^2\theta d\varphi^2 \tag{2}$$

In order to explore some important characteristics of Schwarzschild spacetime, we first show Minkowski spacetime with Figure 1.

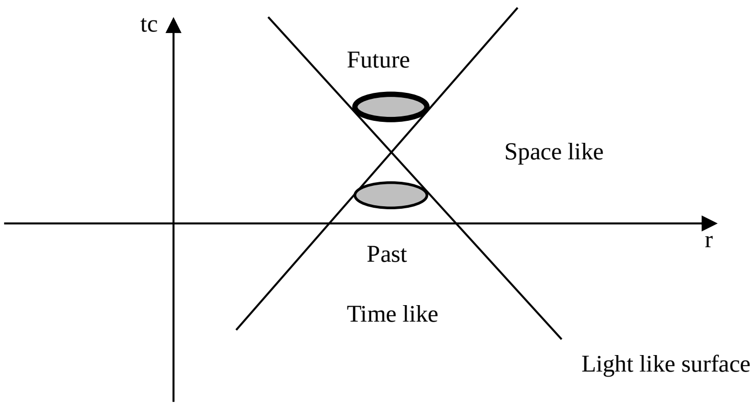

Figure 1 Minkowski space

It can be seen from the figure that the Minkowski spacetime of an object consists of three parts, namely time-like spacetime, space-like spacetime, and light like surface. The light like surface is the dividing surface that separates the time-like spacetime and the space-like spacetime. The time-like spacetime is surrounded by two opposite light cones. The upper light cone is called the "future light cone", and the lower light cone is called the "past light cone". In this way, we can use Minkowski spacetime coordinates to describe the state of an object well.

Since the light-like surface of the light cone represents the speed of light movement, according to the requirements of the theory of relativity, all objects should move in time-like spacetime, and cannot go beyond the light-like surface into space-like spacetime.

For the Schwarzschild external solution, in order to be able to compare with flat spacetime, we use the Schwarzschild metric to solve the equation of the light cone:

For the light cone, the movement of light is the speed of light, so there is

$$\mathrm{d}s^2 = -\left(1-\frac{2GM}{rc^2}\right)dt^2c^2 + \left(1-\frac{2GM}{rc^2}\right)^{-1}dr^2 + r^2d\theta^2 + r^2sin^2\theta d\varphi^2 = 0$$

Then we can get

$$\left(\frac{dr}{dtc}\right)^2 = \left(1-\frac{2GM}{rc^2}\right)^2 \qquad (3)$$

In this way, the equation of the light cone of Schwarzschild spacetime is

$$\frac{dr}{dtc} = \pm\left(1-\frac{2GM}{rc^2}\right) \qquad (4)$$

It can be seen that when $r=R_s$, $dr/dt=0$, which means that the speed of light is 0, which has no physical meaning. Therefore, it can only be said that when approaching the Schwarzschild radius, although the time has a large range of changes, the change of r is close to 0. These results in the light cone can only be infinitely close to the Schwarzschild radius, but can’t cross the past. Of course, when r is limited, the calculated dr/dt is limited. This is a phenomenon that the speed of light seen by an observer at infinity slows down, but it appears to a local observer that the speed of light is still c. The minus sign in formula (4) means negative time.

When the trend of r is infinite, it can be seen that $dr/dt=\pm c$, which meets the requirements of the results observed by observers at infinity, as shown in Figure 2. In the figures of this paper, R_s represents the Schwarzschild radius.

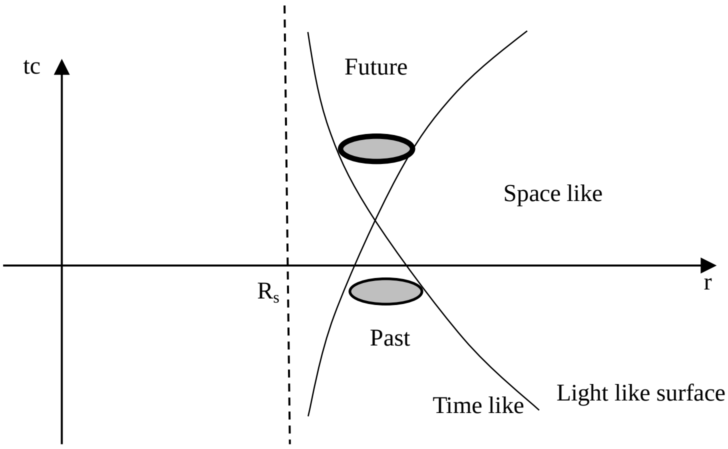

Figure 2 Schwarzschild space

In the spacetime characteristics that exceed the Schwarzschild radius shown in Figure 2, the light cone cannot traverse the Schwarzschild radius, which also reflects that the laws of physical motion that we can observe can only occur outside the surface of the black hole. As for the matter attracted by the black hole, it has exceeded the physical horizon of real spacetime and can be classified into the unobservable virtual spacetime horizon. This is not in contradiction with the general theory of relativity based on the laws of real spacetime.

3 Schwarzschild's internal solution

However, Figure 2 shows the spacetime characteristics beyond the Schwarzschild radius. If it is within the Schwarzschild radius, we can find that some interesting changes have taken place in the spacetime characteristics.

From the perspective of changes in the metric, of course r gradually increases from close to 0 to close to R_s, $g_{00} = -1 + \frac{2GM}{rc^2}$ is close to infinity and gradually decreases to 0. And at the same time, $g_{11} = \left(1 - \frac{2GM}{rc^2}\right)^{-1}$ gradually increases from close to 0 to close to infinity. This is the opposite of the metric change outside the Schwarzschild radius. That is to say, the changing direction of the time and radial radius metric has just been reversed.

From the light cone equation (4), under the condition of $r<R_s$, the light cone surface close to the Schwarzschild radius changes basically the same as the external light cone surface. But inside it is close to the position of r = 0, at this time $dr/dt \to \infty$, which means that although the distance changes greatly, the time change is basically 0.

Then we consider the requirements of the laws of physics, the physical motion must satisfy $ds^2 \leq 0$, and only radial motion, then

$$-\left(1-\frac{2GM}{rc^2}\right)dt^2c^2+\left(1-\frac{2GM}{rc^2}\right)^{-1}dr^2\leq 0 \tag{5}$$

Notice that inside the Schwarzschild radius

$$\left(1-\frac{2GM}{rc^2}\right)^{-1}<0 \tag{6}$$

So

$$\left(\frac{dr}{dtc}\right)^2\geq\left(1-\frac{2GM}{rc^2}\right)^2 \tag{7}$$

That is

$$\frac{dr}{dtc}\geq -1+\frac{2GM}{rc^2} \tag{8}$$

Or

$$\frac{dr}{dtc}\leq 1-\frac{2GM}{rc^2} \tag{9}$$

It can be seen that physical motion can only occur within the limited range of *dt* change. If *dt* exceeds a certain range of change, it is non-physical motion. The light cone of Schwarzschild spacetime drawn according to such changes is shown in Figure 3.

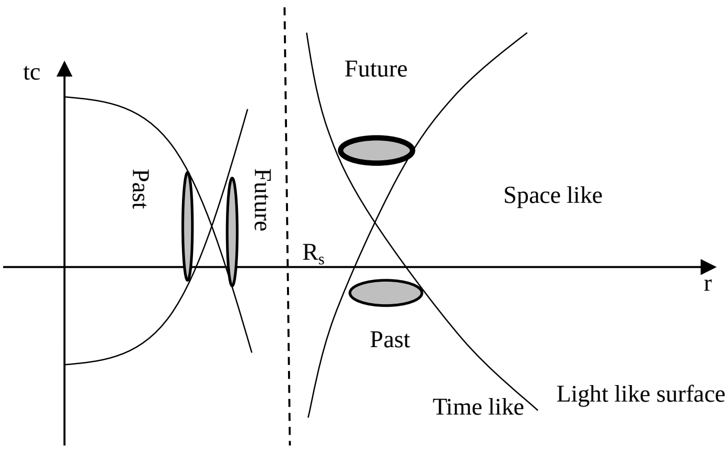

Figure 3 Schwarzschild space

It can be seen that only the movement of particles in the light cone in the lateral position in the figure meets the requirements of the laws of physical motion, that is, the theoretical physical existence. In this way, within Schwarzschild’s radius, time and space have exchanged positions. That is, inside the black hole, time can be either positive or negative, and there is no definite direction of change.

And *dr/dt* can never be 0, indicating that it is impossible for objects inside a black hole to stop at a certain position, and can only move continuously. The continuous radial position of the object changes in two directions. If the radius keeps increasing, it is a normal process of change, and if the radius keeps decreasing, it is a reverse process. This is very similar to the time change process outside the black hole, so from the light cone curve inside Schwarzschild radius in Figure 3, we can see that the past and the future are divided according to the change of radius.

4 Spacetime characteristics of virtual spacetime

4.1 Maxwell's equations of virtual spacetime

Maxwell's equations are the basic laws in electrodynamics. It has been experimentally verified to reflect the physical laws in real spacetime. If the same Maxwell equations can be constructed in virtual spacetime, then it can perfectly reflect the law of electrodynamics in virtual spacetime.

I pointed out in "Foundations of Virtual Spacetime Physics" [2] that the inside of a black hole actually reflects virtual spacetime. The Schwarzschild radius is used as the boundary between virtual spacetime and real spacetime. The outside of the black hole is real spacetime. We can use the Existing Newton's laws of motion, relativity, quantum mechanics and other theories. But inside the black hole, it belongs to the category of virtual spacetime, so another set of physical laws is needed to describe it. In order to obtain the physical laws of virtual spacetime, there is a "symmetric" assumption, that is, virtual spacetime and real spacetime should be symmetrical, so that the physical theory of real spacetime can be transplanted to virtual spacetime. It now seems that this symmetry between virtual spacetime and real spacetime can be supported by Schwarzschild's solution.

From Figure 3, we can see that the time inside the black hole also exhibits a very peculiar characteristic. Compared with the light cone outside the black hole, we can find that inside the black hole, time should also have a two-dimensional or three-dimensional structure. Combined with the change in radius, the shape of the cone is formed. In this way we can draw a conclusion: outside the black hole is a "three-dimensional space + one-dimensional time" structure. Inside the black hole, there is a "three-dimensional time + one-dimensional space" structure.

The one-dimensional space inside the black hole reflects that we can only observe radial motion inside the black hole, and motion in other directions has no physical meaning. This may be related to the fact that the black hole must be a spherically symmetric structure.

Since we have regarded the inside of the black hole as virtual spacetime and the outside as real spacetime, the virtual spacetime should be "three-dimensional time + one-dimensional space", and real spacetime is the structure of "three-dimensional space + one-dimensional time".

Therefore, when we construct the physical laws of virtual spacetime, we only need to correspond to the three-dimensional space coordinates of the physical laws of real spacetime to the three-dimensional time coordinates of the physical laws of virtual spacetime, and the one-dimensional time coordinates of real spacetime correspond to the one-dimensional space coordinates of virtual spacetime.

Here x^{μ} is used to represent the "three-dimensional space + one-dimensional time" of real spacetime.

Use y^{μ} to denote "three-dimensional time + one-dimensional space" of virtual spacetime.

Then, in order to facilitate the symmetric transformation, define the generalized electric field *F* and the generalized magnetic field *G* as：

$$\mathrm{F} = \sqrt{\varepsilon} E$$

$$\mathrm{G} = \sqrt{\mu} H$$

Where, ε and μ are the dielectric constant and permeability respectively. *E* is the electric field strength, and *H* is the magnetic field strength.

Redefine generalized charge density

$$\rho_e = \frac{\rho}{\sqrt{\varepsilon}}$$

Generalized current density

$$J_e = \sqrt{\mu} J$$

Where, ρ and J are charge density and current density, respectively. In this way, the Maxwell equations in real spacetime can be expressed as

$$\begin{cases} \nabla \cdot F = \rho_e \\ \nabla \cdot G = 0 \\ \nabla \times F = -\dfrac{\partial G}{\partial x^0} \\ \nabla \times G = J_e + \dfrac{\partial F}{\partial x^0} \end{cases}$$

The labeling method in general relativity is used here: $x^0 = ct$

In order to obtain the Maxwell equations corresponding to the virtual spacetime, we make an agreement here:

Where the differential operator:

$$\nabla = \hat{x}_i \frac{\partial}{\partial x^i}$$

Where $\hat{x}^i$ is the unit vector of the corresponding dimension, i =1,2,3. The Einstein summation convention is used here.

Then we define the differential operator corresponding to the virtual spacetime:

$$\nabla_y = \hat{y}_i \frac{\partial}{\partial y^i}$$

Since Maxwell's equations involve electric and magnetic fields, from the perspective of symmetry, these two quantities should be symmetrical, that is, the electric field in real spacetime corresponds to the magnetic field in virtual spacetime, and the magnetic field in real spacetime corresponds to the electric field in the virtual spacetime. Considering that there are only electric charges in real spacetime and no magnetic monopoles, the magnetic monopoles should exist in virtual spacetime. Therefore, we can also define the generalized magnetic charge density and generalized magnetic current density as: ρ_m J_m

So we only need to do the following conversion：

$$\begin{gathered} F \leftrightarrow G \\ \rho_e \leftrightarrow \rho_m \\ J_e \leftrightarrow J_m \\ \frac{\partial}{\partial x^\mu} \leftrightarrow \frac{\partial}{\partial y^\mu} \end{gathered}$$

Where, $\mu = 0,1,2,3$

In this way, we can obtain Maxwell's equations in virtual spacetime

$$\begin{cases} \nabla_y \cdot G = \rho_m \\ \nabla_y \cdot F = 0 \\ \nabla_y \times G = -\dfrac{\partial F}{\partial y^0} \\ \nabla_y \times F = J_m + \dfrac{\partial G}{\partial y^0} \end{cases}$$

In this way, we can describe the physical laws of virtual spacetime well and connect them with the physical laws of real spacetime.

4.2 Correspondence between some important physical quantities of virtual spacetime and real spacetime

1 Velocity

Considering that in virtual spacetime, space and time are exchanged with each other, the speed should be expressed as

$$v_y = \frac{dtc}{dr}$$

In this way, the speed of the virtual spacetime inside the black hole needs to be satisfied

$$\left(1 - \frac{2GM}{rc^2}\right)^{-1} \le v_y \le \left(-1 + \frac{2GM}{rc^2}\right)^{-1}$$

The radial velocity in real spacetime needs to meet

$$-1 + \frac{2GM}{rc^2} \le v \le 1 - \frac{2GM}{rc^2}$$

It can be seen that the velocity in the virtual spacetime and the velocity in real spacetime are in an inverse relationship. For flat spacetime, by definition, the speed of light is *c*, and the speed of light in virtual spacetime is $1/c$. If we use *ct* to represent time, the speed of light is 1 regardless of whether it is real spacetime or virtual spacetime.

2 Length

From the perspective of the definition of speed, the length of virtual spacetime is equivalent to the time in real spacetime, and the time in virtual spacetime is equivalent to the length in real spacetime.

However, if we look at the formula for defining the velocity of virtual spacetime, we can also define the length of virtual spacetime as the reciprocal of the length in real spacetime,. This way

$$r \leftrightarrow \frac{1}{r}$$

Another advantage of this definition is that in real spacetime, according to the conditions shown in formulas (8) and (9), the particles of virtual spacetime will not rest on a fixed *r*, but *r* within Schwarzschild's radius Again it is very limited. This means that it will not take much time for the particles to run this distance soon. Now the reciprocal of the radius is used to represent the length of the virtual spacetime, which means that the original very limited length *r* has become extended from 1/*r* to infinity.

However, there is a problem here. Because the two spacetime length units are different, *r* and 1/*r* cannot be directly connected with the equal sign. Therefore, a virtual and real spacetime boundary length l_p is defined here. Now we use *r* to represent the length of real spacetime and *r'* to represent the length of virtual spacetime. Then the three lengths should satisfy the relationship

$$rr' = {l_p}^2$$

Therefore

$$r' = \frac{{l_p}^2}{r}$$

This not only satisfies the above requirement of mutual reciprocal relationship, but also obtains the length *r'* of virtual spacetime, which can be used to calculate the specific physical motion law of virtual spacetime.

3 Time

The same is true for time. Define a time t_p, where *t* represents the time of real spacetime, and *t'* represents the time of virtual spacetime, then

$$tt' = {\mathrm{t}_p}^2$$

So

$$t' = \frac{{\mathrm{t}_p}^2}{t}$$

5 Conclusions

Some important properties of virtual spacetime can be obtained through some important results of general relativity, which shows that there is no contradiction between virtual spacetime physics and general relativity. It can also be said that virtual spacetime physics is an extension of the theory of general relativity.

The concept of virtual spacetime can also explain the singularity of the Schwarzschild black hole surface. After all, since the black hole is formed, the external matter should be able to penetrate the surface of the black hole and enter the black hole. However, the Schwarzschild metric indicates that on the surface of the black hole, the time interval will become infinite, and the radial distance interval will become 0. It seems that when an object reaches the surface of the black hole, it appears from infinity that the object will always be there. It can never fall into the black hole.

In the past, to solve this problem, it was usually done by transforming the coordinate system, including using Eddington-Finkelstein coordinates. However, after using the concept of virtual spacetime, this problem can be solved more simply. That is, the surface of the black hole is the interface between real spacetime and virtual spacetime. Considering that real spacetime cannot directly observe the physical movement of virtual spacetime, even if an object falls through the surface of the black hole, the observers in real spacetime cannot observe the object falling into the black hole, because the object has been transformed into the mass-energy form of virtual spacetime.

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