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SIMULATION OF A ROTATING STRONG GRAVITY THAT REVERSES TIME

Y. MATSUKI, P.I. BIDYUK

Abstract. In this research we simulated how time can be reversed with a rotating strong gravity. At first, we assumed that the time and the space can be distorted with the presence of a strong gravity, and then we calculated the angular momentum density of the rotating gravitational field. For this simulation we used Einstein's field equation with spherical polar coordinates and the Euler's transformation matrix to simulate the rotation. We also assumed that the stress-energy tensor that is placed at the end of the strong gravitational field reflects the intensities of the angular momentum, which is the normal (perpendicular) vector to the rotating axis. The result of the simulation shows that the angular momentum of the rotating strong gravity changes its directions from plus (the future) to minus (the past) and from minus (the past) to plus (the future), depending on the frequency of the rotation.

Keywords: gravitational field, distortion of time and space, angular momentum, curvature tensor, stress-energy tensor.

INTRODUCTION – RESEARCH QUESTION

In our previous research [1] we simulated a rotating strong gravity, in which time and space are distorted; and we found that the direction of the angular momentum changes as the strong gravity changes its frequency of the rotation. However, the scope of the previous research was limited to the space components. In this new research we also simulate the component of the distorted time, and we examine if time can be reversed.

In the previous research [1] we assumed that the component of the rotation matrix of the spherical polar coordinates of ρ has anti-symmetric components, $R_{22} \sin \varphi$, and — $R_{11} \sin \varphi$; and then as the result we found that the angular momentum of the spatial coordinates changed its turning direction. So now, we assume that there are also anti-symmetric components in the distorted time coordinate, τ; and, we assume that the direction of the angular momentum of the τ — vector must also change. Therefore, the research question now is whether or not, the τ — coordinate can reverse its direction backward (change to the vector of time back to the past), because of the anti-symmetry.

Curvature tensors

In this research we used the same curvature tensors that we derived and used in our previous researches [1–3]:

$$R_{\mu\nu} = \begin{bmatrix} R_{00} & R_{01} & 0 & 0 \\ R_{10} & R_{11} & R_{12} & 0 \\ 0 & R_{21} & R_{22} & 0 \\ 0 & 0 & 0 & R_{33} \end{bmatrix},$$

where $R_{00} = \dfrac{5}{9(\rho-\tau)^2}$; $R_{01} = R_{10} = \dfrac{-4}{9(\rho-\tau)^2}$; $R_{11} = \dfrac{20}{3(\rho-\tau)^2} + \dfrac{11\mu}{18m(\rho-\tau)^{4\backslash 3}}$;

$$R_{12} = R_{21} = \frac{-2\cot\theta}{3(\rho-\tau)}, \text{ and } \frac{2\cot\theta}{3(\rho-\tau)};$$

$$R_{22} = \frac{28}{9\mu^2(\rho-\tau)1^{10/3}} + \frac{140m}{9\mu^2(\rho-\tau)^4} + \frac{4}{\sin^2\theta} + \cot^2\theta,$$

and $$R_{33} = \frac{-28}{9\mu^2(\rho-\tau)^{\frac{10}{3}}\sin^2\theta} + \frac{140m}{9\mu^3(\rho-\tau)^4\sin^2\theta} + \frac{4}{\sin^2\theta} + \frac{11\cot^2\theta}{\sin^2\theta},$$

where $\mu = \left(\frac{3}{2}\sqrt{2m}\right)^{2/3}$ [2].

In this research we simulate the distorted time component τ, and the distorted distance component ρ, so that we can formulate the body vector of the rotating object: $R = \begin{bmatrix} R_{00} \\ R_{11} \end{bmatrix}$.

We take only orthogonal components of this gravitational field for simulating its rotation. Then we calculate the angular momentum of this rotation by anti-symmetric rotation operator, $\sin\varphi$ and $-\sin\varphi$, to calculate the projections of the vectors in the normal components (perpendicular to the curved spherical surface), where φ is angle of the rotation.

Distortion of time and space in strong gravity

We used the same assumption of our previus researches [1–3] for simulating the distortion of time and space, as shown in Fig. 1, 2.

Note: r is the distance from the center of the strong gravity, t is the time to travel on the distance, f and g are given functions, and $\tau = t + f(r)$; and $\rho = t + g(r)$.

In these figures τ is a relative time in the coordinate system, which expands and shrinks depending on the distance r, where $\tau = t + f(r)$; and ρ is the relative distance, which expands and shrinks depending on the time t, where $\rho = t + g(r)$; and $f(r)$ and $g(r)$ are functions of r. For the simulation we as assumed Case-1: $f(r) = \log r$ and $g(r) = e^r$ (non-linear); and Case-2: $f(r) = \dfrac{1}{r}$ and $g(r) = r$ (linear).

ALGORITHM

We use the same algorithm that we used for our previous research [1–3] to simulate the relative strengths (intensities) of the curvature tensors, which are reflected by the stress-energy tensor that is placed at the end of the distance r in Fig. 1, 2.

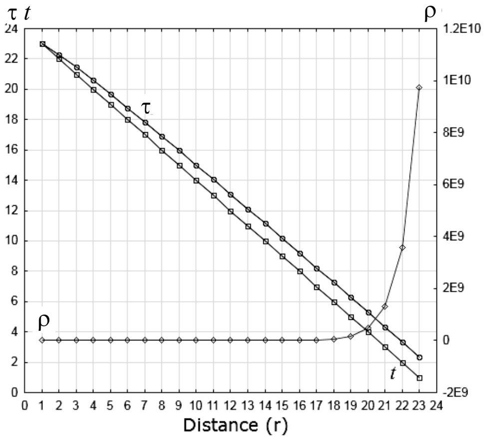

Fig. 1. Time and distance from the center of the gravitational field, Case-1 (non-linear distortion): $f(r) = \log r$ and $g(r) = e^r$

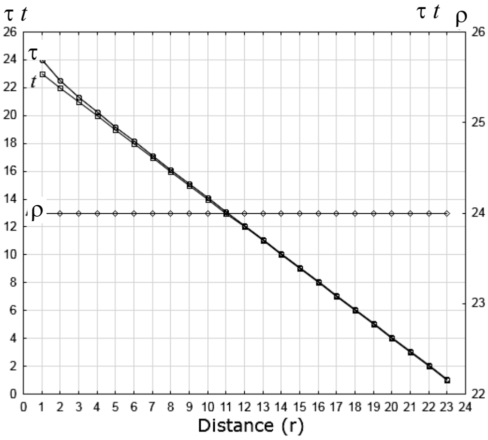

Fig. 2. Time and distance from the center of the gravitational field, Case-2 (linear distortion): $f(r) = (1/4)$ and $g(r) = r$

Einstein's field equation [4] that rules the motion of particles in the gravitational field is: $(R^{\mu\nu} - \frac{1}{2} g^{\mu\nu} R)_{,\nu} = 0$. Then, $R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = kT$, where T is the stress-energy tensor and k is a constant [5]. By calculating c and $V(c)$, as shown below, we estimated the relative strength of each component of $R_{\mu\nu}$ to the stress-energy tensor in the system of spherical polar coordinates:

$H = kT - R_{\mu\nu} = kT - (c_0 X_0 + c_1 X_1)$ and $H^2 = \{kT - (c_0 X_0 + c_1 X_1\}^2$, where c_0 and c_1 are the coefficients, which make a column vector c. And $X = [X_0 \quad X_1]$, then $H = kT - Xc$. Then we set the constraint $X'H = 0$, and then $X'(kT - Xc) = 0$, where X' is transpose matrix of X.

Then $X'Xc = X'kT$, $c = (X'X)^{-1} X'kT$, and $\Sigma = V(c) = \hat{\sigma}^2 (X'X)^{-1}$, where $V(c) = \sigma^2$ is the variance of the c, and $\hat{\sigma}^2 = e'e/(n - l)$, where $e = M \cdot kT$, $M = I - X(X'X)^{-1} X'$, n is the number of rows of each column of X (in this simulation $n = 23$), l is the number of columns of X, I is a (23×23) unit matrix that holds ones on all diagonal elements and 0 for the other elements, $(X'X)^{-1}$ is the inverse matrix of $X'X$, and e' is the transpose vector of e.

Rotation of the object , which contains strong gravity that distorts time and space

When an object rotates as shown in Fig. 3, its coordinate system will be transformed by the transformation matrix D of the Euler's angles [5]. For the rotation around one axis of φ, the tensors of the object's coordinate system will be multiplied by:

$$D = \begin{bmatrix} \cos\varphi & \sin\varphi \\ -\sin\varphi & \cos\varphi \end{bmatrix}.$$

And then the curvature tensor $R_{\mu\nu}$ will be transformed to:

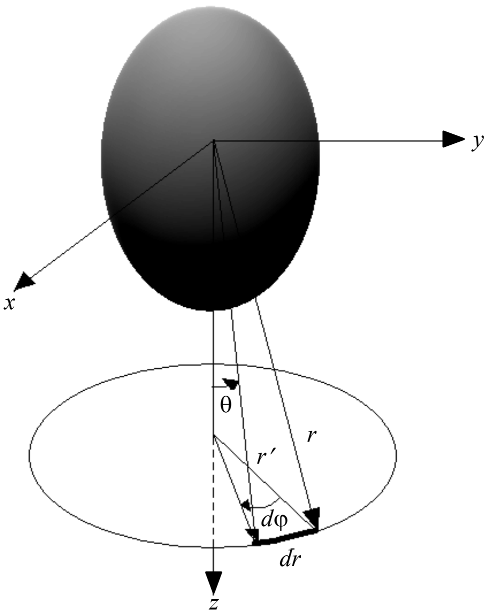

Fig. 3. Rotation of an object

$$DR_{\mu\nu} = \begin{bmatrix} \cos\varphi & \sin\varphi \\ -\sin\varphi & \cos\varphi \end{bmatrix} \begin{bmatrix} R_{00} & 0 \\ 0 & R_{11} \end{bmatrix} =$$

$$= \begin{bmatrix} \cos\varphi \cdot R_{00} & \sin\varphi R_{11} \\ -\sin\varphi \cdot R_{00} & \cos\varphi R_{11} \end{bmatrix}.$$

Here the components $\sin\varphi \cdot R_{11}$ and $-\sin\varphi \cdot R_{00}$ are antisym-metrical, which are perpendicular to the rotational axis $z = x_3$ for φ of Fig. 3.

Given the above transformed curvature tensor after the rotation, at first, we also calculate the anti-symmetrical components of $D \cdot R_{\mu\nu}$, which are as follows: $\begin{bmatrix} 0 & \sin\varphi \cdot R_{11} \\ -\sin\varphi \cdot R_{00} & 0 \end{bmatrix}$ to calculate $\begin{bmatrix} dR_{00} \\ dR_{11} \end{bmatrix} = \begin{bmatrix} -R_{00}\, d\Omega_3 \\ R_{11}\, d\Omega_3 \end{bmatrix}$, and to formulate

$$H = kT - (-c_0 R_{00}\, d\Omega_3 + c_1 R_{11}\, d\Omega_3) =$$

$$= kT - \left\{ -c_0 \frac{5}{(\rho-\tau)^2} \sin\varphi + c_1 \left(\frac{20}{3(\rho-\tau)^2} + \frac{1}{(\rho-\tau)^{4/3}} \right) \sin\varphi \right\},$$

then the same algorithm follows as explained above.

Note 1. As shown in the Introduction, $R_{11} = \dfrac{20}{3(\rho-\tau)^2} + \dfrac{11\mu}{18m(\rho-\tau)^{4/3}}$, but in our calculation we use $R_{11} = \dfrac{20}{3(\rho-\tau)^2} + \dfrac{1}{(\rho-\tau)^{4/3}}$.

Note 2. Here $\begin{bmatrix} 0 & d\Omega_3 & 0 \\ -d\Omega_3 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} = \varepsilon$ is an infinitesimal rotation operator; while in general $\varepsilon = \begin{bmatrix} 0 & d\Omega_3 & -d\Omega_2 \\ -d\Omega_3 & 0 & d\Omega_1 \\ d\Omega_2 & -d\Omega_1 & 0 \end{bmatrix}$, according to the Reference [5], but in this our simulation $d\Omega_1 = d\Omega_2 = 0$ and $d\Omega_3 = \sin\varphi$. It calculates a rotated vector as the cross-product of $R_{\mu\nu}$, and $d\Omega$,

$$\begin{bmatrix} dR_{11} \\ dR_{22} \\ dR_{33} \end{bmatrix} = R_{\mu\nu} \times d\Omega = \begin{bmatrix} R_{11} \\ R_{22} \\ R_{33} \end{bmatrix} \times \begin{bmatrix} d\Omega_1 \\ d\Omega_2 \\ d\Omega_3 \end{bmatrix} = \begin{bmatrix} R_{22}d\Omega_3 - R_{33}d\Omega_2 \\ R_{33}d\Omega_1 - R_{11}d\Omega_3 \\ R_{11}d\Omega_2 - R_{22}d\Omega_1 \end{bmatrix}.$$

And then we also calculate the relative strength of the gravitational field's energy before and after the the rotation by the diagonal components of $DR_{\mu\nu}$, which are $\begin{bmatrix} \cos\varphi \cdot R_{00} & 0 \\ 0 & \cos\varphi \cdot R_{11} \end{bmatrix}$ to formulate

$$H = kT - \left\{ c_0 \frac{5}{(\rho-\tau)^2} \cos\varphi + c_1 \left(\frac{20}{3(\rho-\tau)^2} + \frac{1}{(\rho-\tau)^{4/3}} \right) \cos\varphi \right\},$$

then the algorithm follows as explained above.

SIMULATION

Input data

Time t is set as shown in Fig. 1 for the Case-1, and in Fig. 2 for Case-2, with which its slope to the distance r from the center of the gravitational field is a constant. For simulating the spatial expansion of the gravitational field we assume as if θ becomes larger in far distance. For simulating the rotation of the object we set two cases, assuming φ_1 (the rotation 1) and φ_2 (the rotation 2) also as shown in Fig. 4. With these settings, $\sin\theta$, $\cos\theta$, $\cot\theta$ and $\cos\phi$ behave like as shown in Fig. 5.

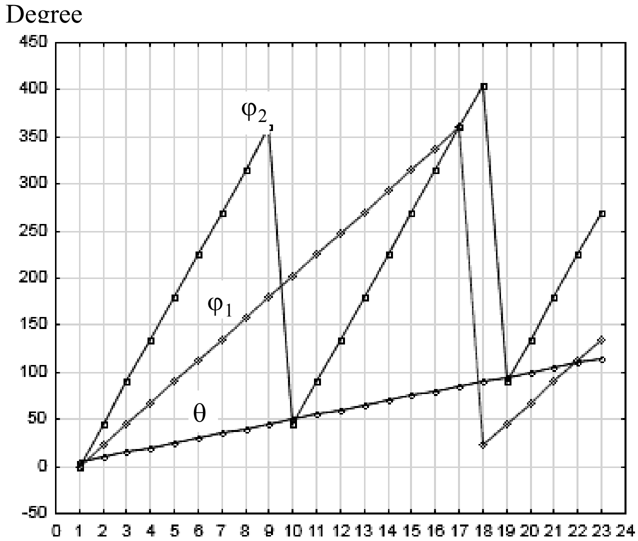

Fig. 4. Angles, θ and φ, for the simulation

In addition, for this simulation we set the stress-energy tensor $kT = 1$; because the purpose of this simulation is to measure the order of magnitude of the relative strength of each component of $R_{\mu\nu}$ and the gravitational waves to the stress-energy tensor.

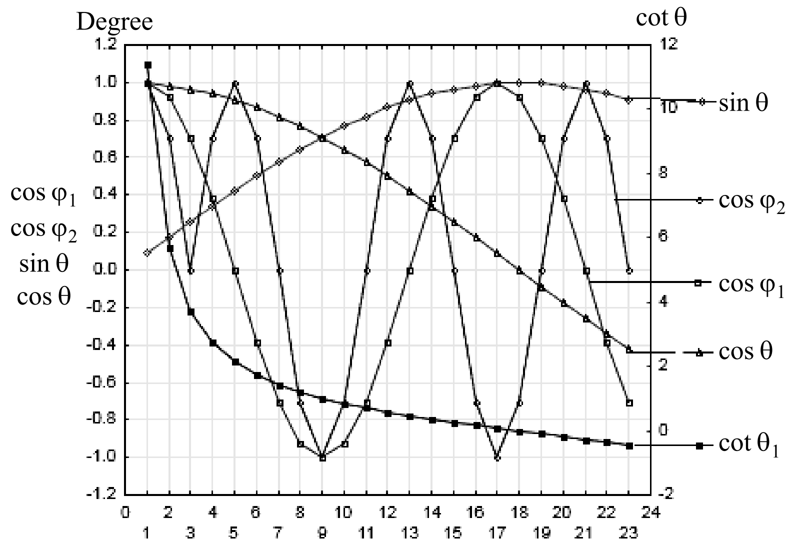

Fig. 5. $\sin\theta$, $\cos\theta$, $\cot\theta$ and $\cos\varphi$ for the simulation

Result

Fig. 6 (Table 1) shows that the perpendicular vector (angular momentum) changes its direction from minus to plus as the frequency of the rotation changes from the rotation 1 to the rotation 2; and Fig. 7 (Table 2) and Fig. 8 (Table 3) also show that the angular momentum changes its direction, while the directions are opposite between the non-linear distortion (Case-1) and the linear-distortion (Case-2).

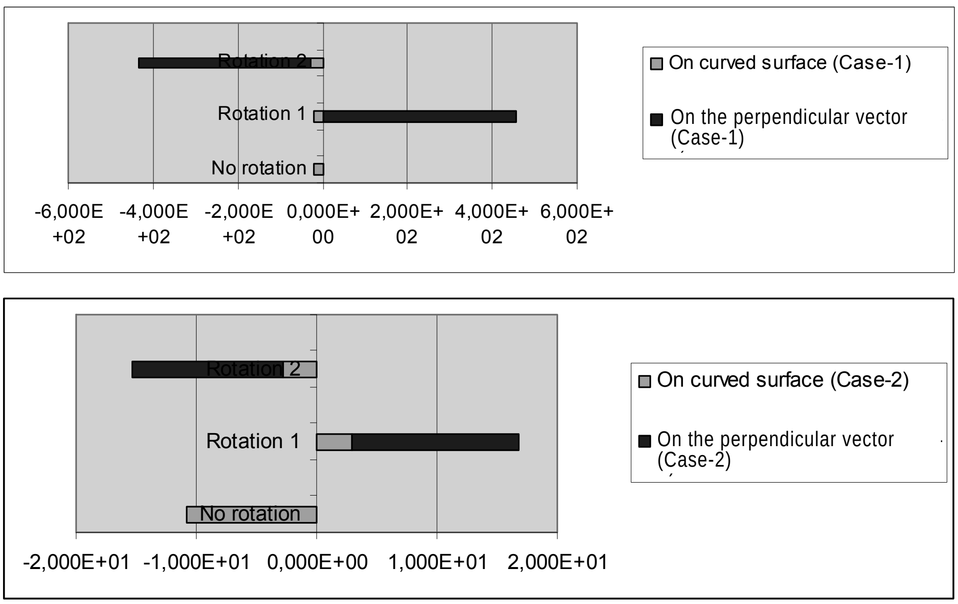

Fig. 6. Gravitational field's energy projected on the curved surface and the angular momentum on the perpendicular direction from the surface

Table 1. Strengths of gravitational field

Case	Case-1		Case-2	
	On curved surface	On perpendicular vector	On curved surface	On perpendicular vector
No rotation	**-21,91**	—	**-10,81**	—
Rotation 1	**-21,63**	**4,561** $\times 10^2$	**2,989**	**13,82**
Rotation 2	**-27,52**	**-4,046** $\times 10^2$	**-2,854**	**-12,53**

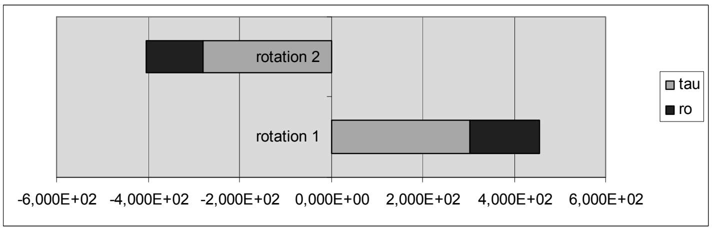

Fig. 7. Rotation momentum of the gravitational field in two directions of τ and ρ, Case-1 (non-linear distortion)

Table 2. Strength of the perpendicular vector to the principal axis z of gravitational field. Case-1

Components	***C*** **and** $\sqrt{V(c)}$ **(Rotation 1)**	***C*** **and** $\sqrt{V(c)}$ **(Rotation 2)**
$dR_{00} = -R_{00} \cdot d\Omega_3 = -\sin\varphi\, R_{00}$ (Component of τ)	**3,022** $\cdot 10^2$ (**2,526** $\cdot 10^2$)	**-2,796** $\cdot 10^2$ (1,958 $\cdot 10^2$)
$dR_{11} = R_{11} \cdot d\Omega_3 = \sin\varphi\, R_{11}$ (Component of ρ)	**1,540** $\cdot 10^2$ (1,158 $\cdot 10^2$)	-1,250 $\cdot 10^2$ (90,88)

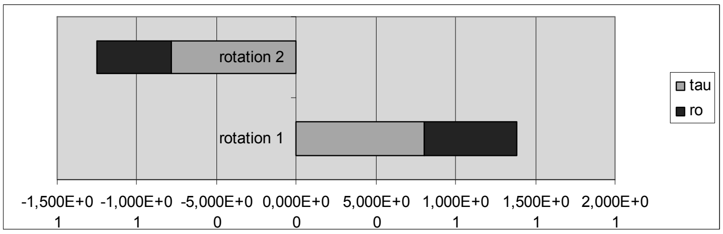

Fig. 8. Rotation momentum of the gravitational field in two directions of τ and ρ, Case-2 (linear distortion)

Table 3. Strength of the perpendicular vector of the rotating gravitational field. Case-2

Components	***C*** **and** $\sqrt{V(c)}$ **(Rotation 1)**	***C*** **and** $\sqrt{V(c)}$ **(Rotation 2)**
$dR_{00} = -R_{00} \cdot d\Omega_3 = -\sin\varphi\, R_{00}$ (Component of τ)	**7,997** (11,83E+01)	**-7,870** (12,09)
$dR_{11} = R_{11} \cdot d\Omega_3 = \sin\varphi\, R_{11}$ (Component of ρ)	**5,819** (7,039)	**-4,662** (7,405)

The spherical surface components (the energy density) don’t show the clear difference in these plus-minus signs in Case-1 (non-linear distortion) in Fig. 9 (Table 4); while the sign of the distance component (ρ) changes in Case-2 (linear distortion) in Fig. 10 (Table 5) as the strong gravity rotates (*Note 3*: In our previous research [1] we had included two other spatial components of the vector, θ and φ ; although we didn’t include these components in this research because the aim of this research is to examine the effect of the rotation in the distorted time coordinate (τ)).

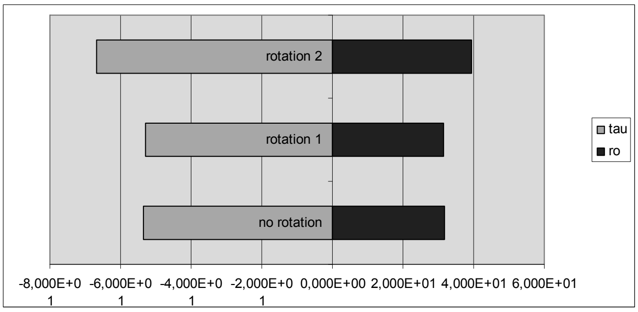

Fig. 9. Gravitational field energy in 2 directions on the spherical curved surface, Case-1 (non-linear distortion)

Table 4. Strength of gravitational field on principal axis z . Case-1

Diagonal Components of $R_{\mu\nu}$	***C* and $\sqrt{V(c)}$ of $R_{\mu\nu}$ before the rotation**	**Diagonal Components of rotated $R_{\mu\nu}$**	***C* and $\sqrt{V(c)}$ (Rotation 1)**	***C* and $\sqrt{V(c)}$ (Rotation 2)**
R_{00}	-53,61 (42,23)	$\cos\varphi \cdot R_{00}$	-52,97 (47,82)	-66,89 (64,99)
R_{11}	31,70 (24,19)	$\cos\varphi \cdot R_{11}$	31,34 (27,42)	39,36 (37,34)
The values in the brackets are: $\sqrt{V(c)}$.				

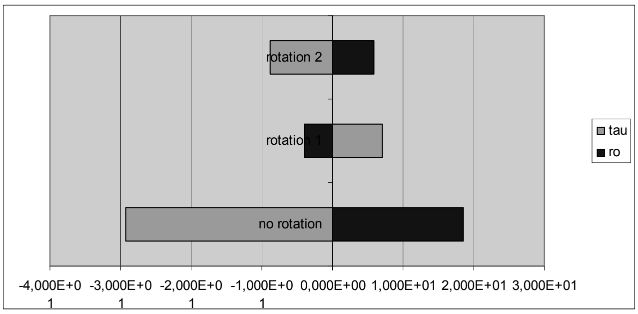

Fig. 10. Gravitational field energy in 2 directions on the spherical curved surface, Case-2 (linear distortion)

Table 5. Strength of gravitational field on principal axis z . Case-2

Diagonal Components of $R_{\mu\nu}$	***C* and $\sqrt{V(c)}$ of $R_{\mu\nu}$ before the rotation**	**Diagonal Components of rotated $R_{\mu\nu}$**	***C* and $\sqrt{V(c)}$ (Rotation 1)**	***C* and $\sqrt{V(c)}$ (Rotation 2)**
R_{00}	-29,32 (5,205)	$\cos\varphi \cdot R_{00}$	**7,011** (14,04)	**-8.767** (12,84)
R_{11}	**18,52** (3,201)	$\cos\varphi\varphi \cdot R_{11}$	**-4,022** (8,713)	**5,912** (7,934)

PHYSICAL MEANING OF THE RESULT

Fig. 11 shows the projected vector on the spherical curved surface, which is tangential to the sphere of the gravitational field. This component of the vector is the energy density of the gravitational field, which our previous researches [1, 6] reported. Fig. 12 shows the projected vector on the perpendicular directions of the distorted time (τ) and the distorted distance (ρ). These components are the angular momentum density, which our previous researches [1, 6] reported.

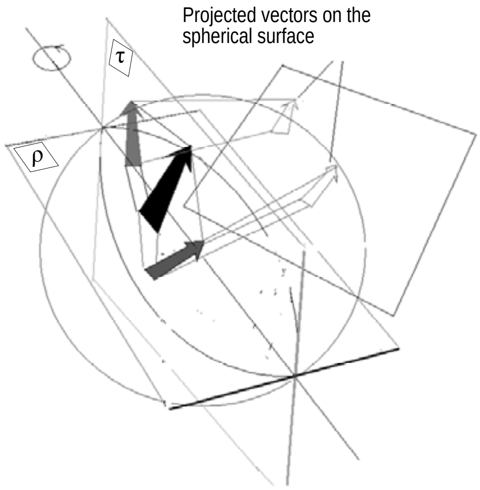

Fig. 11. The Vector projected on tangential (surface) component of the spherical curvature

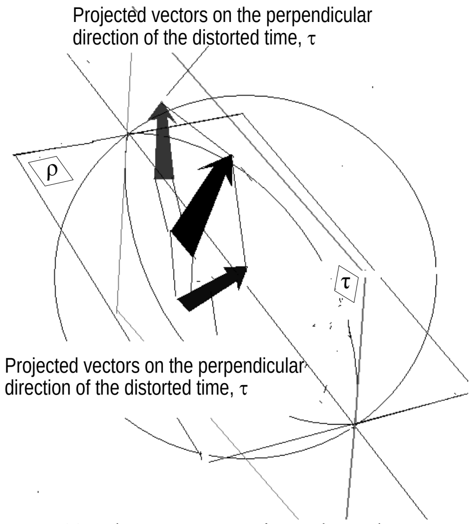

Fig. 12. The Vector projected on the normal (perpendicular) components of the spherical curvature

CONCLUSIONS AND RECOMMENDATIONS

We simulated how a rotating strong gravity can change the direction of time-space, by assuming that the direction of the angular momentum of the rotation indicates the direction of the time. At first, we thought that the time and space could be distorted with the strong gravity, and made the input data upon two cases (the non-linear distortion model and the linear distortion model). Then for simulating the rotating strong gravity, we used the spherical polar coordinate system with the Euler transformation matrix; and then we used Einstein's field equation for calculating the relative strength of the angular momentum to the stress-energy tensor that is placed at the end of the gravitational field.

The result of the simulation shows that the direction of time changes between the future and the past, with the distorted time and space at the presence of a rotating strong gravity.

Further research is needed for verifying this result.

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INFORMATION ON THE ARTICLE

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ІМІТАЦІЙНЕ МОДЕЛЮВАННЯ СИЛЬНОЇ ОБЕРТОВОЇ ГРАВІТАЦІЇ, ЩО ЗМІНЮЄ НАПРЯМ ЧАСУ / Й. Мацукі, П.І. Бідюк

Анотація. Змодельовано, як можна змінити напрям часу за допомогою обертової сильної гравітації. Зроблено припущення, що час і простір можуть бути викривлені за наявності сильної гравітації, обчислено момент імпульсу обертового гравітаційного поля. У моделюванні використано рівняння поля Ейнштейна зі сферичними полярними координатами та матрицю перетворень Ейлера для моделювання обертання. Крім того, припускалося, що тензор енергії-імпульсу, розміщений у кінці сильного гравітаційного поля, відображає величину моменту імпульсу, який є вектором нормалі (перпендикулярним вектором) до обертової осі. Результат імітаційного моделювання показує, що момент імпульсу обертової сильної гравітації змінює її напрям з плюса (майбутнє) на мінус (минуле) та з мінуса (минуле) на плюс (майбутнє) залежно від частоти обертання.

Ключові слова: гравітаційне поле, створення часу і простору, кутовий момент, тензор кривизни, тензор енергії збудження.

ИМИТАЦИОННОЕ МОДЕЛИРОВАНИЕ СИЛЬНОЙ ВРАЩАЮЩЕЙСЯ ГРАВИТАЦИИ, КОТОРАЯ МЕНЯЕТ НАПРАВЛЕНИЕ ВРЕМЕНИ / Й. Мацуки, П.И. Бидюк

Аннотация. Смоделировано, как можно изменить направление времени с помощью вращающейся сильной гравитации. Вначале предполагалось, что время и пространство могут быть искажены при наличии сильной гравитации, а затем вычислили момент импульса вращающегося гравитационного поля. В этом моделировании использовано уравнение поля Эйнштейна со сферическими полярными координатами и матрицу преобразований Эйлера для моделирования вращения. Кроме того, предполагалось, что тензор энергии-импульса, размещенный в конце сильного гравитационного поля, отражает величину момента импульса, который является вектором нормали (перпендикулярным вектором) к вращающейся оси. Результат имитационного моделирования показывает, что момент импульса вращающейся сильной гравитации меняет ее направление с плюса (будущее) на минус (прошлое) и с минуса (прошлое) на плюс (будущее) в зависимости от частоты вращения.

Ключевые слова: гравитационное поле, искажение времени и пространства, угловой момент, тензор кривизны, тензор энергии возбуждения.