ПРОГРЕСИВНІ ІНФОРМАЦІЙНІ ТЕХНОЛОГІЇ, ВИСОКОПРОДУКТИВНІ КОМП'ЮТЕРНІ СИСТЕМИ

UDC 519.004.942
DOI: 10.20535/SRIT.2308-8893.2019.4.01

ANALYSIS OF NEGATIVE FLOW OF GRAVITATIONAL WAVES

Y. MATSUKI, P.I. BIDYUK

Abstact. In this article, we made the mathematical explanation of the anti-gravitational waves, by the inspiration that we got from the observed positron in cosmic rays. Then, we analyzed the mathematical difference between positive and negative flows of gravitational waves; and we calculated the spin of the negative flow of gravitational waves, which is used to stabilize the movement of the waves. In the mathematical formulas we found that positive and negative flows move in opposite directions from each other; therefore, if we see the spin (rotation) of the waves from the planet that emits the waves, the positive flow rotates anti-clockwise, while the negative flow rotates clockwise. We also investigated the possible origin of gravitational waves, and concluded that the negative flow can occur when the positive flow appears, leaving holes behind, in the gravitational field, which is triggered by the movements of a large mass of the planet.

Keywords: Gravitational waves, antimatter, rectilinear coordinates, negative energy flow, spin of gravitational waves.

INTRODUCTION

In our previous research [1], we calculated the energy density of gravitational waves from Moon, assuming that it influences Earth's global temperature. However, the result of the analysis showed that the energy density of Moon's gravitational waves toward Earth's global temperature was negative in comparison with that of Moon's gravitational field.

After this result of the analysis, we held a question: Don't gravitational waves really exist? For answering to this question, we continued the research by setting new tasks: (a) to compare the characteristic of gravitational waves with that of electron and positron, where positron is the antimatter of electron, and (b) to find the mechanism that creates negative flow (antimatter) of the gravitational waves. Here, we set the task (b), because all the particles (waves) must have their antimatters. So, we thought that the existence of antimatters is a prerequisite for confirming the existence of gravitational waves.

In order to implement these two tasks, we took the following steps: (1) to investigate the findings from the observation of electron and positron in the cosmic rays, (2) to review the theory of electron and positron in quantum mechanics, (3) to investigate the mechanism that produces gravitational waves, (4) to make the mathematical formula of negative flow of gravitational waves, and (5) to compare the spin momentum of negative energy flow with the spin momentum of positive energy flow. We selected the spin momentum as an indicator that is to illustrate the characteristic of gravitational waves, which we made in our previous research for positive flow of the waves [1].

Above (4) and (5) are our original, while we analyzed the ratio of positron/electron for the task (1) from the information that we took from [2]; and, we took the necessary equations from Dirac [3, 4] for the tasks (2) and (3).

ANALYSIS

Observed electron and positron in cosmic rays

Fig. 1 shows the observed ratio of positron to electron in cosmic rays, with the intensity of electromagnetic energy that was related to the creation of the positron [2]. It shows that more positrons were observed when the related electromagnetic energy was stronger. And, then, in order to further investigate Fig. 1, we analyzed this data with the method of the Least Squares Estimates of Classical Regression Model.

We show the result of the analysis in Table 1 and the descriptive statistics of the data in Table 2. The regression model is $Y = a + bX$, where Y is the ratio of positron versus electron, X is observed energy of the electromagnetic field, and a and b are coefficients. The calculated coefficient is $b = 5{,}572 \cdot 10^{-4} \pm 9{,}455 \cdot 10^{-5}$ with 95% confidence interval, $\pm 1{,}560 \cdot 10^{-4}$ with 90 % confidence interval, and $\pm 1{,}763 \cdot 10^{-4}$ with 85% confidence interval, where we assumed the standard normal distribution of the coefficients. This calculated result indicates that positron (antimatter of electron) is more observed in the higher energy of the electromagnetic field.

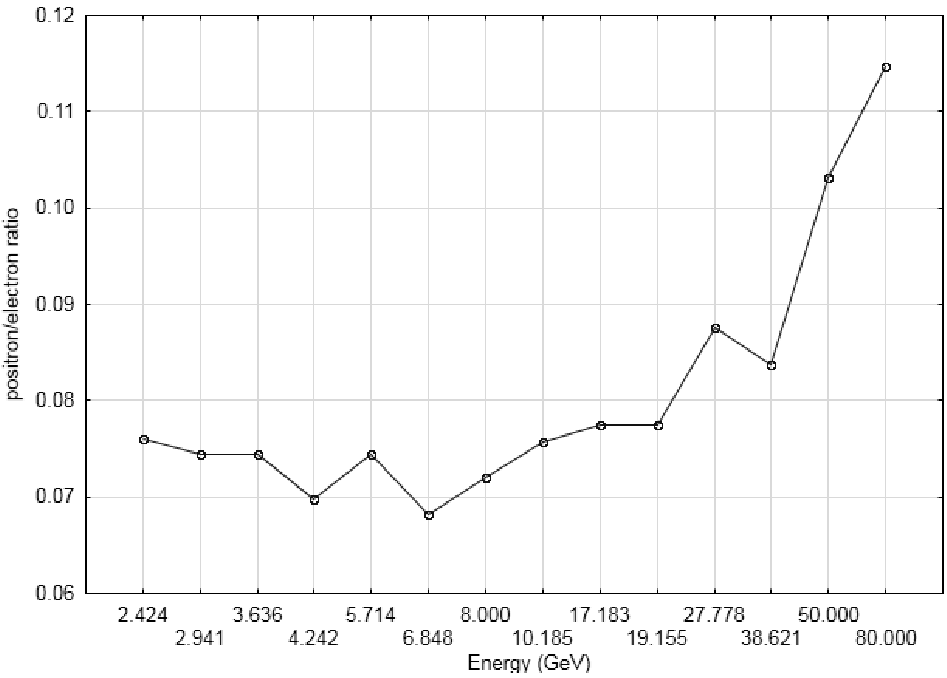


Fig. 1. Observed ratio of positron to electron and energy of the electromagnetic field*

***Note:** Remake from [2]. This source article explains that the lower rate of positron/electron observation below 10 GeV is due to the new solar magnetic field polarity after the year 2001.

Table 1. Summary of the least squares estimates

a		$6{,}964 \cdot 10^{-2}$
b	Coefficient	$5{,}572 \cdot 10^{-4}$
	Standard error of Coefficient	$4{,}824 \cdot 10^{-5}$
R^2 (coefficient of determination)		0,9175
Durbin-Watson Statistic		2,341
Sum of Squared Residuals		$1{,}857 \cdot 10^{-4}$

Table 2. Descriptive statistics

Variable	**Ratio of positron/electron**	**Electro-magnetic energy of electron and positron (GeV)**
Mean	$8{,}065 \cdot 10^{-2}$	19,77
Standard deviation	$1{,}316 \cdot 10^{-2}$	22,61
Minimum	$6{,}820 \cdot 10^{-2}$	2,424
Maximum	0,1147	80,00
Skewness	1,453	1,408
Kurtosis	3,934	3,965
Valid number of observations	14	14

Mathematical formulas of electron and positron

Paul Dirac [4] predicted that both positron and electron are balanced, therefore they are not usually observed; but the positron appears with presence of the electromagnetic field. The equation of motion for an electron in the electromagnetic field of hydrogen atom is:

$$\left\{\left(p_0 + \frac{e}{c}A_0\right) - \alpha_1\left(p_1 + \frac{e}{c}A_1\right) - \alpha_2\left(p_2 + \frac{e}{c}A_2\right) - \right.$$

$$\left. - \alpha_3\left(p_3 + \frac{e}{c}A_3\right) - \alpha_m mc\right\}\Psi = 0 \ . \qquad (1)$$

Here, p_i $(i = 0, 1, 2, 3)$ are momentum of electron, α_i are coefficients that give angular momentum of electron, and $\frac{e}{c}A_i$ are electromagnetic field of hydrogen atom, e is electric charge of electron, c is a constant, and Ψ is the wave function of electron (1).

The equation of motion for positron is:

$$\left\{\left(-p_0 + \frac{e}{c}A_0\right) - \alpha_1\left(-p_1 + \frac{e}{c}A_1\right) - \alpha_2\left(-p_2 + \frac{e}{c}A_2\right) - \right.$$

$$-\alpha_3\left(-p_3+\frac{e}{c}A_3\right)+\alpha_m mc\overline{\Psi}\Bigg\}=0\,.$$

Here, $\overline{\Psi}$ is a wave function of positron.

Equations of motion for gravitational waves and anti-gravitational waves

From the implication of the equations of motions for electron and positron, we formulated the solutions of the equations of motions for positive flow and negative flow of gravitational waves.

For positive flow of the waves (from [1])	**For negative flow of the waves (Our new idea)**
At first, we have the solution of the equation of motion, which is energy density of gravitational waves, which move in one direction of x^3 with the speed of light: $$16\pi t_0^0=\frac{1}{4}(u_{11}-u_{22})^2-u_{12}{}^2 \qquad (2)$$	We think that the negative flow of energy is: $$16\pi t_0^0=\frac{1}{4}\{-u_{11}-(-u_{22})\}^2-(-u_{12})^2 \quad (3)$$

Below, we show how the equations (2) and (3) are derived from the equation (8), which will be explained in the latter part of this article:

According to Dirac [3], the necessary condition for solving the equation of motion of the gravitational waves is $g^{\mu\nu}g_{\rho\sigma,\mu\nu}=0$, while $g_{\rho\sigma,\mu\nu}=\dfrac{\partial^2 g_{\rho\sigma}}{\partial x^\mu \partial x^\nu}$, where x^σ are the contravariant vectors that are described in the 4-dimentional curvilinear coordinates, and $g^{\mu\nu}$ and $g_{\rho\sigma}$ are fundamental tensors. Now we take rectilinear coordinates system as approximation of curvilinear coordinates system, then the second derivatives of $g^{\mu\nu}g_{\rho\sigma,\mu\nu}=0$ are considered to be resolved (integrated) already; and, then, and we define $g_{\mu\nu,\sigma}=u_{\mu\nu}l_\sigma$, where $u_{\mu\nu}$ is the derivative of the function $g_{\mu\nu}$ of $l_\sigma x^\sigma$, where $g_{\mu\nu,\sigma}=\dfrac{\partial g_{\mu\nu}}{\partial x^\sigma}$, and μ, ν, σ are the suffixes that indicate those coordinates; while, we assume that the waves move in only one direction of the space, μ, ν, σ = 0, or 3, where 0 is for time, and 3 is the selected one direction. Also, we put $u_{\mu\nu}u^{\nu\mu}=u_\mu{}^\mu=u$, where $u^{\mu\nu}$ are contravariant two-vector tensors and $u_{\mu\nu}$ are covariant two-vector tensors, and $u_{\mu\nu}=u_{\nu\mu}$; and, l_σ are constants, which satisfy $g^{\rho\sigma}l_\rho l_\sigma=0$. Therefore, $g_{\mu\nu,\sigma}=$ $=u_{\mu\nu,\sigma}l_\sigma$ is regarded as the first integral of $g^{\mu\nu}g_{\rho\sigma,\mu\nu}=0$, then the equation (6), which is shown later in the latter part of this article, becomes $g^{\mu\nu}u_{\mu\nu}l_\nu=\frac{1}{2}g^{\mu\nu}u_{\mu\nu}l_\rho=\frac{1}{2}ul_\rho$, then $(u_{\mu\nu}-\frac{1}{2}g^{\mu\nu}u)l_\nu=0$, and $\Gamma^\rho_{\mu\sigma}=\frac{1}{2}(u^\rho_\mu l_\sigma+u^\rho_\sigma l_\mu-u_{\mu\sigma}l^\rho)$. Meanwhile, the general formula of the action integral is $I=\int R\sqrt{-\det g_{\mu\nu}}\,dx^0dx^1dx^2dx^3$, where R will be

<table>
<tr><td colspan="2">

explained later with the equation (4). $R = g^{\mu\nu}R_{\mu\nu} = g^{\mu\nu}(\Gamma^{\sigma}_{\mu\sigma,\nu} - \Gamma^{\sigma}_{\mu\nu,\sigma}) - L$, where $L = g^{\mu\nu}(\Gamma^{\sigma}_{\mu\nu}\Gamma^{\rho}_{\sigma\rho} - \Gamma^{\rho}_{\mu\sigma}\Gamma^{\sigma}_{\nu\rho})$. Then, L for the waves moving in one direction becomes:

$$L = -g^{\mu\nu}\Gamma^{\rho}_{\mu\sigma}\Gamma^{\sigma}_{\nu\rho} = -\frac{1}{4}g^{\mu\nu}(u^{\rho}_{\mu}l_{\sigma} + u^{\rho}_{\sigma}l_{\mu} - u_{\mu\sigma}l^{\rho})(u^{\sigma}_{\nu}l_{\rho} + u^{\sigma}_{\rho}l_{\nu} - u_{\nu\rho}l^{\sigma}).$$

With the constraint, $\delta L = 0$, the solution of the above action integral is expressed by the pseudo-tensors $t_{\mu}{}^{\nu}$ that lead to the spin momentum densities of the gravitational waves: $16\pi\, t_{\mu}{}^{\nu} = \frac{1}{2}(u_{\alpha\beta}u^{\alpha\beta} - \frac{1}{2}u^{2})l_{\mu}l^{\nu}$, where l_{α} is one direction, in which the waves are moving in. Here, we consider the gravitational waves moving only in the direction of x^{3}, therefore $l_0 = 1$, $l_1 = l_2 = 0$, and $l_3 = -1$.

</td></tr>
<tr><td>

Below, we calculate the spin momentum densities of the positive flow of gravitational waves in rectilinear coordinates, as approximation of curvilinear coordinates

$$16\pi t_{\mu}{}^{\nu} = (1/2)(u_{\alpha\beta}u^{\alpha\beta} - (1/2)u^{2})l_{\mu}l^{\nu}:$$

$$u^{\nu}_{\rho}l_{\nu} = \sum_{\nu=0}^{3} u^{\nu}_{\rho}l_{\nu}.$$

For $\rho = 0$:

$$u^{\nu}_{\rho}l_{\nu} = \sum_{\nu=0}^{3} u^{\nu}_{\rho}l_{\nu} = u^{0}_{0}l_{0} + u^{1}_{0}l_{1} + u^{2}_{0}l_{2} + u^{3}_{0}l_{3} =$$
$$= u^{0}_{0} + 0 + 0 + u^{3}_{0} = g^{00}u_{00} - g^{33}u_{03} =$$
$$= u_{00} + u_{03} = (1/2)ul_{0} = (1/2)u.$$

Here, $g^{\mu\nu} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{bmatrix}$, therefore $g^{00} = 1$, and $g^{33} = -1$.

Also, for contra-variant vector A^{μ} and covariant vector A_{μ}, $A^{\mu} = g^{\mu\mu}A_{\mu}$, and $A_{\mu} = g_{\mu\mu}A^{\mu}$ therefore, for example, $u^{00} = g^{00}g^{00}u_{00}$, $u^{10} = g^{11}g^{00}u_{10}$, and $u^{3}_{0} = g^{33}u_{03}$.

For $\rho = 1$:

$$u^{0}_{1}l_{0} + u^{1}_{1}l_{1} + u^{2}_{1}l_{2} + u^{3}_{1}l_{3} = u^{0}_{1} + 0 + 0 + u^{3}_{1} =$$
$$= g^{00}u_{01} - g^{33}u_{31} = u_{01} + u_{13} = (1/2)ul_{1} = 0.$$

For $\rho = 2$:

$$u^{0}_{1}l_{2} + u^{1}_{1}l_{1} + u^{2}_{2}l_{2} + u^{3}_{3}l_{3} = u^{0}_{2} + 0 + 0 + u^{3}_{2} =$$

</td><td>

Below we calculate the spin momentum density of the negative flow of gravitational waves in rectilinear coordinates, as approximation of curvilinear coordinates

$$16\pi t^{\nu}_{\mu} = (1/2)\{-u_{\alpha\beta}u^{\alpha\beta} - (-(1/2)u^{2})\}l_{\mu}l^{\nu}:$$

$$u^{\nu}_{\rho}l_{\nu} = \sum_{\nu=0}^{3} u^{\nu}_{\rho}l_{\nu}.$$

For $\rho = 0$:

$$u^{\nu}_{\rho}l_{\nu} = \sum_{\nu=0}^{3} u^{\nu}_{\rho}l_{\nu} = -u_{00} - u_{03} = -(1/2)u.$$

For $\rho = 1$:

$$u^{\nu}_{\rho}l_{\nu} = \sum_{\nu=0}^{3} u^{\nu}_{\rho}l_{\nu} = -u_{01} - u_{13} = 0.$$

For $\rho = 2$:

$$u^{\nu}_{\rho}l_{\nu} = \sum_{\nu=0}^{3} u^{\nu}_{\rho}l_{\nu} = -u_{02} - u_{23} = 0.$$

</td></tr>
</table>

$= g^{00}u_{02} - g^{33}u_{32} = u_{02} + u_{23} = (1/2)ul_2 = 0$.

For $\rho = 3$:

$u_3^0 l_0 + u_3^1 l_1 + u_3^2 l_2 + u_3^3 l_3 = u_3^0 + 0 + 0 - u_3^3 =$
$= g^{00}u_{03} - g^{33}u_{33} = u_{03} + u_{33} = (1/2)ul_3 =$
$= -(1/2)u$.

Thus, $u_{00} = -u_{03} + (1/2)u$ and $u_{33} = -u_{03} - (1/2)u$.

Therefore, $u_{00} - u_{33} = (1/2)u - (-(1/2)u) = u$, and $u_{00} + u_{33} = -2u_{03}$, where $u_{03} = u_{30}$. Also, $u_{11} = g_{11}u_1{}^1 l_1 = 0$, and $u_{22} = g_{22}u_2^2 l_2 = 0$, therefore $u_{11} + u_{22} = 0$.

Here, $g^{00} = 1$, $g^{11} = g^{22} = g^{33} = -1$, and $g^{01} = g^{02} = g^{03} = g^{10} = g^{12} = g^{13} = g^{20} = g^{21} = g^{23} = g^{30} = g^{31} = g^{32} = 0$.

Then, $16\pi t_\mu{}^\nu = (1/2)(u_{\alpha\beta}u^{\alpha\beta} - (1/2)u^2)l_\mu l^\nu$ becomes

$$16\pi \cdot t_0^0 = (1/2)\left\{\sum_{\alpha,\beta=0}^{3}(u_{\alpha\beta}u^{\alpha\beta} - (1/2)u^2\right\}.$$

Here,

$$\sum_{\alpha,\beta=0}^{3} u_{\alpha\beta}u^{\alpha\beta} - (1/2)u^2 = u_{00}u^{00} + u_{11}u^{11} +$$
$$+ u_{22}u^{22} + u_{33}u^{33} + 2u_{01}u^{01} + 2u_{02}u^{02} +$$
$$+ 2u_{03}u^{03} + 2u_{12}u^{12} + 2u_{23}u^{23} + 2u_{31}u^{31} -$$
$$- (1/2)u^2 = u_{00}g^{00}g^{00}u_{00} + u_{11}g^{11}g^{11}u_{11} +$$
$$+ u_{22}g^{22}g^{22}u_{22} + u_{33}g^{33}g^{33}u_{33} +$$
$$+ 2u_{01}g^{00}g^{11}u_{01} + 2u_{02}g^{00}g^{22}u_{02} +$$
$$+ 2u_{03}g^{00}g^{33}u_{03} + 2u_{12}g^{11}g^{22}u_{12} +$$
$$+ 2u_{23}g^{22}g^{33}u_{23} + 2u_{31}g^{33}g^{11}u_{31} -$$
$$- (1/2)u^2 = u_{00}^2 + u_{11}^2 + u_{22}^2 + u_{33}^2 +$$
$$+ (-1)2u_{01}^2 + (-1)2u_{02}^2 + (-1)2u_{03}^2 +$$
$$+ 2u_{12}^2 + 2u_{23}^2 + 2u_{31}^2 - (1/2)(u_{00} - u_{33})^2 =$$
$$= u_{11}^2 + u_{22}^2 + 2u_{12}^2 - (1/2)(u_{00} - u_{33})^2 =$$
$$= (1/2)(u_{11} - u_{22})^2 - 2u_{12}{}^2.$$

Because: $u_{11} + u_{22} = 0$, $u_{11} = -u_{22}$, $u_{11}^2 = u_{22}^2$, $u_{11}^2 + u_{22}^2 = 2u_{22}^2$, $(u_{11} - u_{22})^2 =$

For $\rho = 3$:

$$u_\rho^\nu l_\nu = \sum_{\nu=0}^{3} u_\rho^\nu l_\nu = -u_{03} - u_{33} = (1/2)u.$$

Thus, $-u_{00} = u_{03} - (1/2)u$ and $-u_{33} = u_{03} + (1/2)u$.

Therefore, $-u_{00} + u_{33} = -u$ and $-u_{00} - u_{33} = 2u_{03}$, where $u_{03} = u_{30}$. Also, $u_{11} = g_{11}u_1^1 l_1 = 0$, and $u_{22} = g_{22}u_2^2 l_2 = 0$, therefore $-u_{11} - u_{22} = 0$.

Then, $16\pi t_\mu^\nu = (1/2)\{-u_{\alpha\beta}u^{\alpha\beta} - (-(1/2)u^2)\}l_\mu l^\nu$ becomes

$$16\pi t_0^0 = (1/2)\left\{\sum_{\alpha,\beta=0}^{3}(-u_{\alpha\beta}u^{\alpha\beta} - (1/2)(-u^2)\right\}.$$

Here,

$$\sum_{\alpha,\beta=0}^{3}(-u_{\alpha\beta}u^{\alpha\beta} - (-(1/2)u^2) =$$
$$= -(u_{00})^2 - (u_{11})^2 - (u_{22})^2 - (u_{33})^2 +$$
$$+ 2u_{01}{}^2 + 2u_{02}{}^2 + 2u_{03}{}^2 - 2u_{12}{}^2 -$$
$$- 2u_{23}{}^2 - 2u_{31}{}^2 + (1/2)u^2 =$$
$$= -u_{11}{}^2 - u_{22}{}^2 - 2u_{12}{}^2 + (1/2)u^2 =$$
$$= 2u_{22}^2 + 2u_{12}{}^2 = (1/2)(-u_{11} + u_{22})^2 -$$
$$- 2(-u_{12})^2.$$

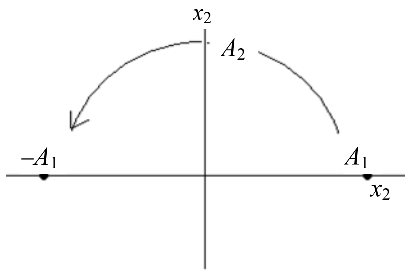
Because: $-u_{11} - u_{22} = 0$, $-u_{11} = u_{22}$,

$= (-u_{22} - u_{22})^2 = (-2u_{22})^2 = 4u_{22}^2$,

$(1/2)(u_{11} - u_{22})^2 = 2u_{22}^2$.

So, $16\pi t_0^{\ 0} = (1/4)(u_{11} - u_{22})^2 - u_{12}^2$.

And then, we assume an infinitesimal rotation operator, R, in the plane of contravariant vectors $x^1 x^2$. If it is applied to any vector, A_1, A_2, it has the effect: $RA_1 = A_2$, $RA_2 = -A_1$, and $R^2 A_1 = RA_2 = -A_1$, so iR must have the eigenvalues ± 1 when applied to a vector [3]. Here, $iR = \pm 1$. So, the operator R makes anti-symmetric change of the vectors.



When we apply this infinitesimal rotation operator, R, to $u_{\mu\nu} = A_\mu A_\nu$, the rotations will occur as follows:

$Ru_{11} = R(A_1 A_1) = (RA_1)A_1 + A_1(R(A_1) =$

$= A_2 A_1 + A_1 A_2 = u_{21} + u_{12} = 2u_{12}$,

where $u_{21} = u_{12}$.

$Ru_{12} = R(A_1 A_2) = (RA_1)A_2 + A_1(RA_2) =$

$= A_2 A_2 + A_1(-A_1) = u_{22} - u_{11}$.

$Ru_{22} = R(A_2 A_2) = (RA_2)A_2 + A_2(RA_2) =$

$= -A_1 A_2 + A_2(-A_1) = -u_{12} - u_{21} = -2u_{12}$.

$R(u_{11} + u_{22}) = R(A_1 A_1 + A_2 A_2) =$

$= (RA_1)A_1 + A_1(RA_1) + (RA_2)A_2 + A_2(RA_2) =$

$= A_2 A_1 + A_1 A_2 - A_1 A_2 - A_2 A_1 =$

$= 2u_{12} - 2u_{12} = 0$.

$R(u_{11} - u_{22}) = R(A_1 A_1 - A_2 A_2) = A_2 A_1 +$

$+ A_1 A_2 + A_1 A_2 + A_2 A_1 = 4A_1 A_2 = 4u_{12}$.

$R^2(u_{11} - u_{22}) = R(R(u_{11} - u_{22})) =$

$= R(Ru_{11} - Ru_{22}) =$

$= R(2u_{12} - (-2u_{12}) = 2Ru_{12} + 2R_{12} =$

$= 2(u_{22} - u_{11}) + 2(u_{22} - u_{11}) =$

$u_{11}^2 = u_{22}^2$, $u_{11}^2 + u_{22}^2 = 2u_{22}^2$,

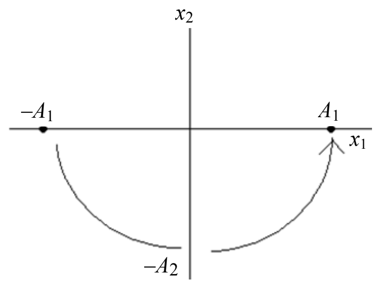
$-u_{11}^2 - u_{22}^2 = -2u_{22}^2$,

$\{-u_{11} - (-u_{22})\}^2 = \{-(-u_{22}) - (-u_{22})\}^2 =$

$= (u_{22} + u_{22})^2 = \{-(-2u_{22})\}^2 = 4u_{22}{}^2$,

$(1/2)(-u_{11} + u_{22})^2 = 2u_{22}{}^2$. So, $16\pi t_0^0 = (1/4)\{-u_{11} - (-u_{22})\}^2 - (-u_{12})^2$.

Then, we assume an infinitesimal rotation operator, R, in the plane of contravariant vectors $x^1 x^2$. If it is applied to any vector, A_1, A_2, it has the effect: $R(-A_1) = -A_2$, $R(-A_2) = A_1$, and $R^2(-A_1) = R(-A_2) = A_1$.



When we apply this infinitesimal rotation operator, R, to $-u_{\mu\nu} = -A_\mu A_\nu$, the rotations will occur as follows: $R(-u_{11})$

$= R(-A_1 A_1) = (R(-A_1))A_1 - A_1(R(A_1) =$

$= -A_2 A_1 - A_1 A_2 = -u_{21} - u_{12} = -2u_{12}$,

where $u_{21} = u_{12}$. $R(-u_{12}) = R(-A_1 A_2) =$

$= -A_2 A_2 - A_1(-A_1) = -u_{22} + u_{11} =$

$= -(u_{22} - u_{11})$. $R(-u_{22}) = R(-A_2 A_2) =$

$= (-RA_2)A_2 - A_2(RA_2) = A_1 A_2 + A_2 A_1 =$

$= u_{12} + u_{21} = -(-u_{12} - u_{21}) =$

$= -(-2u_{12}) = 2u_{12}$;

$R(-u_{11} - u_{22}) = R(-A_1 A_1 - A_2 A_2) =$

$= -(RA_1)A_1 - A_1(RA_1) - (RA_2)A_2 -$

$-A_2(RA_2) = -A_2 A_1 - A_1 A_2 + A_1 A_2 -$

$-A_2(-A_1) = -2u_{12} + 2u_{12} = 0$;

$R(-u_{11} + u_{22}) = R(-A_1 A_1 + A_2 A_2) =$

$= -A_2 A_1 - A_1 A_2 + (-A_1)A_2 + A_2(-A_1) =$

$= -4A_1 A_2 = -4u_{12}$.

$R^2(-u_{11} + u_{22}) = R(R(-u_{11} + u_{22})) =$

$= R(-Ru_{11} + Ru_{22}) = R(-2u_{12} - 2u_{12}) =$

$= -2Ru_{12} - 2Ru_{12} = -2(u_{22} - u_{11}) -$

$=4(u_{22}-u_{11})=-4(u_{11}-u_{22})$. $u_{11}+u_{22}$ is invariant because $R(u_{11}+u_{22})=0$ as shown above, and iR has the eigenvalues ± 2 when applied to $u_{11}-u_{22}$ or u_{12}. Therefore, $(1/4)(u_{11}-u_{22})^2-u_{12}^2$ (the components of $u_{\alpha\beta}$ that contribute to the momentum density of gravitational waves) corresponds to spin 2 [3]. (See note* bellow.)	$-2(u_{22}-u_{11})=-4(u_{22}-u_{11})$ $=-4(-u_{11}+u_{22})$. $-u_{11}-u_{22}$ is invariant because $R(-u_{11}-u_{22})=0$ as shown above, and iR has the eigenvalues ± 2 when applied to $-(u_{11}-u_{22})$ or $-u_{12}$. Therefore, $(1/4)\{-u_{11}-(-u_{22})\}^2+(-u_{12})^2$ corresponds to spin -2. We add minus-sign to 2, in order the show the direction of negative flow, as shown in Fig. 2. (Also see note* bellow to compare this result with electron's spin momentum.)

The geometric relation between the positive flow and negative flow of gravitational waves is shown in Fig. 2.

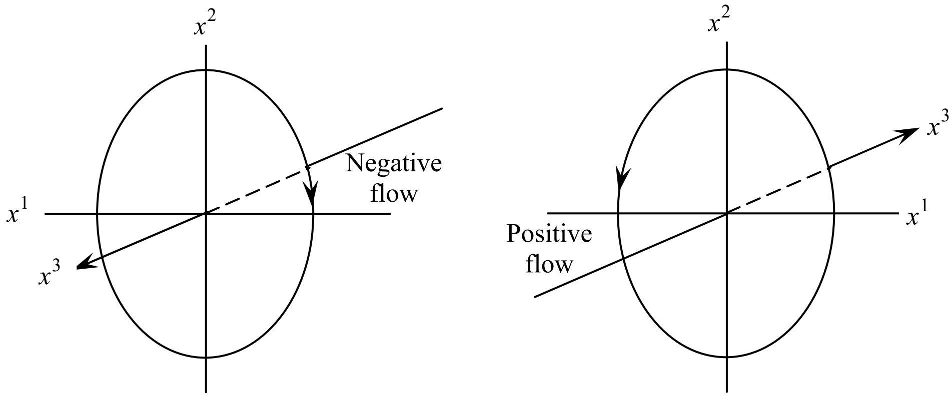


Fig. 2. Calculated directions of spins

Note*: In the equation of motion (1) for electron in the electromagnetic field of hydrogen atom, the infinitesimal operator iR for the rotation of the electron in the plane of x^2x^3 is $-\alpha_1 p_1$; and it has the eigenvalue of $\pm(1/2)$; because, the necessary condition for solving the equation (1) is : $\dot{m}_1+i\hbar\dot{\sigma}_1=i\hbar c\rho_1(\sigma_2 p_3-\sigma_3 p_2)+$ $+2ic\rho_1(\sigma_3 p_2-\sigma_2 p_3)=0$, and $2ic\rho_1(\sigma_3 p_2-\sigma_2 p_3)$ is invariant with $i\hbar\dot{\sigma}_1$. So, $i\hbar=2i$, then $i=(1/2)\hbar$. Therefore, the spin momentum of electron is $(1/2)\hbar\sigma_1$. Here m is the orbital angular momentum of electron in hydrogen atom, $\dot{m}$ is its time-differential of m and $\dot{\sigma}_1$ is the time-differential of σ_1, and the suffix 1, 2, 3 represent matrices of tensors in 3 space coordinates, c is a constant, and $\rho_1=\begin{bmatrix}0&0&1&0\\0&0&0&1\\1&0&0&0\\0&1&0&0\end{bmatrix}$; $\hbar$ is Planck's constant and σ_1 is a matrix $\begin{bmatrix}0&0&0&1\\0&0&1&0\\0&1&0&0\\1&0&0&0\end{bmatrix}$, which makes α_1 by $c\rho_1\sigma_1=\alpha_1$.

Here, it is noted that, in quantum mechanics [4], rectilinear coordinates are used, but not curvilinear coordinates; while, the rectilinear coordinates system holds 4×4 combinations of vectors, the curvilinear coordinates has $4\times\infty^3$ combinations of vectors.

For positron, instead of electron, $i\hbar$ is replaced by $-i\hbar$ in the above equations.

Mechanism to create gravitational waves

The next research question is "how are both positive and negative flows of gravitational waves made?" We think that the answer for positive flow of gravitational waves is described in Einstein's General Theory of Relativity [3]. In this theory, Einstein used Riemann's geometry to describe his idea of gravitational field of a planet. The gravitational field is a tide of vectors ξ^i, where $i = 0, 1, 2, 3$, and the tide is to be made as the effect of differential, $\frac{d^2\xi^i}{dt^2} = R\xi^i$, in the curvature of the 4-dimensional coordinates, where $R = \frac{1}{a^2}$, and a is a radius of the curved surface [5].

In order to further generalize the curvature of the 4-dimensional coordinates, Einstein used Riemann tensor for setting the condition to solve the equation of motion, $\nabla_u\nabla_u\xi + \text{Riemann}(\ldots, u, \xi, u) = 0$, where $\nabla_u\nabla_u = \frac{d^2}{ds^2}$, u is the vector $u = \frac{dx^\mu}{d\tau}e_\mu = u^\mu e_\mu$, which are tangent vectors to the center of the curvature, and e_0, e_1, e_2, e_3 are basis vectors that lie in the directions of their increasing order of the coordinates of x^0, x^1, x^2, and x^3; also, $\Delta\zeta = \Delta x^\alpha e_\alpha$, where $d\zeta\cdot d\zeta = ds^2 = g_{\alpha\beta}dx^\alpha dx^\beta$, and ds is the length of the travel of particles along the geodesics, and Riemann tensor is Riemann, $(w^\alpha, x^\mu, e_\alpha, x^\nu)$, where $\alpha = 0, 1, 2, 3$, and w^α is the gradient (deviation) of the coordinates, which means $w^\alpha = dx^\alpha$. And then, the condition for solving the equation of motion becomes $\frac{d^2\xi^\alpha}{ds^2} + R^\alpha_{\beta\gamma\delta}\frac{dx^\beta}{d\tau}\xi^\gamma\frac{dx^\delta}{d\tau} = 0$.

Then, in case of $w^\alpha = e_\alpha$, Ricci tensors become $Ricci(u, v) =$ $=$ Riemann, $(w^\alpha, x^\mu, e_\alpha, x^\nu)$, which is $R_{\mu\nu} = R^\alpha_{\mu\alpha\nu}$. Then, in case of $\mu = \nu$, Ricci tensors become the curvature scalar, R, where $R = Ricci(w^\alpha, e_\alpha) = R^\alpha_\alpha$. Meanwhile, Einstein defined the differential symmetries of Riemann tensors to describe the gravitational field with the curvature: $G_{\mu\nu} = R_{\mu\nu} - \frac{1}{2}g_{\mu\nu}R$; then, he assumed

$$R_{\mu\nu} = 0 \tag{4}$$

in the empty space where only gravitational field of a planet exists.

Then,

$$R_{\mu\nu} = \Gamma^{\alpha}_{\mu\alpha,\nu} - \Gamma^{\alpha}_{\mu\nu,\alpha} - \Gamma^{\alpha}_{\mu\nu}\Gamma^{\beta}_{\alpha\beta} + \Gamma^{\alpha}_{\mu\beta}\Gamma^{\beta}_{\nu\alpha} = 0,$$

where $\Gamma_{\mu\nu\sigma} = \frac{1}{2}(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$.

In rectilinear coordinates as an approximation of curvilinear coordinates, $-\Gamma^{\alpha}_{\mu\nu}\Gamma^{\beta}_{\alpha\beta} + \Gamma^{\alpha}_{\mu\beta}\Gamma^{\beta}_{\nu\alpha} = 0$, then $R_{\mu\nu} = \Gamma^{\alpha}_{\mu\alpha,\nu} - \Gamma^{\alpha}_{\mu\nu,\alpha} = 0$.

On the other hand,

$$R_{\mu\nu\rho\sigma} = \frac{1}{2}(g_{\mu\sigma,\nu\rho} - g_{\nu\sigma,\mu\rho} - g_{\mu\rho,\nu\sigma} + g_{\nu\rho,\mu\sigma}) + \Gamma_{\beta\mu\sigma}\Gamma^{\beta}_{\nu\rho} - \Gamma_{\beta\mu\rho}\Gamma^{\beta}_{\nu\sigma}.$$

By interchanging ρ and μ, and neglecting $\Gamma_{\beta\mu\sigma}\Gamma^{\beta}_{\nu\rho} - \Gamma_{\beta\mu\rho}\Gamma^{\beta}_{\nu\sigma}$ to replace curvilinear coordinates by rectilinear coordinates we have:

$$R_{\mu\nu} = g^{\rho\sigma}R_{\mu\nu\rho\sigma} = g^{\rho\sigma}(g_{\rho\sigma,\mu\nu} - g_{\nu\sigma,\mu\rho} - g_{\mu\rho,\nu\sigma} + g_{\mu\nu,\rho\sigma}) = 0.$$

Then,

$$g^{\mu\nu}(g_{\mu\nu,\rho\sigma} - g_{\mu\rho,\nu\sigma} - g_{\mu\sigma,\nu\rho} + g_{\rho\sigma,\mu\nu}) = 0. \quad (5)$$

On the other hand, the moving particle in a scalar field of potential energy V follows d'Alambert equation $\nabla V = g^{\mu\nu}(V_{,\mu\nu} - \Gamma^{\alpha}_{\mu\nu}V_{,\alpha}) = 0$. In order to describe the gravitational waves moving in the 4-dimensional space, we replace V by vectors x^{λ} by a certain coordinate system in which $x^{\lambda}_{,\alpha} = g^{\lambda}_{\alpha}$, then d'Alambert equation becomes $g^{\mu\nu}g^{\lambda}_{\alpha,\nu} - g^{\mu\nu}g^{\lambda}_{\alpha}\Gamma^{\alpha}_{\mu\nu} = 0$ then $g^{\mu\nu}\Gamma^{\lambda}_{\mu\nu} = 0$. Meanwhile,

$$\Gamma^{\lambda}_{\mu\nu} = g^{\lambda\rho}\Gamma_{\rho\mu\nu} = \frac{1}{2}g^{\lambda\rho}(g_{\rho\mu,\nu} + g_{\rho\nu,\mu} - g_{\mu\nu,\rho}),$$

so

$$g^{\mu\nu}\Gamma^{\lambda}_{\mu\nu} = \frac{1}{2}g^{\lambda\rho}g^{\mu\nu}(g_{\rho\mu,\nu} + g_{\rho\nu,\mu} - g_{\mu\nu,\rho}) = g^{\lambda\rho}g^{\mu\nu}(g_{\rho\mu,\nu} - \frac{1}{2}g_{\mu\nu,\rho}) = 0,$$

where $g_{\rho\nu,\mu} = y_{n,\rho\mu}y^{n}_{,\nu} + y_{n,\nu\mu}y^{n}_{,\rho} = y_{n,\rho\nu}y^{n}_{,\mu} + y_{n,\mu\nu}y^{n}_{,\rho} = g_{\rho\mu,\nu}$, where μ and ν are in symmetrical relation in the equation, therefore they are exchangeable; and, $y^{n}_{,\mu} = \dfrac{\partial y^{n}(x^{\mu})}{\partial x^{\mu}}$, $\mu = 0, 1, 2, 3$, while x^{μ} are located in *N*-dimensional physical space of y^{n}, $n = 1, 2, \ldots, N$.

Therefore,

$$g^{\mu\nu}\left(g_{\rho\mu,\nu} - \frac{1}{2}g_{\mu\nu,\rho}\right) = 0. \quad (6)$$

Then, in order to describe the waves moving in the gravitational field, it is differentiated by x^{σ} once again,

$$\frac{d}{dx^{\sigma}}g^{\mu\nu}\left(g_{\rho\mu,\nu} - \frac{1}{2}g_{\mu\nu,\rho}\right) = g^{\mu\nu}_{,\sigma}\left(g_{\rho\mu,\nu} - \frac{1}{2}g_{\mu\nu,\rho}\right) + g^{\mu\nu}\left(g_{\mu\rho,\nu\sigma} - \frac{1}{2}g_{\mu\nu,\rho\sigma}\right) =$$

$$= g^{\mu\nu}\left(g_{\mu\rho,\nu\sigma} - \frac{1}{2} g_{\mu\nu,\rho\sigma} \right) = 0 . \qquad (7)$$

In the equation (7), $g^{\mu\nu}_{,\sigma}(g_{\rho\mu,\nu} - \frac{1}{2} g_{\mu\nu,\rho}) = 0$, because $g_{\rho\mu}$ is constant in rectilinear coordinates system, therefore $g_{\rho\mu,\nu} = 0$.

By interchanging ρ and σ,

$$g^{\mu\nu}(g_{\mu\sigma,\nu\rho} - \frac{1}{2} g_{\mu\nu,\sigma\rho}) = g^{\mu\nu}(g_{\mu\sigma,\nu\rho} - \frac{1}{2} g_{\mu\nu,\rho\sigma}) = 0 . \qquad (8)$$

By adding (5), (7) and (8),

$$g^{\mu\nu} g_{\rho\sigma,\mu\nu} = 0 . \qquad (9)$$

It satisfies d'Alambert equation, so it describes the waves that travel in empty space.

Note: The equation (2) is the first integral of equation (9) in rectilinear coordinate system (flat space); however, here is a paradox: the gravitational waves are predicted in the curvilinear coordinate system (curved space) where the waves move on the curved surface of the coordinates. However, if it is in the curvilinear coordinates, $-\Gamma^{\alpha}_{\mu\nu}\Gamma^{\beta}_{\alpha\beta} + \Gamma^{\alpha}_{\mu\beta}\Gamma^{\beta}_{\nu\alpha} \neq 0$ for the equation (4), $\Gamma_{\beta\mu\sigma}\Gamma^{\beta}_{\nu\rho} - \Gamma_{\beta\mu\rho}\Gamma^{\beta}_{\nu\sigma} \neq 0$ for the equation (5), and $g^{\mu\nu}_{,\sigma}(g_{\rho\mu,\nu} - \frac{1}{2} g_{\mu\nu,\rho}) \neq 0$ for the equation (7); then, we are not able to get the equation (9), which enables us to calculate the spin momentum densities with the equation (2). It means that the equation (9) is only an approximation, which is given by the condition that the waves move only in one direction of $l_\sigma x^\sigma$ as if the waves move in the rectilinear coordinates system.

Mechanism to create negative flow of gravitational waves

On the other hand, we think that the negative flow of gravitational waves must be described by:

$$- g^{\mu\nu} g_{\rho\sigma,\mu\nu} = 0 .$$

This means that the negative waves move backward from the direction of the positive flow of the waves. When the positive flow moves forward, it creates vacuum or hole in the geometric structure of the gravitational field of the equation (4). This explanation corresponds to Dirac's explanation about the creation of positron [4]. And, then, we have made the following explanation: Usually, the positive flow and the negative flow should be balanced; therefore, neither of the positive flow nor negative flow of gravitational waves is observable. However, when planet moves, the movement of the mass of the planet breaks the balance; then gravitational waves of both positive flow and negative flow appear.

CONCLUSIONS AND RECOMMENDATION

In this research, we investigated a question: "Do gravitational waves really exist?" As the result of our investigation, we didn't find the straight answer, but we found that the gravitational waves must have both positive and negative flows if they exist. So, we also investigated one more question: "How are both positive and negative flows of gravitational waves created?"

To find the answer for this second question, we made the negative image of the energy flow of gravitational waves, and calculated its spin momentum, and we compared it with the spin of the positive flow. As the result, we found that the negative flow of gravitational waves moves in one direction, spinning clockwise, while the positive flow of gravitational waves moves in opposite direction to that of negative flow, spinning anti-clockwise, when looking at both flows of the waves from the producer (planet) of the waves.

Then, we found a possible explanation about the process that creates the negative flow of gravitational waves. In the process that creates positron (antimatter of electron), electron and positron are usually not observable because they are balanced in the space. However, getting magnetic radiations, electron appears and also positron appears as the hole from where electron goes out. Similarly, positive flow and negative flow of gravitational waves are usually not observable, but when the planet moves, the gravitational waves appear from the gravitational field; and then, when positive flow appears, negative flow also appears as the vacuum of the gravitational field, which is made by the positive flow.

A paradox still remains. The mathematical explanation of gravitational waves is made by the curvature of the gravitational field; however, our approach, shown in this report, used the system of rectilinear coordinates, and it is only an approximation for very small range of the curvilinear coordinate system. Therefore, we still need further investigation in curvature coordinate system, to find more general explanation.

REFERENCES

1. *Matsuki Y.* Calculating energy density and spin momentum density of Moon's gravitational waves in rectilinear coordinates (part 4) / Y. Matsuki, P.I. Bidyuk // System Research & Information Technology. — 2019. — N 3. — P. 7–17.
2. *Beringer J.* Particle Data Group / J. Beringer et al. // Phys. Revi. D86, 010001. — 2012. — P. 306 (Figure 26.2 Differential spectrum of electrons plus positrons multiplied by E^3).
3. *Dirac P.A.M.* General Theory of Relativity / P.A.M. Dirac. —New York: Florida University, A Wiley-Interscience Publication, John Wiley & Sons, 1975. — P. 69.
4. *Dirac P.A.M.* The Principle of Quantum Mechanics / P.A.M. Dirac. — Fourth Edition. — Oxford: Clarendon Press, 1958. — P.312
5. *Goldstein H.* Classical Mechanics / H. Goldstein, C.P. Poole, J.L. Safko. — 3rd Edition. —Pearson Education, Inc., (2002). — P. 646 (especially Chapter 7.11 "Introduction to the general theory of relativity", P. 324–328).
6. *Matsuki Y.* Empirical Investigation on Influence of Moon's Gravitational-Field to Earth's Global Temperature (Part-3) / Y. Matsuki, P.I. Bidyuk // System Research & Information Technology. — 2019. — N 2. — P. 18–24.

Received 02.09.2019

From the Editorial Board: the article corresponds completely to submitted manuscript.