The Physical Interpretation of the Energy-Momentum Transport Wave Function for the Gravitational and Electrostatic Interactions

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In the paper [1] we have presented simple model of the energy-momentum transport wave function (EMTWF). In this paper we will discuss **the physical interpretation of the EMTWF** for the elementary quanta of action connected with the gravitational and electrostatic interactions.

elementary quanta of action, the energy-momentum transport wave function, wave equation

1. Introduction

In the paper [1] we have presented simple model of the energy-momentum transport wave function (EMTWF). For the relativistic case we have found *the wave equation*

$$\nabla^2\Psi(\mathbf{r},t)-\frac{1}{c^2}\frac{\partial^2\Psi(\mathbf{r},t)}{\partial t^2}=-\frac{m^2c^2}{q^2} \tag{1}$$

where q is *the elementary quantum of action* [2, 3, 4], m – *mass of the particle (body),* c – *speed of light.*

2. Physical interpretation of the EMTWF

If we assume that the wave equation (1) has form

$$\nabla^2\Psi(\mathbf{r},t)-\frac{1}{c^2}\frac{\partial^2\Psi(\mathbf{r},t)}{\partial t^2}=0 \tag{2}$$

and additionally we assume that

$$\Psi(\mathbf{r},t)=\psi(\mathbf{r})\exp\left(\frac{Et}{q}\right) \tag{3}$$

then we get the equation

$$\nabla^2\psi(\mathbf{r})-k^2\psi(\mathbf{r})=0 \tag{4}$$

where $k=\frac{E}{qc}$, E is the energy of the particle. Equation (4) is *the screened Poisson equation* with the solution

$$\psi(r) = \frac{q}{mc}\frac{1}{r}e^{-kr} \tag{5}$$

2a. Gravitational interaction

For the elementary quantum of action q connected with the gravitational interaction

$$q = h_g = \frac{Gm^2}{c_g} \tag{6}$$

where c_g is *the speed of gravitation*, equation (5) has form

$$\psi(r) = \frac{r_g}{r}e^{-kr} \tag{7}$$

where: G is the gravitational constant, $k = \frac{E}{qc_g} = \frac{E}{Gm^2}$, the factor k has dimension [1/m]. When the particle is in the rest, his energy $E = mc_g^2$ and $k = 1/r_g$, where $r_g = Gm/c_g^2$ is *the gravitational radius* and the equation (7) has form

$$\psi(r) = \frac{r_g}{r}\exp\left(-\frac{r}{r_g}\right) \tag{7a}$$

If we will multiply both sides of the equation (7a) by the factor c_g^2 then we get

$$c_g^2\psi(r) = V_g^2(r) = c_g^2\frac{r_g}{r}\exp\left(-\frac{r}{r_g}\right) = \frac{Gm}{r}\exp\left(-\frac{r}{r_g}\right) \tag{8}$$

and if assume also that $r >> r_g$, then we get *the scalar field of the square of the velocity* $(V_g(r))^2$ [5] [1].

$$c^2\psi(r) = V_g^2(r) = -\phi_g(r) = \frac{Gm}{r} \tag{9}$$

Similarly, if we will multiply both sides of the equation (7a) by the velocity **v** and if assume also that $r >> r_g$, then we get *the vectorial field of the velocity* $\mathbf{V_{gm}}(r)$ [5] (or *the gravitational vectorial potential*).

We can see that the EMTWF $\psi(\mathbf{r})$ for the gravitational interaction has **the very simple physical interpretation**. For the gravitational interaction the product of the $c_g^2 \cdot \psi(\mathbf{r})$ we can interpret as *the scalar (Newtonian gravitional potential* $\phi_g(r)$ (*the scalar field of the square of the velocity* $(V_g(r))^2$), however the product of the $\mathbf{v} \cdot \psi(\mathbf{r})$ we can interpret as *the vectorial gravitional potential* $\boldsymbol{A_g}(\mathbf{r})$ (*the vectorial field of the velocity* $\boldsymbol{V_{gm}}(r)$).

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[1] If we multiply both sides of the equation (8) by factor $-c_g^2$ and assume that $r >> r_g$, then we get the classical *Newtonian gravitational potential* $\phi_g(r)$.

2b. Electrostatic interaction

For the elementary quanta of action connected with electrostatic interaction

$$q = h_e = \frac{k_e e^2}{c} \tag{10}$$

equation (5) has form

$$\psi(r) = \frac{r_e}{r} e^{-kr} \tag{11}$$

where: $k = \frac{E}{qc} = \frac{E}{ke^2}$, $r_e = (k_e e^2)/(m_e c^2)$ is *the classical electron radius*, $k_e = 1/4\pi\varepsilon_0$ is *the Coulomb law constant in the SI system of units*, ε_0 *is the vacuum permittivity*, e is *the electric charge*, m_e *is the mass of the electron*. When the particle is in the rest, his energy $E = m_e c^2$ and $k = 1/r_e$ and equation (11) has form

$$\psi(r) = \frac{r_e}{r} \exp\left(-\frac{r}{r_e}\right) \tag{14a}$$

If we multiply both sides of the equation (11a) by the factor $(m_e c^2/e)$ and assume that $r >> r_e$, then we get *the classical electrostatic potential* $V_e(r)$

$$\frac{m_e c^2}{e}\psi(r) = V_e(r) = \frac{k_e e}{r} \tag{15}$$

Similarly, if we will multiply both sides of the equation (11) by the factor $(m_e/e)\mathbf{v}$ and if assume also that $r >> r_e$, then we get *the vectorial potential* $\mathbf{A_e}(r)$.

We can see that the EMTWF $\psi(\mathbf{r})$ for the electrostatic interaction has **the very simple physical interpretation**. For the electrostatic interaction the product of the $(m_e c^2/e)\cdot\psi(\mathbf{r})$ we can interpret as *the classical scalar electrostatic potential $V_e(r)$,* however the product of the $(m_e/e)\mathbf{v}\cdot\psi(\mathbf{r})$ we can interpret as *the vectorial potential $\mathbf{A_e}(r)$.*

The verification of the physical interpretation of the EMTWF for the both interactions

Let's multiply both sides of the equation (1) by the factor c_g^2 then we get

$$\nabla^2 V_g^2(\mathbf{r},t) - \frac{1}{c_g^2}\frac{\partial^2 V_g^2(\mathbf{r},t)}{\partial t^2} = -\frac{c_g^2}{r_g^2} = -\nu_g^2 \tag{16}$$

Let's compare this equation with the equation (8d) being in the publication [5]

$$\nabla^2 V_g^2(\mathbf{r},t) - \frac{1}{c_g^2}\frac{\partial^2 V_g^2(\mathbf{r},t)}{\partial t^2} = -4\pi G\rho(\mathbf{r},t) \tag{17}$$

where ρ *is the mass density*. Both equations (16) and (17) are equal if and only if, when the $\nu_g(\mathbf{r}, t) = (4\pi G\rho(\mathbf{r}, t))^{1/2}$, where ν_g is *the gravitational frequency* and has the dimension [1/s].

Let's multiply both sides of the equation (1) by the factor ($m_e c^2/e$) then we get

$$\nabla^2 V_e(\mathbf{r},t)-\frac{1}{c^2}\frac{\partial^2 V_e(\mathbf{r},t)}{\partial t^2}=-\frac{m_e}{e}\frac{c^2}{r_e^2}=-\frac{m_e}{e}\nu_e^2 \tag{18}$$

Let's compare this equation with the well known equation for the scalar electrostatic potential

$$\nabla^2 V_e(\mathbf{r},t)-\frac{1}{c^2}\frac{\partial^2 V_e(\mathbf{r},t)}{\partial t^2}=-k_e\rho_e(\mathbf{r},t) \tag{19}$$

where ρ_e *is the charge density*. Both equations (18) and (19) are equal if and only if, when

$$\nu_e(\mathbf{r},t)=\sqrt{\frac{e}{4\pi\varepsilon_0 m_e}\rho_e(\mathbf{r},t)} \tag{20}$$

where $\nu_e(\mathbf{r}, t)$ is *the electrostatic frequency* and has the dimension [1/s].

Conclusion

In this paper we have presented the physical interpretation of the energy-momentum transport wave function for the gravitational and electrostatic interaction. For those interactions the EMTWF $\psi(\mathbf{r})$ have **the very simple physical interpretation**.

For the gravitational interaction the product of the $c^2\cdot\psi(\mathbf{r})$ we can interpret as *the scalar gravitional potential* $\phi_g(r)$ (or *the scalar field of the square of the velocity* $(V_g(r))^2$), but the product of the $\mathbf{v}\cdot\psi(\mathbf{r})$ we can interpret as *the vectorial gravitional potential* $\boldsymbol{A_g}(r)$ (or *the vectorial field of the velocity* $\boldsymbol{V_{gm}}(r)$).

For the electrostatic interaction the product of the $(m_e c^2/e)\cdot\psi(\mathbf{r})$ we can interpret as *the classical scalar electrostatic potential* $V_e(r)$, but the product of the $(m_e/e)\mathbf{v}\cdot\psi(\mathbf{r})$ we can interpret as *the vectorial potential* $\boldsymbol{A_e}(r)$.

We will receive these same results for the nonrelativistic case [1].

References

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