The space-time wormhole and time direction of travelling light

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Abstract

The investigation of Scharzschild solution using new one transform leads to the spherical solution of light path. Spherical solution forms space-time wormhole with finite throat. It was shown that wormhole throat diameter could by manipulated by changing value of Schwarzschild radius. Using symmetric formulation of Maxwell's equations one can obtain the physical time negative solution. Detailed investigation of wormhole of light for Schwarzschild radius of the earth shows that light can travel not only to the future but also to the past too.

Keywords— Maxwell's equations; negative mass; positive mass; Schwarzschild radius; time symmetry; wormhole

1 Introduction

The theory of wormholes goes back to 1916 shortly after Einstein published his general theory and Schwarzschild found spherical solution of equation of general relativity, which has mathematical singularities both at zero and at the so-called Schwarzschild radius (Schwarzschild, 1916). Ludwig Flamm investigated the Schwarzschild solution and realized that Einstein's equations allowed a second solution, now known as a white hole, and that the two solutions, describing two different regions of (flat) spacetime were connected (mathematically) by a spacetime conduit (Flamm, 1916). In 1935, Einstein and Nathan Rosen proposed transformation of elementary path of Scharzschild solution to avoid singularities at the Schwarzschild radius. New transformed elementary path has spherical symmetric space-time path solution their named "bridge" that today has the formal name "Einstein-Rosen bridge". Wheeler's named in 1955 paper (Wheeler, 1955) this bridge as the wormhole and discusses this wormholes in terms of topological entities called geons and, incidentally, provides the first (now familiar) diagram of a wormhole as a tunnel connecting two openings in different

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regions of spacetime. A geon is in theoretical general relativity an gravitational wave which is held together in a confined region by the gravitational attraction of its own field energy.

The seminal work of Morris and Thorne (Morris & Thorne, 1988) identified the main concepts behind traversable wormholes, and Morris, Thorne, and Yurtsever (Morris, Thorne, & Yurtsever, 1988) further developed the energy condition requirements for wormholes and their conversion into time machines. Morris, Thorne, and Yertsever concluded that to keep a wormhole open would require matter with a negative energy density and a large negative pressure larger in magnitude than the energy density, so called exotic matter.

Traversable wormholes are creatures of classical GTR and represent non-trivial topology change in the spacetime manifold. This makes mathematicians cringe because it raises the question of whether topology can change or fluctuate to accommodate wormhole creation. Black holes and naked singularities are also creatures of GTR representing non-trivial topology change in spacetime, yet they are accepted by the astrophysics and mathematical communities the former by Hubble Space Telescope discoveries and the latter by theoretical arguments due to Kip Thorne, Stephen Hawking, Roger Penrose and others (Davis, 1998). The Bohm-Aharonov effect is another example which owes its existence to non-trivial topology change in the manifold. The topology change (censorship) theorems discussed in (Visser, 1995) make precise mathematical statements about the ”mathematicians topology” (topology of spacetime is fixed!), however, Visser correctly points out that this is a mathematical abstraction. In fact, (Visser, 1990) proved that the existence of an everywhere Lorentzian metric in spacetime is not a sufficient condition to prevent topology change. Furthermore, (Visser, 1990), (Visser, 1995) elaborates that physical probes are not sensitive to this mathematical abstraction, but instead they typically couple to the geometrical features of space. (Visser, 1990) also showed that it is possible for geometrical effects to mimic the effects of topology change.

In 1917, physicist Tullio Levi-Civita (Levi-Civita, 1917) read a paper before the Academy of Rome about creating artificial gravitational fields (spacetime curvature) by virtue of static homogeneous magnetic or electric fields as a solution to the GTR equations. This paper went largely unnoticed. Other scientist (Maccone, 1995) extended and matched Levi-Civitas solution to the Morris and Thorne solution and claimed that the earlier describes a wormhole in spacetime. More specifically, Maccone claims that static homogeneous magnetic/electric fields with cylindrical symmetry can create spacetime curvature which manifests itself as a traversable wormhole. Although the claim of inducing spacetime curvature is correct, Levi-Civitas metric solution is not a wormhole. In 2013 (Maknickas, 2013) proposed interconnection between Biefeld-Brown effect and space curvature of electric field. Interconnection of gravity and electric field energy yields to prediction of decreasing of capacitor gravity mass from capacitor capacitance and voltage values, observed in Biefeld-Brown effect. As a additional effect of magnetic field must be increasing of mass of an inductance coil, but this effect isn’t observed still now.

Aims of this article are investigation of Scharzschild solution using new one transform which leads to spherical solution of light path. Detailed investigation are directed to prove proposition that electromagnetic field wave (light) can travel backward direction or in other words to the past.

2 Time symmetry of Maxwell's equations

According authors (Munera & Guzman, 1997) Maxwell's equations can be expressed in symmetric way for the new field variables P and N in CGI units as follow

$$\begin{aligned}
\mathbf{E} &= (\mathbf{P}-\mathbf{N})/2 &(1)\\
\mathbf{B} &= (\mathbf{P}+\mathbf{N})/2 &(2)\\
\nabla\times\mathbf{P} &= -\frac{\partial\mathbf{N}}{\partial\omega}+4\pi\frac{\mathbf{J}}{c} &(3)\\
\nabla\times\mathbf{N} &= \frac{\partial\mathbf{P}}{\partial\omega}+4\pi\frac{\mathbf{J}}{c} &(4)\\
\nabla\cdot\mathbf{P} &= 4\pi\rho &(5)\\
\nabla\cdot\mathbf{N} &= -4\pi\rho &(6)
\end{aligned}$$

where $\omega = ct$, c is light speed in vacuum, t is time variable and continuity condition is

$$\nabla\cdot\mathbf{J}+c\frac{\partial\rho}{\partial\omega}=0, \quad (7)$$

accordingly. Analysing this symmetric Maxwell's equations one can show that replacing t, ρ and P to the $-t$, $-\rho$ and N do not change system of symmetric Maxwell's equation (3,4,5,6) where $\mathbf{J}=\rho\mathbf{v}$. Maybe that fact led father of electrodynamics Richard Feynman to make conclusion that elementary particle positron is one other elementary particle electron travelling in negative time direction. The same way authors (Munera & Guzman, 1997) shows that Maxwell's equations can be expressed in symmetric way for the new field variables P and M in CGI units as follow

$$\begin{aligned}
\mathbf{E} &= (\mathbf{P}-\mathbf{M})/2 &(8)\\
\mathbf{B} &= (\mathbf{P}+\mathbf{M})/2 &(9)\\
\nabla\times\mathbf{P} &= \frac{\partial\mathbf{M}}{\partial\omega}+4\pi\frac{\mathbf{J}}{c} &(10)\\
\nabla\times\mathbf{M} &= -\frac{\partial\mathbf{P}}{\partial\omega}-4\pi\frac{\mathbf{J}}{c} &(11)\\
\nabla\cdot\mathbf{P} &= 4\pi\rho &(12)\\
\nabla\cdot\mathbf{N} &= 4\pi\rho &(13)
\end{aligned}$$

Analysing this symmetric Maxwell's equations one can show that replacing t and P to the $-t$ and N do not change system of symmetric Maxwell's equations (10, 11, 12, 13) too. So, one can make conclusion that solutions **P** and **M** of given equations differs just in time direction or in other words if one of fields evaluates to the future the other evaluates to the past. Since vectors of electric field **E** and magnetic field **B** are physically observable, linear combinations of this vectors **P** and **M** must be physically observable too.

3 Negative and positive mass

According (Maknickas, 2013) one cane explain Biefeld-Brown effect as space curvature of electromagnetic field as follow

$$R = \frac{32\pi G}{c^4}\left(\rho c^2 + \frac{\alpha_g c^2}{2\mu_0}\left(B^2 - \frac{E^2}{c^2}\right)\right), \tag{14}$$

yielding the equivalent form of Richi tensor

$$R_{\mu\nu} = g_{\mu\nu}\frac{8\pi G}{c^4}\left(\rho c^2 + \frac{\alpha_g c^2}{2\mu_0}\left(B^2 - \frac{E^2}{c^2}\right)\right), \tag{15}$$

where α_g is electromagnetic gravity coupling constant. So, space curvature of spheric gravity mass with radius r in terms of additional mass generated by electromagnetic field could be expressed as follow

$$R = \frac{24G}{c^2 r^3}\left(M - M_{eg}\right), \tag{16}$$

$$M_{eg} = \frac{\alpha_g V}{2}\left(\varepsilon_0 E^2 - \frac{B^2}{\mu_0}\right), \tag{17}$$

$$V = \frac{4\pi r^3}{3}, \tag{18}$$

where M_{eg} is electromagnetic mass and V is volume of electromagnetic field and is equal to volume of gravity-antigravity devices, which is inside this electromagnetic field.

4 The Schwarzschild solution

As is well known, Schwarzschild found the spherically symmetric static solution of the gravitation equation (Schwarzschild, 1916)

$$ds^2 = -\frac{1}{1-2m/r}dr^2 - r^2(d\theta^2 + \sin(\theta)d\phi^2) + \left(1 - \frac{2m}{r}\right)dt^2 \tag{19}$$

here $(r > 2m, \theta$ from 0 to π, ϕ from 0 to $2\pi)$ and $G = c = 1$. On the other hand g_{11} for $r = 2m$ becomes infinity and hence we have there a singularity.

If one introduces in place of r a new variable according to the equation

$$u^2 = r^2 - 4m^2 \tag{20}$$

one obtains for ds^2 the expression

$$ds^2 = -\left(1 + \frac{2m}{\sqrt{u^2+4m^2}}\right)du^2 - (u^2+4m^2)(d\theta^2 + \sin(\theta)d\phi^2) + \left(1 - \frac{2m}{\sqrt{u^2+4m^2}}\right)dt^2 \tag{21}$$

For $u = 0$ g_{44} vanishes, however we are dealing with a solution of the (new) field equations, which is free from singularities for all finite points as explained in (Einstein & Rosen, 1935).

If one tries to interpret the regular solution (19) in the space of r, θ, ϕ, t, one arrives at the following conclusion. The four dimensional space is described mathematically by two congruent parts, corresponding to $u > 0$ and $u < 0$, which are joined by a hyperplane $r = 2m$ or $u = 0$ in which g vanishes.

In order to understand the real meaning of such metric one cane write the equation of null geodesic:

$$g_{\mu\nu}(x)\frac{dx^{\mu}}{d\lambda}\frac{dx^{\nu}}{d\lambda} = 0 \qquad (22)$$

The first step consists of reducing it to two-dimensions by fixing the angular coordinates to constant values $\theta = \theta_0, \phi = \phi_0$. In this way the metric (21) reduces to:

$$ds^2 = -\left(1 + \frac{2m}{\sqrt{u^2 + 4m^2}}\right)du^2 + \left(1 - \frac{2m}{\sqrt{u^2 + 4m^2}}\right)dt^2 \qquad (23)$$

Next, in the reduced space spanned by the coordinates u and t one can look for the null-geodesics. From the equation:

$$-\left(1 + \frac{2m}{\sqrt{u^2 + 4m^2}}\right)\left(\frac{du}{d\lambda}\right)^2 + \left(1 - \frac{2m}{\sqrt{u^2 + 4m^2}}\right)\left(\frac{dt}{d\lambda}\right)^2 = 0 \qquad (24)$$

one can obtain

$$\frac{dt}{du} = \pm\sqrt{\frac{\sqrt{u^2 + 4m^2} + 2m}{\sqrt{u^2 + 4m^2} - 2m}} = \pm\frac{\sqrt{u^2 + 4m^2} + 2m}{u} \qquad (25)$$

and finally

$$t = t_0 \pm \left(-2\,|m|\,\operatorname{asinh}\left(\frac{2\,|m|}{|u|}\right) + 2\,m\log(u) + \sqrt{u^2 + 4\,m^2}\right) \qquad (26)$$

Now one can visualise eq.(26) for mass $m = M_{jupiter}$. Results are presented in Fig. 1 where upper curve is positive solution and lower curve is negative solution of eq. (26). Both curves intersect x axis and this intersection denotes wormhole throat. In case of light length less than wormhole throat light could travel in r direction both time directions, accordantly, where space coordinate r could be expressed as square root of u effective coordinate as follow

$$r = \sqrt{u^2 + (2Gm/c^2)^2}. \qquad (27)$$

The same way, one can visualise eq.(26) for mass $m = -M_{jupiter}$. Results are presented in Fig. 2 where upper curve is positive solution and lower curve is negative solution of eq. (26). Both curves intersect x axis and this intersection denotes wormhole throat, but now wormhole for a given max gravity mass $m = -M_{jupiter}$ is approximately ~ 10 time bigger.

So, one can compare dependence of wormhole throats form value of gravity mass. Results are presented in Fig. (3). Analysing obtained curves one can show that wormhole throat of positive gravity mass evaluate as square of mass and in opposite wormhole of negative gravity mass evaluate near linearly.

Finally, earth mass in $2GM/c^2$ units approximately equals 0.008873 and one can visualise dependence of wormhole throat of positive gravity mass field at the surface of earth (Fig. 4). Obtained results shows that wormhole of electromagnetic wave at a surface of the earth is approximately $5.5\sqrt{2} = 7.778$ cm. Recalculation to the frequency units gives value 3.843 GHz or second frequency mod of today's cellphone radio-communication band 1.9 GHz. So, cellphone radio-communications frequency second mode can travel in earth gravity field to the past and this phenomena must be observed experimentally.

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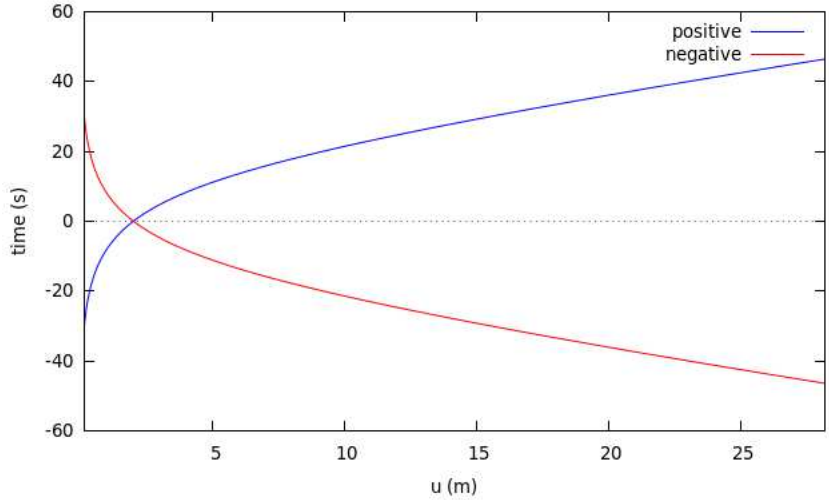

Figure 1: Time radial path of light versus effective space coordinate u for $M_{jupiter}$ positive gravity mass field

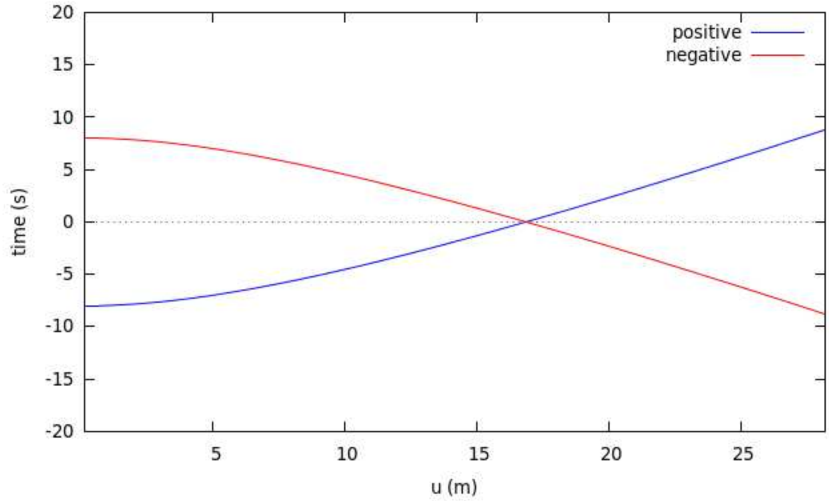

Figure 2: Time path of light versus effective radial space coordinate u for $-M_{jupiter}$ negative gravity mass field

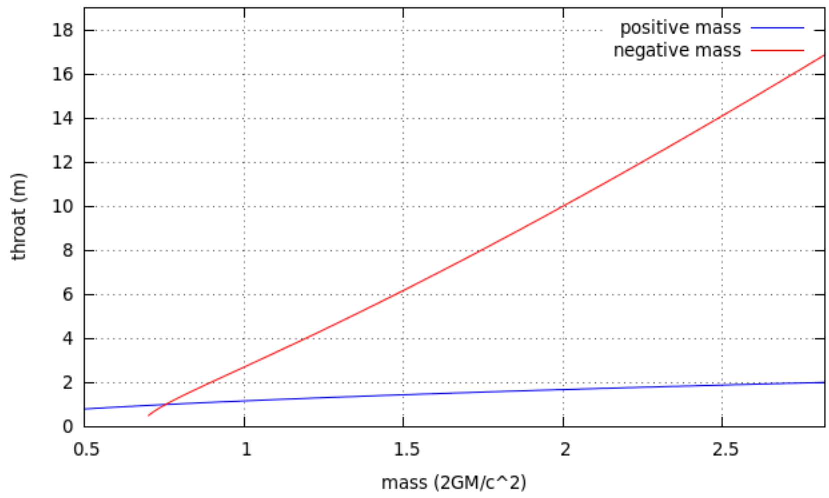

Figure 3: Comparison of wormhole throat of positive and negative gravity mass field

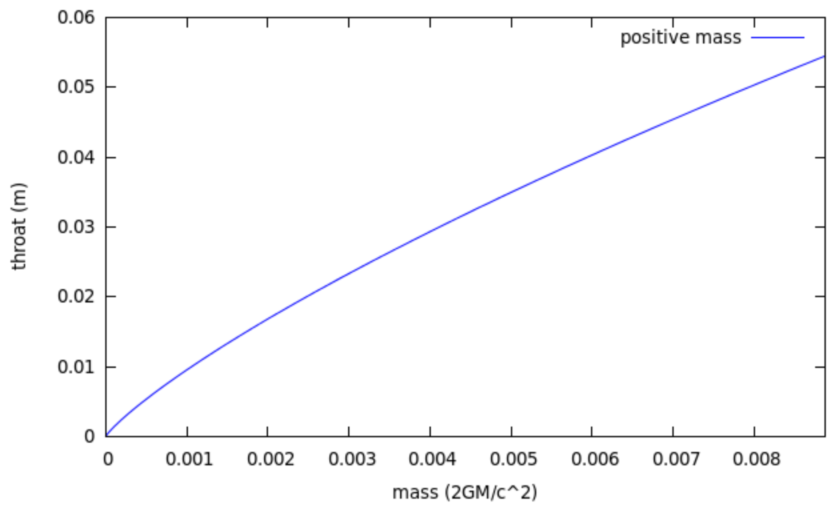

Figure 4: Wormehole throat versus effective gravity mass