Speed of Light and Momentum within the Frame Work of Generalized Special Relativity

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Abstract:

In this work generalized special relativity is utilized to obtain an energy expression satisfying the Newtonian limit and explaining the gravitational red shift . The speed of light in gravity is found to be that of free space useful expression for momentum in the gravitational field.

Key words: generalized SR , Newtonian limit , momentum

Introduction:

Einstein theory of special relativity (GR) is one of the biggest achievements in physics. It changes radically the classical concept of space and time. The GR theory is based on two postulates. On of them is concerned with the homogeneity of space and time the other is concerned with the constancy of speed of light [1].

The theory of GR succeeds in explaining a large number of experimental observations, like meson decay, pair production and nuclear mass defect [2].

Unfortunately GR suffers from noticeable setbacks. first of all, it can not explain the change of neutrino mass, it does not satisfy correspondence principle, since its expression of relativistic energy does not satisfy Newtonian limit since it does not consist of a term representing the potential energy [3].

It cannot explain also the gravitational red shift which indicates that the photon mass as well as its periodic time change with the gravitational field [4].

In this paper section 2 is devoted for GR and its short comings .the Einstein generalized special relativity (EGSR) is exhibited in section 3.section 4, ,and 5 are concerned with the speed of light in gravitational field, discussion and conclusion .

Set backs of the Theory of Special Relativity

In GR theory the expression of time t , space l , mass m , and energy E

$$t = \frac{t_\circ}{\sqrt{1 - \frac{v^2}{c^2}}} \qquad (1)$$

$$l = l_{\circ}\sqrt{1-\frac{v^2}{c^2}} \qquad (2)$$

$$m = \frac{m_{\circ}}{\sqrt{1-\frac{v^2}{c^2}}} \qquad (3)$$

$$E = mc^2 \qquad (4)$$

Where t_0 , l_0 , m_0 , stands for time, length ,and mass in arrest frame. While t , l , and m represents time , length and mass in frame moving with velocity v with respect to the rest frame .

The expression of relativistic mass in the Newtonian limit, where the light speed is law is by

$$E = m_{\circ}c^2\left((1-\frac{v^2}{c^2})\right)^{\frac{-1}{2}} \approx m_{\circ}c^2\left(1-\frac{1}{2}\frac{v^2}{c^2}\right) \qquad (5)$$

$$E \approx m_{\circ}c^2 + \frac{1}{2}m_{\circ}v^2$$

Which is not typical to the Newton expression of energy [5].

$$E = \frac{1}{2}m_{\circ}v^2 + V = T + V \qquad (6)$$

Since it dose not consists of on expression representing the potential energy.

The gravitational red shift phenomena is also related to GR . It is concerned with the change of photon frequency from f to f' when it enters a gravitational field of potential V . According to the principle of Newtonian energy conservation

$$hf' = hf + V \tag{7}$$

Since the photon energy is also given by(4) it follows that

$$\begin{aligned} hf' &= m'c^2 \\ hf &= mc^2 \end{aligned} \tag{8}$$

Thus

$$\begin{aligned} m'c^2 &= mc^2 + V \\ \Delta m &= m' - m = \frac{V}{c^2} \end{aligned} \tag{9}$$

Equation (9) indicates that the photon changes with the potential which is in direct conflict with the equation (3) , which states that the mass does not change with the potential V .

Generalized Special Relativity Theory

Einstein GSR is proposed by some anthers [6] to remedy and cure the afore noted defects.

Attempts is also made by savickas to construct a generalized Newtonian equation in a curved space [7].

In GSR the time, space, mass and energy expressions are given by

$$t = \frac{t_\circ}{\sqrt{1 + \frac{2\varphi}{c^2} - \frac{v_\circ^{\,2}}{c^2}}} = \frac{t_\circ}{\gamma} \qquad (10$$

$$l = l_\circ \sqrt{1 + \frac{2\varphi}{c^2} - \frac{v_\circ^{\,2}}{c^2}} = \gamma l_\circ \qquad (11)$$

$$\gamma = \sqrt{1 + \frac{2\varphi}{c^2} - \frac{v_\circ^{\,2}}{c^2}}$$

$$m = \frac{m_\circ \left(1 + 2\,{}^{\varphi}\!/_{c^2}\right)}{\sqrt{1 + \frac{2\varphi}{c^2} - \frac{v_\circ^{\,2}}{c^2}}} \qquad (12)$$

φ is the potential per unit mass

$$E = mc^2 \qquad (13)$$

In this model the energy is given by

$$mc^2 = m_\circ \left(1 + 2\varphi/c^2\right)\left(1 + 2\varphi/c^2 - v^2/c^2\right)^{\frac{-1}{2}} c^2 \tag{14}$$

$$\approx m_\circ \left(1 + 2\varphi/c^2\right)\left(1 - 2\varphi/c^2 + \frac{1}{2} v^2/c^2\right) c^2$$

$$\approx m_\circ c^2 + m_\circ \varphi + \frac{1}{2} m_\circ v^2$$

$$\approx m_\circ c^2 + V + T$$

The gravity red shift can be explained by setting

$$m_\circ \neq 0$$

$$T = \frac{1}{2} m_\circ v^2 \approx 0$$

$$mc^2 = hf'$$

$$m_\circ c^2 = hf$$

To get

$$hf' = hf + V + T \tag{15}$$

$$\approx hf + V$$

Cleary expression (14) satisfy Newtonian limit (6) for consisting of a term representing kinetic and potential energy.

Speed of Light and Momentum in the Gravitational Field

Consider a light clock moving up ward with speed v as shown below(Fig(1))

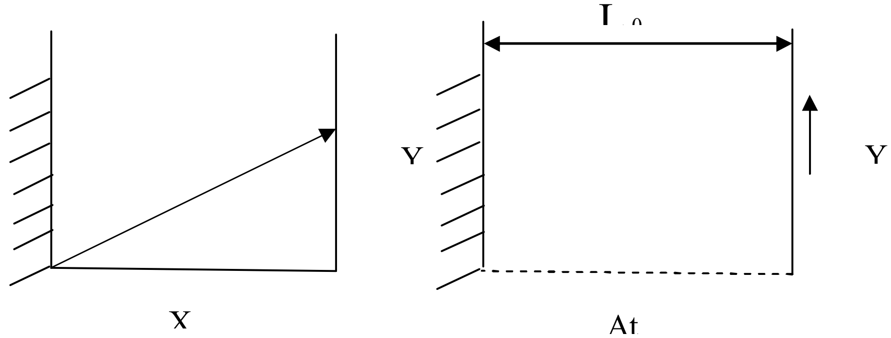

Figure (1). a light clock moving up ward with speed υ In arrest frame

$$x = l_{\circ} = ct_{\circ} = c\gamma t \quad (16)$$

When moving with initial speed v_0 under the action of gravitational acceleration g

The velocity at a height y is given by

$$v^2 = v_{\circ}^{\ 2} - 2gy = v_{\circ}^{\ 2} - 2\varphi$$

Where

$$V = m\varphi = mgy \quad (18)$$

Thus

$$y = vt = \sqrt{v_{\circ}^{\ 2} - 2\varphi t}$$

The light speed in a curved trajectory of length element ds is given by

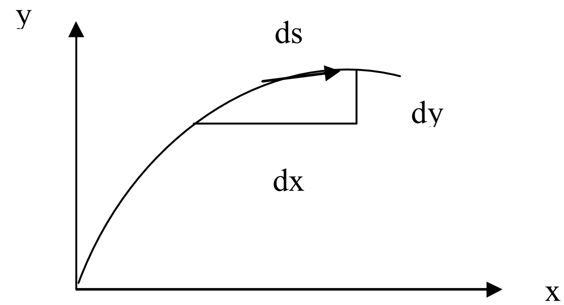

Figure (2) light speed in a curved trajectory of length

$$ds = \sqrt{(dx)^2 + (dy)^2}$$ Form equation (16) and (19)

$$ds = \sqrt{c^2\gamma^2 + v_\circ^{\,2} - 2\varphi dt}$$
$$= c\sqrt{1 + 2\varphi - v_\circ^{\,2} + v_\circ^{\,2} = 2\varphi dt}$$
$$= cdt$$

Thus the light speed in the gravity field

$$c_g = \frac{ds}{dt} = c \qquad (20)$$

Thus the speed of light in the gravitational field is also constant the momentum p in the gravity field is given according to equation (12) by

$$p = mv = \frac{m_{\circ} v \left(1 + 2 \varphi / c^2\right)}{\sqrt{1 + 2 \varphi / c^2 - v_{\circ}^{2} / c^2}} \qquad (21)$$

Discussion

According to equation (6) and (14) EGSR satisfy Newtonian limit . equation (15) together with (7) shows that EGSR can explain the gravitational red shift phenomena .

In view of equation (20) it is clear that the speed of light in the gravitational field is equal to its speed in free space which is in agreement with experiments . equation (21) show that the momentum is a affected by the gravity potential.

Conclusion

The exhibited derivations of EGSR shows that this theory can cure the defect of SR by incorporating the effect of the field in the expressions of time , length , mass and energy. There is a hope that EGSR can bridge the gap between SR and Quantum mechanics.

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