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Deriving of the Length Contraction in the Presence of the Gravitation in General Special Relativity by Using a Light Clock

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Abstract **:***Generalized special relativity is one of the most promising models that is found to cure many defects of special relativity. These defects include un capability of explaining gravitational red shift and satisfaction of the Newtonian limit.*

Despite these successes generalized special relativity suffers from noticeable setbacks. First of all its way of derivation make it restricted to weak fields only. Although recent derivation make it applicable to fields other than the weak and gravitational field, but this derivation needs to be strengthen.

In this work a light clock is used to derive a useful expression for time, length, in General special relativity. These expressions are typical to that derived before by using curved space. Time, but they are not restricted gravitational and weak fields. The expressions for time, length holds for all fields.

Keywords**:***alight clock mirror, Generalized (GSR), gravitational, length contraction, Time dilation.*

I. 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. One 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 cannot 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.

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 [3].

II. Set backs of the Theory of Special Relativity

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

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

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

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

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

Where $t_{\circ}, l_{\circ}, m_{\circ}$ 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 energy in the Newtonian limit , where the light speed is law is given by [4,5,6,7].

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

$$E \approx m_{\circ} c^2 + \frac{1}{2} m_{\circ} v^2 \tag{5}$$

This is not typical to the Newton expression of energy[8].

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

Since it does not consist of an expression representing the potential energy.
The gravitational red shift phenomenon 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

$$hf' = m' c^2$$
$$hf = mc^2 \tag{8}$$

Thus

$$m' c^2 = mc^2 + V$$

$$\Delta m = m' - m = \frac{V}{c^2} \tag{9}$$

Equation **(9)** indicates that the photon mass 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 [9].

III. General Expression for Kinetic and Potential Energy

The ordinary relation between mass *m*, velocity *v*, force *F*, and potential v is given by

$$m \frac{dv}{dt} = F = -\nabla V = -\frac{\partial V}{\partial x} \tag{10}$$

For m independent of x and ϕ dependent on x only [9].

When

$$V = m\phi$$

$$m \frac{dv}{dx} \frac{dx}{dt} = -m \frac{d\phi}{dx} \tag{11}$$

$$m \int_{v_0}^{v} v dv = -m \int_{0}^{\phi} d\phi \tag{12}$$

Hence

$$\frac{1}{2} m \left[v^2 - v_0{}^2 \right] = -m\phi \tag{13}$$

Eliminating *m* form both sides of equation (13) yields

$$v^2 = v_0^2 - 2\phi \quad (14)$$

This can be also be derived from the relation

$$v^2 = v_0^2 - 2ay \quad (15)$$

$$V = potential = Fy \quad (16)$$

$$may = m\phi$$

$$\phi = ay$$

For particles moving down ward, we replace v by $v_\circ$ to get

$$v_0^2 = v_f^2 - 2\phi \quad (17)$$

IV. Derivation of Time Dilation in the presence of Fields

Consider an attractive field like gravitational field. Let a light mirror of length $l_\circ$ move down ward with initial speed $v_\circ$.

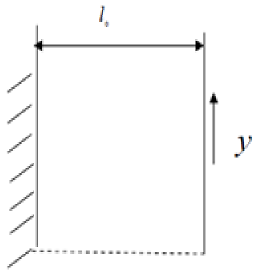

Figure (1) a clock in free space

When clock moving up its speed be comes v at a time t .

For the clock in free space the time to is given by

$$t_\circ = l_\circ / c$$

$$l_\circ = ct_\circ \quad (18)$$

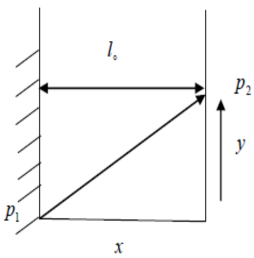

Figure (2) For a clock moving under the action of the field

$$y = vt$$

$$x = l_0 \quad (19)$$

The velocity v_f and the vertical displacement y can be expressed in terms of the initial velocity $v_\circ$ and acceleration a as follows

$$v_f = v_\circ + at$$

$$y = v_{\circ} t + \frac{1}{2} a t^{2} = (v_{\circ} + \frac{1}{2} a t) t$$

Since the average velocity v is given by

$$v = \frac{v_{\circ} + v_{f}}{2}$$

$$= \frac{2 v_{\circ} + a t}{2}$$

$$= v_{\circ} + \frac{1}{2} a t \qquad (20)$$

It follows that

$$y = vt$$

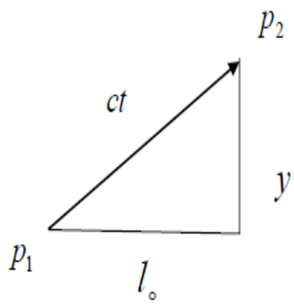

Figure (3) light moving with speed c form p_1 to p_2

Assuming the light moving with speed c form p_1 to p_2 in a trajectory inclined to the vertical plane one can get

$$c^{2} t^{2} = l_{0}^{2} + y^{2} = c^{2} t_{0}^{2} + y^{2}$$

But

$$y = vt$$

$$y^{2} = v^{2} t^{2}$$

$$c^{2} \left[1 - v^{2} / c^{2} \right] t^{2} = c^{2} t_{0}^{2} \qquad (21)$$

Using relations (17) and (20) , one gets

$$v^{2} = \frac{(v_{0} + v_{f})^{2}}{4} = \frac{v_{0}^{2} + v_{f}^{2} + 2 v_{0} v_{f}}{4} \qquad (22)$$

$$v^{2} = \frac{4 v_{f}^{2} - 8\phi}{4} = v_{f}^{2} - 2\phi \qquad (23)$$

$$t = \frac{t_{0}}{\sqrt{1 - v^{2} / c^{2}}} = \frac{t_{0}}{\sqrt{1 + \frac{2\phi}{c^{2}} - \frac{v^{2}}{c^{2}}}}$$

(24)

This expression holds for any field [10].

V. Derivation of Length Contraction in the presence of Fields

Consider a rod moving down ward with respect to a clock with speed *v*.

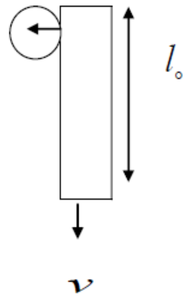

Figure (4) A rod moving down ward

For observer at rest with respect to a rod, this rod is at rest with respect to him.

Thus its length is equal to $l_\circ$. But the clock is moving with respect to him. Hence the time is given according to equation (22)

$$t = \frac{t_0}{\sqrt{1 + \frac{2\phi}{c^2} - \frac{v^2}{c^2}}} \quad (25)$$

Thus the speed for him is given by

$$v = \frac{L_0}{t} \quad (26)$$

For observer at rest with respect to clock. The clock is at rest with respect to him .

Thus the time is $t_\circ$. But the rod is moving with respect to him .Thus the rod length is l . The speed is given by

$$v = \frac{L}{t_0}$$

$$\frac{L}{t} = \frac{L_0}{t} \quad (27)$$

Thus the length in the presence of the field is given by

$$L = L_0\left(\frac{t_\circ}{t}\right) = L_0\sqrt{1 + \frac{2\phi}{c^2} - \frac{v^2}{c^2}} \quad (28)$$

This expression holds for any fields.

VI. Discussion

A useful expression for time and length Contraction were found in equations (24) and (28). These expressions were derived by considering a light mirror clock moving in a field. The motion of this clock is obeys the ordinary equations of motion in any arbitrary field. Fortunately the two expressions are found to be typical to that obtained in GSR.

VII. Conclusion

The expressions for time and length by using a light clock to derive GSR, shows that the GSR can hold for any field, gravitational or non-gravitational, this derivation holds for any fields

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